

**Book Information**

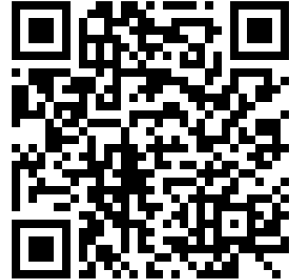
*Astrotripping: A Cosmic Joyride*

Eagle Gamma

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First Edition

Capesterre Belle-Eau, Guadeloupe



<http://eaglegamma.com/writing/astrotripping-a-cosmic-joyride/>

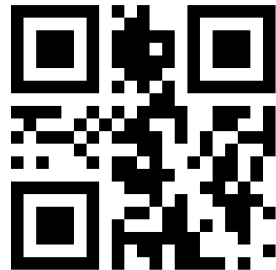
ISBN: 978-2-9575323-0-8

Cover photo: United States National Astronomical Observatory,  
Kitt Peak, Arizona

Font: Liberation Serif

Worlds O Wisdom (WOW) Publishing

<http://worldsowisdom.com/wow>



*Astrotripping: A Cosmic Joyride*

Eagle Gamma

To you.





To all the bright sparks of life and love who inspire me.



*Astrotripping: A Cosmic Joyride*

Eagle Gamma

And to firefighters.



*Astrotripping: A Cosmic Joyride*

Eagle Gamma

And to existence.



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## Travel Map

This map shows Eagle's travels from Canada through the end of *Astrotripping* into Texas, then the following travels to the Caribbean. You can find the latest travel map at <http://eaglegamma.com/riding/>



## **Acknowledgments**

Thank you! ☺

I owe way too much gratitude to thank everyone appropriately, as with any book or adventure. I want to thank everyone who has contributed their love and support, giving life to this book. In particular, my publicist, my editors, and especially my readers. Thank you for reading this book!

Many people made critical contributions to *Astrotripping*. In some cases, I did not mention them by name, but I am as thankful for them as for anyone.

I appreciate the valuable time and thought that astronomers gave me in conversation and demonstration, shedding unique light on our universe.

Very gratefully, I received the opportunity from magazine editors to write articles about these research advances. Bob Naeye at Sky & Telescope gave me a fortunate shot on my first outing. Chris Bramley of BBC Sky at Night accepted several stories. Kathryn Jepsen of the US Department of Energy National Laboratories published a piece.

Thanks for all the people who shared the unforgettable experiences throughout this trip.

A special thank you to Avril Olachea, who shared some of the most marvelous times, and for many “personal readings” that were fun and helped improve this book.



Many thanks to Carmella Guiol for showing me a different side of nature, and offering valuable writing feedback.

Sincere appreciation to Elvera Lo for involvement in the project and providing critical comment.

Thank you to Bunni Zimberoff for providing edits of this book.

I appreciate Dr. Adrian Bejan for inspiration.

I am deeply grateful to all the people who have helped me out along the way. Whether with a couch to surf, a yarn to spin, a spare bike part, a word of advice, or an encouraging smile. Without each one, there would be no *Astrotripping*.

I want to thank my parents for teaching me to ride a bicycle, teaching me about space science, and teaching me about travel, among other things.

Also, thanks for the vendors of tacos and burritos fueling this ride.

If you find any errors, blame my editors.



## **Introduction: An Astrophysics Adventure**

Greater Los Angeles, California, United States of America

August, Year One

*Writing about astrophysics, Eagle rides by bicycle around North America. Along the way, we go to observatories and laboratories, and learn about modern theories and observations. We also encounter outlandish hijinx.*

As I was wrapping up a draft of this book, I got struck by lightning.

Not the metaphorical kind, where you suddenly get an idea that explains everything. But, like, actual lightning. A stream of high-voltage plasma-spewing electrons, straight to the sternum.

I had been riding my bicycle along the Mississippi River levee in Louisiana, and just got to the state capital, Baton Rouge, the night before a thunderstorm was expected. Deciding to chance it and camp out that night before going into town in the morning, I awoke around dawn to pounding rain and wind. As I was deciding whether to stay in the rapidly diminishing dryness of the tent or brave the elements, I felt a fierce crack in the center of my chest, and my body shot up into the air. There was a lingering smell of smoke.



That moment – the immense power of nature, usually well outside of daily experience, colliding with an otherwise fun outdoorsy adventure – reveals something of the wonderful yet terrifying and revolutionary experience of *Astrotripping*. Physical phenomena undergird our experience, so we can learn valuable new worldviews from either: by adventure travel or by astrophysics, we can probe the extremes of knowledge.

Oh, and for my new post-lightning superpower I chose being able to eat a lot, although I could already do that beforehand so maybe I just have a different perspective in life.

We are about to embark on an incredible ride. I hope you enjoy!

Starting from the winter of 2013 and over the following two years, I have traveled thousands of miles by bicycle, visiting telescopes and other research sites, and writing about astrophysics. In the course of interviewing and touring, I have come across many fascinating discoveries. You now hold those stories.

From late February, I started riding down from Canada along the Pacific coast. After the states of Washington and Oregon, I rode south through California. Before going from Los Angeles to San Diego, I did a big loop through the Mojave Desert. Then, after San Diego, I spent half a year traveling through Mexico. I biked the length of the Baja Peninsula, before an adventurous sea crossing by sailboat, then followed by further





travels into the heart of the Mexican mainland. After returning to California, I continued throughout the Southwest, visiting Nevada, Arizona, and New Mexico, before crossing into Texas.

Many new destinations remain ahead. What unites the astrophysics endeavors I cover with my own adventures is a common dedication to the pursuit of our curiosity, even through unconventional means. *Especially* through unconventional means. To get to interesting destinations sometimes requires crossing boundaries – personal, social, physical, metaphysical.

## **Space Quest**

At heart, space science is a quest for knowledge. We tend to emphasize the knowledge, but the quest also matters. When researchers go to extraordinary lengths to learn important information, it often results in interesting advances. Inventing new tools to look at the stars opens incredible new worldviews, from Galileo's first telescope to today's most innovative technological marvels. We are now entering a new golden age in space science.

*Astrotripping* brings you an amazing array of stories...

From an experimental aircraft designer and flyer building a massive mirror out of liquid mercury in the Canadian forest, to the USA's national radio observatory modernizing its flagship array in remote New Mexico, the diversity on display astounds. Mexico's largest scientific project ever takes shape in the mountains of Puebla, alongside a mirrorless look at the



most energetic phenomena in the universe. The Vatican runs its newest telescope in the gun-slingin' Wild West of Arizona. Right next door, the planet's most powerful optical device searches for signs of distant life. In northern Arizona, The Discovery Channel teams up with a legendary observatory to build a gigantic new type of telescope camera. At Mexico's national observatory, an international team builds a robotic data collector to scan the Solar System. The US national solar program moves to a different way of understanding the sun, in New Mexico. And at the American optical observation headquarters back in Arizona, a new generation of astronomy starts with the most massive data system on the planet. A controversial space research effort in the California desert challenges fundamental physics to get us off the planet. Meanwhile back in Mexico, theoretical astrophysics investigations question the most basic aspects of the universe.

The narratives here touch on many evocative themes. Some relate to relatively pure inquiry, such as the highly technical and scientific advances revolutionizing the entire field of astronomy. Others delight the imagination, with tantalizing possibilities ranging from extraterrestrial intelligence and religious revelation to time travel and the settlement of space. How seriously should we take these topics? Different people ascribe a range of credibility to each, sometimes surprisingly. Don't forget that, until very recently, even the notion of stepping foot on the Moon remained within the realm of science fiction.



## **Earth Quest**

Meanwhile, back on planet Earth, my travels involve not only the phenomena that astrophysicists study, but also the phenomena that I personally experience. I love to immerse myself among awe-inspiring redwoods, vast empty deserts, stunningly beautiful beaches, monumental mountains, densely intricate cities, a bewildering array of human practices, and countless unpredictable situations. Here I'll show you some unconventional parts of the planet.

Mostly camping, I have slept in simply incredible locations, often luxuriating in a fresh, cool breeze under the starry night sky. However, the environment also poses challenges, which range from offensive animals and loud machines through intense rains and snows and winds, and to painful heat and cold. Sleeping with barbed wire pushing against one side and highway traffic pushing against the other, or on a cliff between the mountain and the sea, feels quite sharp! Nighttime interlopers add suspense – whether wildlife, drug gangs, agents of the state, or stumbling drunks.

Traveling lightly, I carry all of my essential belongings with me – sleeping gear, bicycle parts, and writing tools. Writing in different environments can prove challenging, yet inspiring. Words flow from the surroundings as well as from the writer, whether in a crowded café or on an empty stretch of land, by a fountain in a garden, or on a military base next to warnings of various kinds of impending doom.



The adventure starts when the smooth-going stops. Or before the smooth-going starts! Going off on a trip without a gig or gear or proper preparation. After getting soaking wet and freezing in the rainforest for days on end, with belongings getting waterlogged and bicycle equipment breaking down and body and mind drowning – or after the inverse experience with dry heat in the desert – that’s when the real discoveries happen. Frequent close encounters with death intensify one’s thirst for life, and refresh the desire to learn about the frontiers of knowledge and experience.

Why go? Lots of motivations combine to make this a very compelling choice. Curiosity drives us to learn more about the world around us and the world within us. This resonates with the curiosity that drives astronomers to study the stars. I had long dreamed about going to space. Also, I considered moving to California, to make a new home. This planet has so many wonderful places, and so many wonderful people. And, to paraphrase Forrest Gump: “I just felt like riding!” Both personally and professionally, the desire to explore a variety of experiences makes *Astrotripping* a living dream. Realizing dreams, that’s what we do.

### **Everyday Life**

With novel results in astrophysics continually expanding our worldviews, I find it funny how often my own outcomes turn on criteria as primitive as weather conditions, physical efforts, or random bits of material. In contrast with the technical sophistication I see at telescope sites large and small, I still struggle to spin wheels, or write words, or start fires!



Along the way, I sometimes stay with people I meet. This puts me in contact with a wide range of characters, who often have vast local knowledge, welcome amenities, and above all, unique insights and outlooks. As a modest part of exchanging the favor, I try to share some of the meaning of modern space science with my considerate hosts. I've had the opportunity to stay with individuals, families, polyamorous groups, and co-ops, housing every imaginable kind of person.

People have so much more of a positive side than we easily see in everyday life, and I have no hesitation in saying that the amazing generosity of humanity ranks among the most remarkable lessons of this voyage. People from all walks of life have volunteered places to stay, rides, food, mechanical help, psychological support, and every conceivable act of kindness.

Traveling by bicycle to write about astrophysics makes for a wonderful lifestyle, with every day providing a very new canvas. Riding and writing. The open road and the blank page. I especially value the liberty.

Growth comes from challenges, and by putting myself out of my element on an essentially constant basis, I have to learn a lot just to stay in the saddle. Surviving disasters becomes almost routine, and new highs come faster than I can fully comprehend. I now have a better sense for how nature does her thing, both theoretically and practically, and a newfound appreciation for the gifts of life.



Sometimes, so much happens in a day that I forget the name of the town where I awoke, and often I don't know where I'll arrive by the end of the day, let alone the week. Fortunately, *Astrotripping* has opened many fresh perspectives from which to learn and grow. Hopefully you gain as much from reading as I have from writing. Exploring Earth and space – what a trip!

### **Seeing the Light**

Going on a bicycle ride across thousands of miles, through different terrains in different countries, transports the rider and the reader through various conditions unlike what one already knows. This removal from ordinary conditions also removes a lot of false preconceptions. Without these blinding prejudices, we can see more clearly, with greater light.

Very similar things have been written about psychedelic drugs. These mind-manifesting wonders alter the neurological circuitry of the human brain, changing our perception, and revealing a simpler, clearer, brighter, lighter view of the universe, of nature, of reality, of existence. Depending on whom you ask. At any rate, some pretty geometrical patterns.

Another place you can look for pretty geometrical patterns, or an ego-transcendent trip, is astrophysics. Through the advent of innovative technologies, which augment our naturally evolved vision, we can detect electromagnetic radiation, in the form of waves of light and invisible energy, traveling across the vast light years of cosmic space. Arriving billions of years later, these beams of light carry signals from ancient worlds, messages of our origins, rays of possibility.



Wow!

We can look out into the dark, mysterious, cosmic depths of the universe. We can see new light. We can glean incredible information which reveals more about who we really are. By seeing without the prejudices built into our biological vision, we gain a clearer, truer, more beautiful picture of reality. We go on a cosmic voyage of discovery. What will we find? We have to explore, to see for ourselves.

And this exploration is fun.

Seriously. Or playfully.

Prepare to have your socks rocked, or your hippie sandals or riding shoes or whatever footwear.

Whether you ride a bike around the planet, or drop acid, or study the little charts and graphs produced by today's multibillion dollar eyeglasses, you are in for the adventure of a lifetime!

Your whole world revolves around your perception. Opening its doors lets in new light...

When you take a brave dive into the unknown, when you reveal a little bit of what your own ignorance conceals, you transcend a little bit of your limitations. We're all imperfect enough bits of universe to have many glaring blind spots. Yet, we have increasingly many and increasingly capable tools to help penetrate the darkness, and go on a fun adventure of discovery.



Who knows where it'll take us? Into the unknown future, into the bright tomorrow...

We start with wonder. We open our eyes and our minds. We give a lot of effort. And we observe.

Ready?

Let's go *Astrotripping!*

Rock & Roll!! ☺





## **Liquid Astronomy**

Liquid-Mirror Observatory, Maple Ridge, British Columbia, Canada

September, Year Zero

*In the forests of British Columbia, we visit the Liquid-Mirror Observatory. It has the planet's largest telescope mirror made out of liquid metal. In addition to conducting surveys of the deep universe, the device studies Earth's atmosphere. Currently the observatory serves to prepare the next generation of megatelescopes.*

Deep within the forests of British Columbia, on a granite outcrop atop a hill, sits a hidden gem — a shining pool of mercury. At 6 meters in diameter, the Large Zenith Telescope (LZT) ranks among the world's largest telescopes. It's also the largest of a unique type of instrument: the liquid-mirror telescope.

After a long trek through tranquil forests — surrounded by scents of western red cedar and sights of sprawling woodland growth — it feels surreal to stand next to the cool, clear primary mirror, like stumbling on a spaceship in a fairy tale. A thin layer of mercury, mere millimeters deep, rests on a dish designed to minimize the volume of liquid. This dish spins the mercury at a constant speed of 8.5 revolutions per minute,



creating a smooth, highly reflective parabolic surface. Stir a cup of coffee with circular motions, and you'll see a similar valley form in the center. In combination with corrector lenses and other hardware, the immense mirror functions as a telescope.

This unique instrument is clearing the way for other incredible technology. Researchers are using studies of Earth's atmosphere undertaken with the LZT to design the next generation of megatelescopes, particularly the Thirty Meter Telescope (TMT) and the 39-meter European Extremely Large Telescope (E-ELT). Liquid-mirror telescopes might also be the inexpensive solution astronomers need in order to pursue survey work that eats up valuable time at conventional observatories.

### **Simple Has its Perks**

Paul Hickson (University of British Columbia, Canada) built and directs the Liquid-Mirror Observatory, the home of the LZT. He leads the world in designing these exotic telescopes. A clever, acute man with a sense of adventure, Hickson also flies and builds experimental aircraft, and his telescope's design has influences from aerospace.

When it came time to build the Liquid-Mirror Observatory, his team surveyed several candidate sites within reach of the university — looking at weather statistics and maps, flying overhead, and driving around by Jeep. They selected this forest sanctuary, far away from city lights, over several other locations.



The LZT has a relatively tiny price tag. Large conventional telescopes cost many millions of dollars to build, and tens of thousands of dollars per night to operate. That's orders of magnitude more than the Liquid-Mirror Observatory, which was built for half a million dollars.

Canadian physicist Ermanno Borra (Laval University), pioneer of liquid-mirror telescopes, thinks that cost is the essential advantage of these instruments. "It's something like a factor of 100, the difference in the cost of the mirrors," he says. "It's really very, very inexpensive."

The same simplicity that makes liquid-mirror telescopes so affordable also results in excellent optical quality. The LZT produces astronomical observations with resolutions comparable to a conventional telescope of similar size, and it observes stars and distant spiral galaxies at around the atmospheric resolution limit. Because a fluid naturally flows to a smooth shape, liquid mirrors achieve impeccable optical quality far more easily than polished glass, with the potential to produce a perfect mirror.

That perfection depends on finely tuned hardware. A display in the control room shows variations in the rotational speed of the spinning mirror: nine parts of error per million. When Hickson first built the mirror, he measured the rotational error at 1,000 parts per million. The ensuing jitters set mercury sloshing, destroying the reflected images.



## **Liquid Technology**

Isaac Newton first described the rotating-fluid concept that makes the liquid-mirror telescope possible. When a liquid spins at a constant speed, the combination of gravity and rotational acceleration finds a dynamic equilibrium that makes the top surface of the fluid form a smooth parabolic shape. The paraboloid arises because a liquid surface always forms its local surface perpendicular to the net acceleration it experiences.

In the case of a spinning mirror, the net acceleration becomes stronger and more inclined with distance from the spin axis at the mirror's center. Put a camera at the focal point of the paraboloid, where the reflecting surface focuses light into a single point, and you have yourself a liquid-mirror telescope.

Despite coming up with the rotating-fluid idea, Newton apparently did not consider a telescope based on a liquid paraboloid. The concept went through several periods of development and dormancy. In 1982 Ermanno Borra revived the idea and soon realized, in his words, "Whoa, wait a second, you can do science with that!"

In 1994 he and Hickson built a successful 2.64-meter telescope. After that, Hickson created a series of mirrors, enhancing the size and performance with each iteration. At first he essentially worked out of his garage, building liquid mirrors for North American universities. Then NASA found out about his work and contacted him.



The agency wanted a large, affordable telescope — both of which describe liquid-mirror telescopes. Hickson built a 3-meter mirror for a device housed at NASA’s Johnson Space Center in Houston. NASA later moved the telescope to the Orbital Debris Observatory, in Cloudcroft in the Lincoln National Forest of New Mexico. The telescope collected data on space garbage for many years, earning a NASA Group Achievement Award. Some surplus NASA components made their way into the Large Zenith Telescope.

### **To the Zenith**

A liquid-mirror telescope’s defining trait is its rotating primary mirror. With correcting lenses and a detector, the parabolic liquid surface becomes an inexpensive large-aperture telescope. The construction of the Large Zenith Telescope started with its supporting steel trusses. Over these went segments made of a composite of fiberglass, foam, and epoxy.

On the dish, liquid mercury spins into the shape of the primary mirror. Mercury vapors from the Large Zenith Telescope can be dangerous during the first hours after its setup. But oxidation soon prevents vapor emission, and after a day or so, gas masks are unnecessary.

Hickson added an optical encoder to measure angular movement, allowing better control. He also installed an optically clear cover of Mylar film, only a few microns thick, which sits a few centimeters above the mercury and rotates with the mirror. This cover protects the liquid from wind blowing in through the open roof, and also prevents the



formation of small vortices in the air above the moving liquid, which create tiny waves that degrade images.

As the name implies, the Large Zenith Telescope only sees the portion of the sky directly above the observatory: tipping the mirror would spill the mercury, so the liquid mirror must face straight up. Researchers get around the limitation somewhat by “drift scanning”: delaying the CCD’s readout to match the sky’s drift speed and allow for artificial tracking. But liquid-mirror telescopes still only serve for astronomical studies that do not require steering. The observatory sits at a latitude of  $49^\circ$ , which means that as Earth rotates, the telescope observes a strip of sky at  $49^\circ$  declination. Such zenith strip surveys are useful for a variety of scientific pursuits, ranging from cosmology to the detection of supernovae.

The LZT currently pursues other targets, though. It has a far greater demand on its time: guiding astronomers in designing the upcoming generation of gargantuan telescopes by studying sodium in the atmosphere.

### **Solving the Sodium Problem**

A new generation of so-called “extremely large telescopes,” such as the Thirty Meter Telescope and the European Extremely Large Telescope, have major design challenges to tackle. The telescopes will house primary mirrors three to four times the diameter of today’s largest optical telescopes. Huge mirrors make it possible to get large, sharp, intense images — yet that very same sensitivity subjects the telescopes to atmospheric distortions that smaller instruments don’t see.



Optical sensitivity grows proportionally with the diameter to the fourth power, which means that increases in size have dramatic impacts on telescopes' abilities.

One particular challenge facing the upcoming giants is their adaptive optics. Adaptive optics systems compensate for the atmosphere's blurring effects. At some observatories, astronomers map these atmospheric changes by beaming a laser into the mesosphere's sodium layer, effectively creating a bright fluorescent lamp in the sky that acts as an artificial "guide star." The telescope then adjusts its shape rapidly and repeatedly — sometimes more than 1,000 times per second — in order to match the distortions in the atmosphere detected from the laser guide star. Large, ground-based telescopes require adaptive optics to perform better than the seeing limitation imposed by Earth's atmosphere.

The atmosphere's sodium layer varies over time. Several nights of observation by the Large Zenith Telescope show multiple, transitory layers, with densities, altitudes, and structures that evolve over time. The brightest layers are about two to three times denser in sodium than the background. Blind spots, which show up as dark vertical bars, come from overflying aircraft interruptions.

The sodium layer consists of several distinct levels. Ocean-like waves roll along the entire layer, and turbulence induces variability. These irregularities, coupled with changes in the entire layer's average altitude, change the structure and distance of guide stars, confusing the adaptive optics system.



Even five meters of variation in the sodium layer’s altitude can affect the system.

“If a meteor trail occurs in the middle of an observation, it can change the average range to the sodium layer by a hundred times that much, or more,” says Brent Ellerbroek, department head of instrumentation for the TMT. The consequent error would be much bigger for larger telescopes. Such errors would wreak havoc on the behemoths’ observations. “So it’s very important to understand how the sodium layer is evolving in time.”

Astronomers had come to this conclusion by extrapolating from data taken on timescales six orders of magnitude longer than those on which adaptive optics operate. To verify that the sodium layer would behave on small scales as they thought it would — before building the billion-dollar observatories — the astronomers needed a way to measure the actual variations of atmospheric sodium density at a fine enough resolution to correct for any errors. The best existing data in the world would not do.

It turns out that the LZT can collect precise enough data to resolve the problem. During a lull created by a broken camera sensor, Hickson and one of his graduate students installed a laser at the facility. The laser effectively turned the observatory into the world’s largest station for “lidar,” or light radar. Using lidar, the LZT picked up never-before-seen eddies and vortices in the sodium layer, showing details of both its structure and dynamics. Observations have revealed the first





detection of turbulence waves in the mesosphere — curling licks of sodium that interact intricately with neighboring layers of the atmosphere.

Ellerbroek lauds the unique situation that such a large telescope can be devoted to lidar studies. The LZT has 100 to 500 times the collecting area of other lidar systems, he says, and its incredible sensitivity enables measurements with resolutions in meters and on timescales of much less than one second. “For an 8-meter telescope that’s not important,” he says. “But for future 30- to 40-meter telescopes, understanding how the range to the sodium layer changes on that timescale becomes important.”

Ellerbroek says that he and his colleagues use the LZT’s lidar data to design the wavefront-sensing equipment they’ll use on the TMT, even to determine what kind of lasers they need to buy. “We’re actually able to input this data into simulations of the adaptive optics systems, then predict how well the components we’re designing and buying will work with the sodium layer as we understand it,” he explains. A carefully planned adaptive optics system will give the TMT three or four times better resolution than one of the Keck telescopes on Mauna Kea, Hawaii, which are among the world’s premier ground-based visible and near-infrared telescopes and the standard by which others are measured. “It’s going to have a dramatic impact on the types of observations that can be done.”



### **Futuristic Scopes**

The LZT may herald a new wave of liquid-mirror telescopes. Hickson says that they chose the observatory's site because it's a good location for testing and developing liquid-mirror technology, but the site sees few clear nights. Good weather comes mostly in the short summer nights. "Our aim all along was to put one of these telescopes at a competitive astronomical site once the technology had been perfected," he says.

One of these future instruments, the 4-meter International Liquid Mirror Telescope (ILMT), has developed independently from the LZT but benefited from knowledge gleaned from its forest counterpart. The ILMT is being installed at Devasthal ("home of the gods"), in the Indian Himalayas. The high-altitude site already hosts two conventional observatories.

Bigger dreams include a network of liquid mirrors, reminiscent of the Atacama Large Millimeter Array in Chile. Moreover, a few years ago Hickson and Borra contributed to a proposal to place a telescope of ionic liquid (basically, molten salt) as large as 100 meters in diameter on the Moon. The innovative technology, including superconducting bearings and a cryogenic vacuum, would allow astronomers to observe the early universe at higher resolutions and fainter magnitudes than the upcoming James Webb Space Telescope (JWST). Even a much smaller Moon-based liquid mirror would be a useful instrument in connection with JWST's observations.



Borra also proposed that technological developments in future decades might allow scientists to launch an orbital liquid-mirror telescope as large as one kilometer across. “It was propelled by a solar sail,” he says. “It was really a monster.”

The space proposals received serious consideration: at the time, Borra says, NASA thought that the 100-meter mirror would be a major reason for going back to the Moon. Despite changes in NASA’s current focus, Borra thinks that the gigantic lunar liquid-mirror telescope will one day see first light. In the meantime, astronomers’ next-generation telescopes will stand on the shoulders of a shining pool of mercury in the forests of British Columbia.



## **Western Ways**

Pacific Northwest, USA

February – April, Year One

*Eagle grows wings – everything goes wrong. After Vancouver, we ride down the west coast of the United States of America. Riding by bicycle through the Pacific Northwest states of Washington and Oregon, we find new worlds of adventure. A rough start teaches valuable lessons. Through rain and sunshine, many mechanical and deeper problems push us to new heights.*

On my first day in the USA, all my plans fell apart. Yet, in the midst of the maelstrom, I found joy.

The first part of the trip, along the west coast of the US, was wonderful. It could've stood as a standalone trip, as conceived, yet it grew into something more marvelous, much bigger than originally imagined. And it started off through the Pacific Northwest, that rainy wonderland of Cascadian surprises. When I started riding, in the winter, it was still snowy.

Through Washington, Oregon, and California some of the most scenic roads in the country go, along with many of the most advanced ideas and innovative people. This coast, the “edge of the world,” attracts no end of thinkers, dreamers, and



doers. Astronomy has been among the lucky recipients of this influx. The draw also makes life itself more interesting here.

### **Rough Start**

The first leg of my trip, crossing from Canada into the USA, went roughly. Just about everything that could go wrong, did. It was a disaster. Yet, the disaster yielded a new worldview, a readiness to roll on under all kinds of adverse conditions. And when you're free from the expectations of a smooth ride, you learn to enjoy the rough times as well.

I planned to ride across the border, into the USA. Before setting off, I had arranged to spend my first night with a hospitality host in northern Washington State. However, when I checked messages after crossing the border, I found that my prospective host's partner had been in a ski accident, so they had to go to a hospital in Seattle, and were thus unavailable.

Looking for a new solution, and hungry, I went into a Mexican restaurant to grab a bite to eat and figure out an alternative place to stay. Presumably due to the different populations in the respective countries, the US seems to have way more and way better Mexican eateries than Canada, even as far north as the Canadian border.

Inside the restaurant, as soon as I powered on my laptop, the screen flashed and went dead. Uh oh. Now I had no place to stay, and no computer. Not a great start.

At this point, it was getting dark out, so I decided to ride ahead anyways, to find a place to sleep. Winding my way through the



unknown streets, exhausted and worried about the prospects of this trip, I looked eagerly for a place to stay. Dogs barked angrily. A police car pulled up beside me.

The officer asked where I was going, and some other questions. It may have been a routine follow-up after the border crossing. He told me that I couldn't ride a bike on the interstate highway I'd come down on, and that I couldn't ride at night without lights, which I hadn't yet put on in the fading evening.

Carrying on into the night, I found a large green area. Upon closer inspection, it turned out to be the local country club. I went to the central building where people were gathered, to ask for information, but the people I talked with were drunk. A bit further on, I finally found a park, and decided that this would make a decent place to set up a tent – a skill I had yet to master. Fumbling clumsily with the tent poles and fabric in the darkness, I barely managed to set *something* up, then collapsed to sleep gladly.

From that point, I would gradually improve my skills at planning routes, riding, meeting people, camping, and overall traveling. Like how astronomers iteratively improve their technology, allowing them to look ever farther into space, a traveler gradually gets better at all the mechanics of moving, extending the reachable range to ever greater distances. You can apply this anywhere in life: as you continue along a path, you progressively improve your capabilities.



From this rough start in the corner of Cascadia, I found that simply riding, through whatever challenges and failures and triumphant successes, yields a kind of freedom – like flight, like the weightless travel of light across the parsecs. Adventures. Astrophysics. New ways of exploring new worlds. Leaving behind conventional presumptions, and diving out to the darkest edges of our knowledge. The quest for light, for clarity.

And riding off into the rain of Seattle.

### **Science in Seattle**

Riding down Washington State, it dawned on me that I was now going clear across the coast. Despite the rain, wind, cold, hills, animals, and whatever other obstacles, I was on the road. It felt ecstatic. Riding free, I whooped it up. Caught up in the emotions, I even jokingly cheered myself on with an exaggerated southern drawl, despite being so far north. I also joked to myself about entering the US unconventionally by bike, as some Mexicans unconventionally cross in the desert by foot – even then I felt a kinship with Mexico, where I would later spend considerable time.

Before setting out, I'd looked at maps and planned an approximate route, as well as making some arrangements for places to stay early on. However, as with the hospitality situation, I soon found out that routes and overall plans change. Roads go under construction, alternative ways present themselves, turns get missed, and like most aspects of travel –



on the road and in life – navigation is a constant work in progress.

In science, researchers start with a hypothesis. In travel, route planning starts with a map. In any journey, in life, it helps to start with a plan. Yet you also have to pay attention to the route itself. Sometimes hypotheses are falsified, or new opportunities for discovery arise. To get the best of both worlds, plan *and* adapt!

I headed south towards Seattle. I'd decided to go through the city rather than around the more idyllic areas that some people recommend, such as the Olympic peninsula. It was rainy in the Pacific Northwest, obviously, and the peninsula gets even more rain than a little bit inland. The amenities of a city would help. Also, I wanted to experience Seattle.

Arriving in Seattle late, I had misjudged distances, which I still struggled with a lot. On the map, it's just a little squiggly line! But highways twist and turn, traffic jams pop up, and life in general happens. In fact the planning fallacy makes things take longer than expected – apparently even if you're aware of the planning fallacy.

I arrived *really* late, which was unfortunate. However, the ride into the city was incredibly beautiful. A huge, long path leads all the way down through forested hills, offering seemingly endless views, finally revealing the shining city lights falling down on the water. The gorgeous ride made me want to keep on riding practically forever. After a lot of hard struggling, when you get to cruise easily for a while, you can make great





strides, although eventually you do have to get back on the grind.

At this early point in the trip, I had actually conceived of the book idea as “adventure science,” covering a broader range of topics than just astronomy, with unusual research methodology. So when I got to Seattle, I went to visit several scientific research sites, in order to write magazine stories. Most of these stories fizzled. Magazines only publish a small proportion of the story proposals they receive, in spite of the difficulty of researching and writing them. Magazine writing makes for a poor business, but an interesting time.

One site was a malaria lab, which had just gotten the world’s deadliest strain of malaria to grow in a new transgenic mouse containing human cells. The same lab also ran live tests on humans, so there are people walking around Seattle infected with malaria. Don’t worry, they’re not contagious and they get treated afterwards, although apparently the treatment isn’t appropriate for large-scale deployment.

I also went to a lab with a new method to detect breast cancer, using techniques from physics. Seattle has lots of medical research happening, along with technology businesses, and of course, coffee. Beyond Starbucks, the city is littered with little booths that sell drive-thru coffee. Some even have baristas in bikinis. Overall, the city seems like an American cousin of Vancouver – steel and glass on the Cascadian coast.



I spent a little while in Seattle, meeting her friendly people. The rain did occasionally clear up, allowing the sun to shine down on the lovely lake. It felt like a dream.

### **Of Bikes and People**

At one point, while riding across a bridge over Seattle, I felt my trailer – a two-wheeled child carrier in which I pulled my personal belongings – repeatedly pushing up against the side walls of the bridge. The lane was way too narrow. On arriving at the other side, I noticed a sign that said that the bridge lane was for pedestrians only. Oops! I also noticed that my trailer no longer moved.

At the nearby flagship store of REI, a fancy national sports store, the bike mechanics asked me to sign a waiver before forcibly bending the metal trailer back into shape. The thing roughly held together.

On the way out of Seattle, I rode through the lengthy suburban section stretching to the south. This area, and other realms of suburbia, are among the least amenable places to ride. Fast multilane traffic doesn't expect, or want, a bicycle on the road. No dedicated bike lanes exist. The rough sidewalks go alongside many miles of strip malls. Also, suburban streets tend to be relatively confusing and laborious to get around. It can give you a headache. However, the people here are exceedingly friendly.

Just outside of Seattle, a wheel fell off my trailer. With the trailer wheel rolling off onto an adjoining side street, I pulled off after it, around the intersection. A passing pickup truck



stopped and picked me up. The young woman driving it took me to a branch of Freddy Meyer, a huge regional department store, which didn't have the right stuff to hold the wheel together. Nor did any of the automotive stores.

I wound up getting incredible help from local cyclists (thanks Mark, Jay & Dan!), who not only rescued me and got me going again, but gave me the confidence that most problems on the road are manageable. This world has many generous, caring, capable people, who make it a joy. We can all try to give back, or pay it forward, as small steps towards improving the world. And when you feel stuck, like you've run into a problem that you can't solve, sometimes you just need a little help from your friends.

Many of the people I met and stayed with showed me such hospitality and generosity, it made me realize how fortunate we are to live together as humanity, and the importance of going out of our way to help other people out. People opened their homes to me, and shared parts of their own lives. I also learned a lot about the diversity of possible living arrangements, and the universality of human drives like love despite its variance.

At one point, I visited a family practicing polyamory. Spouses and partners kept coming and going. It was special to speak with this family, discussing social and bicycle possibilities. My host was planning a bike trip ten years out. That strikes me as a very long way away to plan. I was ready to go within like seconds or minutes of having my flash of inspiration!



Another household hosted me and also helped me get through the challenge of a broken bike setup outside of Seattle. The young couple drove out to pick me up from the rain, stuffing my bike and broken trailer and my bags and belongings and me into their car. They invited me back to their beautiful house way up high in the scenic part of town. They fed me a delicious meal, including ice cream with sweets, and I got to take a warm shower in a bathroom that even included a heated floor. What luxury after being broken down and soaking wet in the rain!

The creature comforts can feel really nice after some suffering. At the same time, the suffering can teach its own valuable skills. Learning how to transcend our immediate surroundings and needs can open the way to new possibilities – better routes of which we were previously unaware. Finding the bigger picture often requires sacrificing the smaller views. There’s a role for both. It’s kind of like how there are fast and wide survey telescopes that complement narrow and deep-piercing telescopes. Maybe. I think we can make an analogy for anything out of anything else. At least, that’s the fulcrum of the cloud.

Anyways. Discovery: of people and places, of nature, of our world. By bicycle or by telescope. It opens our minds. It manifests the underlying nature or reality of the world, of existence. Going to new worlds is an essential part of expanding who we are, of growing as people. The whole wide world is this big, intricate universe. It has so much variety in it, which we can explore. It has stars, planets, people, plants,



roads. It has love in it, it has us in it, and we love. Going for a ride can offer the freedom to experience more of this wonderful world. So can gazing at the stars.

What started out as disaster quickly turned into victory. One big lesson was the strength of community. The people I've encountered while traveling fill me with hope and joy. Riding long distances and exploring new cities and meeting new people and learning new things really gets your neurotransmitters flowing!

### **Seattle to Portland**

After Seattle, I rode down through Washington State to Oregon. From Seattle down to Portland, I mostly followed the route used by the Seattle-to-Portland organized ride. It passes through many charming towns and the countryside. I especially love riding on protected bike trails, often made on former railroad track routes (rail-to-trail conversions), which avoid vehicular traffic and go through naturally beautiful areas, all while bringing together many recreational trail users.

Crossing from Washington into Oregon, it was a cold and rainy day, unsurprisingly. I stopped in a bar in an industrial area in Longview for food. Then, over a bridge on the Columbia River with a tiny little lane to ride in, with logs passing by on the water below, and the intense smell of forestry all around. Rain pouring down, pedaling hard, it felt fantastic to cross a state border. As contrived as a lot of milestones are – political boundaries, round numbers on



distance markers, whatever – it still tickles human brains to cross thresholds.

Portland, Oregon has beautiful parks and neighborhoods. The city is smaller than I expected, and seemed less bicycle-friendly than its top-of-class reputation, although the city does have active street life. If you ever go to Portland, try some of the food trucks, and check out Powell’s book store.

While in Portland, I couchsurfed and did some urban camping. One night I found a place in a park overlooking a really splendid rose garden. It turned out to be the International Rose Test Garden. Another night I found a larger park with huge trees, and some kids smoking pot. Pretty much anywhere on Earth you go, you can find a place to camp. Whether in the suburbs, or out in the middle of nowhere, or right in the center of a city. Also, pretty much anywhere in space you look, you can find something interesting if you look far enough.

With my barely functional cargo trailer, it didn’t seem safe to carry on any farther than Portland. I talked to some bike shops about fixing it. Plenty of bike shops in a very bike-oriented place. However I had a hard time finding one that could fix it. At one shop, the store owner called the trailer manufacturer. The representative woman answered: “We make trailers?”

None of the bike shops in arguably the bike capital of America could fix the trailer. Finally, a Portlandier told me about an interesting local character. Rather than a bike shop, this was just a mechanic doing repairs out of his house. He was blind.



I gave it a shot. We went over the trailer situation, and the freewheelin' mechanic told me that it wouldn't be practical to repair it, but that he had extra trailers available in his basement. I bought one, which worked out well. While there, I also paid the blind mechanic to tune up my bicycle. With awesome classic rock songs blaring as we talked, and the mechanic going by sense of feel, he made adjustments to the bike, and then checked, repeatedly. The whole process took a while, but afterwards my bike rode smoothly like never before.

Rock & Roll! ☺

### **Radical Departures**

Oregon is the quiet one on the Pacific coast. Much more down-to-earth than Washington or California, the state can even feel empty.

Riding inland down from Portland, I'd go to Eugene then head back to the coast. Eugene has an unusually large proportion of anarchists. It was home to Ken Kesey, of the original Electric Kool-Aid Acid Tests. Tripping, whether through LSD or bicycle travels or astrophysical journeys, reveals new worldviews that change our perspective, knowledge, and understanding. All of these activities share a lot of common characteristics, in forcing us out of our comfortable presumptions, thereby giving us a greater clarity. These three different technical means of "leaving home" take us on the road of discovery, thereby leading us to a new home. Out of your country, out of your mind, out of this world!



Some of the more ridiculous roadside attractions in Oregon include a walk-through safari with wildcats and chimps, and a life-size dinosaur statuary. The Oregon coast struck me as somehow out of place, an anomaly along the Pacific, although the sand dunes are nice, and the hilly foresty rides are enjoyable. From Eugene, I rode over to the coast. The road passed through some little towns with Italian names, like Florence, where the Grateful Dead once played an important gig.

When I hit the coast again, I felt free. I love the ocean. I've invented a psychiatric condition: Ocean Attachment Disorder.

What do you have a hard time leaving?

Along the coast, I bumped into another cyclist from Vancouver, and we rode together for a while, camped out, and made fire. He had moved from Ireland to Canada, doing construction work. His was a short trip, before heading back to work. A trip doesn't have to be long to be meaningful. You can learn a lot and have fun even on a weekend getaway or an overnigher. Likewise, while we can learn a lot from deep space, many of the most pressing astronomical observations focus right within our Solar System. Some of the important lessons in life come from epic adventures, but many come from closer to the heart, closer to home.

The two of us also met some regional motorbikers, who were impressed that we could ride without the help of an engine. Sitting out in the sun, we exchanged travel tales. Meeting other





travelers along the way has proven to be one of the most informative and fun parts of the ride.

Different sorts of people seem to live travel lifestyles, compared with those who stay at home, and I think that there are even personality types for each particular mode of transportation, just as different regions of a country offer different sedentary lifestyles. Partly, of course, you adapt yourself to your way of life, but also you pick a way of life suitable for your tastes. The causality is intertwined, intricately mixing. Anyways, pedal bikers seem to have an open-minded curiosity, childlike, while motorbikers seem to have an adrenaline habit. Hikers seem to have some kind of deep-seated psychological desire to get away. Whatever you do, it's generally valuable to get out of your comfort zone and into a discovery zone. What's your personality type, and preferred way to travel?

Continuing south, I followed the coast of Oregon. It's sparsely populated, serenely beautiful. I had planned a few towns to go through, and roughly followed my trajectory, while making allowances along the way. In southern Oregon it was fairly straightforward, as I just followed the coastal road. It did climb and drop a lot, making for onerous exertions. I was already in pretty good shape before starting, and I rocked the climbs as I climbed the rocks – although I believe that pretty much anyone who wants to strongly enough can get to a fitness level sufficient for bicycle touring, even doing so while riding. A lot of people stop themselves from achieving their dreams, by believing that only a select few are born or have trained to



accomplish big goals, but you can do amazing things by getting started with what you have and learning along the way.

Bicycle touring is not only physically tough, though, it's also a highly mental activity. As Yogi Berra is reputed to have said, "all of baseball is half mental." Much more often than coming down to a question of physical fitness, a successful ride comes down to the desire and control to complete a journey.

Leaving a sedentary lifestyle, leaving a state or country, leaving anything behind, takes some kind of courage. A lot of people have asked me about fear, risk, and other problems. They're real, although it's important to put them in perspective. I think that we should neither ignore nor exaggerate the psychological challenges of the road. Instead, treat them as extremely valuable guides to our behavior. We evolved fear to warn us of dangers. Sometimes that feeling is justified, and sometimes not – we have to evaluate our fears rather than blindly fleeing them. And for me personally, I find riding so exhilarating, I love it much more than enough to take on some accompanying dangers. Much more than fear, I feel sadness at having to leave behind a place as I go somewhere new.

Then I got to another landmark, and the first part of the ride that I'd been really excited about during the planning. Onwards to California!

Rock & Roll!!! ☺



## **California Dreaming**

April – May, Year One!

Coastal California, USA

*Crossing into California, a surprising time in the state. Making our way down Northern California, we travel through the hippie forests and cities. Then the breathtaking central coast of Big Sur. Afterwards, we roll down into Southern California. Revolutionary!*

When I first dreamed up *Astrotripping*, one of the main motivations alongside visiting interesting research sites was to explore places around the planet where I may have wanted to live. At the very least, I wanted to visit some places about which I had long dreamed, to experience them in person, and really *get* the places. These included California, the golden state.

California has beautiful beaches, plentiful sunshine, open-minded people, and so much more. I had built up my expectations pretty high, and worried that the reality could disappoint. However, I found in California a remarkably wonderful land overflowing with appeal. As so often happens on the road, it *surpassed* my expectations.



Northern California offered some fresh perspectives and fun times, including many youthful, free folks with mind-altering attitudes. Beforehand, I had little knowledge or expectation about Big Sur, a central coastal area that turned out to be one of the most spectacular places I have ever seen. And Southern California, the dream factory, is even more surreal than its reputation.

### **California Redwoods**

Under the shining sun, I rode the bike lane on the majestic countryside highway. Crossing into California, there are overwhelmingly more highway signs than elsewhere. Everything in the state is highly regulated, with the accompanying signage to prove it. You can't walk into a café without being reminded of the carcinogens. The Northern California coast has a bunch of dairy farms and some touristy things like an above-ground boat as a restaurant. Then you get into the marvelous redwoods.

The first town going south, and the gateway to the redwoods, Crescent City struck me as irredeemably straight-laced. All the parks and gardens are neatly linear and trim. I thought I'd camp in a park by the water, which had a nice ocean view. However, a car in the adjoining parking lot seemed suspicious, so I packed up and went to a nearby bar for a round of karaoke. Then I returned to the park. I found that I couldn't camp there.

Tired, I went and found another place, by the lighthouse. With waves crashing against the rock, a large sign warned of serious



danger. Anyways, the rocky ground and crashing waves didn't really offer any good flat ground, although the site did have great ambiance. I set up camp.

In the dark, in my tent, a bright light shone in suddenly. Several police officers stood there, and they told me that camping is illegal – in all of the city. Uh oh.

So, I rode out of town a bit, on the highway. I figured I'd find a place a little further on to camp. But the scary highway just kept on going, without any exits. At this point it was late and dark and I was exhausted. I just wanted to sleep, but didn't even see any remotely decent places.

Finally, I found an exit, basically a highway junction with a few houses. I found a tiny strip of land next to some trees, within earshot of loud barking dogs. There was a large wooden sign facing the other way, which I thought I'd read in the morning. When I woke up after a rough night's sleep, I walked around and saw the sign: "Organ Donor's Grove."

I carried on. Down south. One way. Deeper into the redwoods.

### **Touch the Sky**

The redwoods themselves are awesome. Both in the casual sense of the word and literally inspiring awe. It is a humbling experience to stand next to the giant redwoods, let alone touch them. These gargantuan trees grow to unmatched size over time. The tallest trees on Earth, they live for thousands of years. Some of these trees were alive while Jesus was. The trees host whole ecologies in their vertically branching limbs.



They seem to convey their personalities through their impressive beauty.

Our senses can transport us. We receive signals from our environment, in the material world. Smells convert incoming chemicals from the nearby environment into felt emotions with relatively little preprocessing, jerking us through time. Touch is so immediate, so emotional. Sense of presence, too. Sound waves, by contrast, travel considerably farther, and can feel piercing, or a bit more distant, otherworldly, as our brains read mysterious meanings into rhythms and tones. And sight – well, even unaugmented by modern telescopes, we can see stars that are light years – trillions and trillions of miles – away.

Wow.

As abstract and intellectual as the contemplation of such a vast, wild world can be – the whole cosmos exposed to our minds, through the combined powers of our intellects and our tools – it can also be compellingly emotional. Sure, we have to think about space, we can't just touch all of it with our hands. Yet, our hands, and all the rest of us, *are* in connection with space. We all are made of space, come from space, and are going through space. Our whole lives. And it has a *feeling*.

Some clear night, look up at the starry night sky. It makes you wonder. At the vastness, the grandeur of our world. With our senses, it's so easy to get caught up in our immediate surroundings. But, through gravity and other forces, we are in touch – even on an everyday basis – with overwhelmingly vast swathes of space. It's amazing.



We are part of this vast, intricate universe. We are little bits of life afloat in a flourishing sea of space.

And, back here on our cute little rock, even Earth still dwarfs us, and offers us a big wide world for us to explore. Rolling through the mountains of California, or rolling through the light years of space, we can expose our minds to wonderful currents of revelations. It's awesome.

Wow! 😊

### **Northern Rain**

Northern California has Humboldt County, famous for its pot production. It also does a lot of rain production, and I got rained on for days on end. During the offseason, when I arrived, the campgrounds were all closed. I went in anyways, and had huge wonderful redwood forests all to myself. Going through NorCal was glorious at times, although with lots of long hilly riding through cold rain, sleeping in icy cold water, and worries about breaking electronics and catching illness.

After climbing a relatively big hill, fifteen hundred feet of elevation or so, soaking wet and exhausted, I started to ride down. Right near the top, along an emergency pull-off lane for big trucks, I got a flat tire. Looking through my trailer, I couldn't find spare parts. Anyways, I could still hardly change a flat. I tried hitchhiking for a while, but it was getting late and dark, and nobody stopped. So I walked, for several miles, feeling down, feeling blue.



Finally, I approached the edge of town. A police car pulled over. It was no longer worth hitchhiking anyways. I kept on walking, pushing the bike on its flat tire. Then, as I was getting ready to call it a night, a pickup truck pulled over, and offered me a ride. Very exhausted, I got in, and we went to a Walmart, where I got a tube, then to a Motel 6, where I got a room.

The following morning, I installed the tube. It was the wrong size. I tried riding on it anyways. When I sat down, my wheel collapsed. Uh oh.

At that point I was close enough to the next sizable town, Arcata, that I decided to walk. The bent rim wouldn't even rotate in the frame, so the whole way I went rolling one wheel, lifting the heavy load on the other wheel. After my long and arduous but good ordeal, I finally arrived in Arcata.

There in lovely Arcata, California, I got sunny weather, pizza, a friendly bike shop, and great people. Arcata is a college town in Humboldt County, with a predilection for pizza and good times. I met lots of impressive students – the students seemed to run the town.

Couchsurfing in Arcata, my hosts were doing prison-style tattoos. One girl was having her breast tattooed, as part of a trade. “Tit-for-tat,” I quipped.

At the bike shop, the only replacement wheel that would fit my frame cost around a hundred dollars, almost the replacement cost of the bike itself. You can go a long ways without much bike!





The store had a fat tire bike on display, with gigantic tires, which I hadn't seen before, useful for riding on sand or snow. Since then, they've taken off in some areas. I've also noticed that larger "29er" wheels are taking off. Generally, I've traveled with a simple, cheap, tough mountain bike, with standard parts. This makes it much easier to fix or replace along the way, when something goes wrong. There are already so many potential problems on the road, so it helps to have as much resilience as you can. Alternatively you can buy a touring bike built specifically for the job, which costs a bit more but offers some benefits in terms of speed and comfort. You can also ride on whatever bike you like – touring is more about getting out there and doing it and having fun, rather than the technical specifics.

Here's one place where I feel there's a discrepancy between the worlds of space science and bicycle touring. You can experience most of the discoveries of bike travel equivalently with any bike, however most new discoveries in astronomy are so subtle that they require high-power telescopes. Of course, you can still learn a lot just by looking at the stars with any backyard telescope, or even with the naked eye. And you can still bike travel by hobbling around with half a bike, at least long enough to get to the next town.

After that point, on leaving Arcata, I felt like more of a seasoned rider.

Then, a scenic ride around the bridgeful bay leads to the sister city of Eureka. There, I stayed with a devout Christian who



brewed his own beer and root beer. He told me that Eureka was the more industrial, dangerous sibling to Arcata. The yang to its yin (paraphrasing).

Riding further south down the coast, I met only a handful of people. This remote area attracts a kind of low-key personality. I met people who slept in trees. Like, actually inside the trees. The redwood forests also have drive-thru trees. Look up a photo online, it's pretty funny. America has drive-thru everything: banks, general stores, pharmacies, liquor stores, cafés, pretty much anything you can imagine. O, America!

At one beautiful point along the way, I was going to stop for a bite to eat before camping in the woods. I went into a charming highway shop that advertised "bikers welcome," although referring more to motorbikes than to cyclists. They had expensive almond milk among other products, and apparently world-famous burritos. I ordered a burrito, but my bank card didn't work and I was out of cash. Broken bank cards are a recurring problem that cause many hassles while traveling, especially internationally. I have a theory that banks exist for the primary purpose of frustrating travelers. The kind counter girl got me the burrito anyways.

People everywhere are so generous, by the way. You notice it more when you're on the road, but we should have a more positive attitude towards each other considering how caring people actually are. When you're more vulnerable, like while traveling by bicycle, you become more sensitive to nuances of human behavior. And people are generally really friendly. A



lot of people are wary of other people, and of course there are problems, but overall I believe that we can do well to trust each other more, which I've come to believe more strongly through travel.

I met some friendly folks throughout the surrounding counties. Mendocino with her lovely forests, Sonoma with her gorgeous wine country, Marin with her beautifully cultivated roads, and so many more. So many splendid lands, so many charmingly endearing towns.

Kept on riding south.

### **Sunny San Francisco**

Approaching San Fran, I had in my mind that song "I'm going to San Francisco, twelve flowers in my hair." As I got into Marin County, accustomed to riding alone through the countryside, I came across a spandex-clad sea of cyclists. I got directions into San Francisco, and talked with some of the riders on their way out of town for the weekend. Many of them gay, by the way – the city does live up to that reputation. Then I hit the Golden Gate Bridge. It's bigger and more beautiful in person, and touching it transports one through the ages.

After crossing the bridge, when I arrived in San Francisco itself, I found myself at the Presidio, the fortified park on the tip of land. It features a large and beautiful area with water and trees and old Spanish buildings. I met a few people, mostly tourists who came for the famous parts of San Francisco. Then I went to the beach!



From there, I met up with a Warm Showers (bicycle touring hospitality) host, who made me feel comfortable and welcome. It's an amazing act of kindness, and it also provides an unparalleled way to see a place. I was fortunate enough to get an insider view of many fine parts of San Francisco, as we rode around the parks and neighborhoods. These hostings harken back to older hospitality traditions, and make new ways of travel possible. I'm amazed by people who traveled long distances in previous eras, relying solely on relatives and chance meetings. Still, it's a fundamental part of humanity to travel and offer hospitality, as much as the fundamental laws of physics govern the movements of the stars. It's been written that the most basic form of narrative is that a guest arrives.

In town, I went to the Latin-vibe Mission District, which has beautiful murals and delicious foods from Mexico and Central and South America. The neighborhood makes great burritos, and on Cinco de Mayo they have a big party. Both of those activities – making great burritos and celebrating Cinco de Mayo – lean more towards Mexican-American than Mexican traditions, yet are very awesome.

While in San Fran, I still had “adventure science” in mind rather than *Astrotripping*, so I visited some more research sites for more magazine stories that didn't turn into stories. At a biomedical lab near the baseball stadium, a research team told me about their invention of an artificial kidney. One benefit of aging is that things I only dreamed of as a child, like smart phones, are now commonplace. I often feel like I live in the future!



San Francisco is notorious for its chilly foggy weather. Mark Twain has been ascribed (perhaps falsely) the line that the coldest winter he spent was a summer in San Francisco. Yet, for all the talk of bad weather, things turned sunny when I got to SF, and stayed that way basically the whole time. I love the region, mostly for its creativity and diversity, and it felt bittersweet to carry on – as it so often does.

Before leaving San Francisco, I got a free spirit reading. That's a spirit reading that's free, not a reading of a free spirit. Although both could apply.

A few Christian fellows gathered in a hip café in the hippie part of town. They spent five minutes listening, feeling, being with the spirit. And they told me about my future. I had a big adventure coming up, with a lot of challenges. And I should learn to accept gifts gratefully.

It was a pretty spot-on reading of my upcoming times beyond the bay. The spirit reading seemed to involve sensing what was going on in my mind, a skill which was credited to the power of Christ.

On the way out of town, I went over Twin Peaks. This was possibly a silly mistake. As I climbed up and over the two hills, my bicycle trailer struggled under the load. *Snap!* A critical component broke, the trailer falling off to the side of the road. I rolled down to the bottom of the hill with the trailer dragging behind. Coming to a stop in front of a correctional facility, I could see the saddened faces of a family with a member dealing with the law.



I walked around the neighborhood, got some simple hardware at a pharmacy, and tried to fix the trailer. After failing, probably due largely to my mechanical ineptitude, I wound up spending another day in SF, checking out super-cool neighborhoods, going to a car mechanic to get the trailer fixed, and learning more about life!

When the unexpected happens, we can turn it to our advantage and create new and more desirable experiences than we had initially contemplated. It just takes an open mind.

Then, I rode around the rest of the bay.

### **Around the Bay**

Overall, I spent a few weeks in the Bay Area. While SF has lots of great food, music, culture, and interesting creative people, it can also feel crowded and expensive, and many people I met spoke of the merits of moving over to the East Bay. Oakland and Berkeley were much hipper, with seemingly endless social events happening. When I got to Oakland, right off the ferry there was a big bike party. Thousands of people filled the streets, performing stunts and enjoying live music and more. In Berkeley I stayed in a co-op, with around ten people living in a large house. This is a recipe for good times.

California is responsible for a lot of the digital age. The Bay Area alone spawned Google from Stanford, and many other research results that have gone mainstream. Around the Bay, I interviewed Earthquake researchers at the United States Geological Survey. The whole area feels modern and technological.



On the other side of the spectrum, the East Bay has some serious poverty. I went through an enghettoed area, where I had some of the most delicious barbecue food at a barbecue joint in a gas station. Outside, a lot lizard patrolled the parking area, truckers idled, cops came by, and I spoke with a semiliterate young woman who had severely deformed fingers and told me about a relative of hers who had been in the international news recently, after getting killed by a police officer on the public transportation system. It amazes me how stark the contrasts can be in cultures between areas so close in geography. I would later notice the same phenomenon along the Mexican border.

I went camping in the ghetto. I found beautiful spots in a few different parks. I woke up, which was a good start.

In one park, when I woke up, I noticed someone else nearby. I looked out, and there was a man moving with an unusual gait around a playground area. He had some kind of weapon or long stick.

We got to talking. The man was practicing a kind of martial art/performance art of his own devising. He would spell out the letters of the alphabet with his stick as he moved his body around. We all have our own peculiarities. He told me about some of the criminal practices of the area, such as “harvesting.” People from the poorer side of town would go to an area where it meets the richer part of town, and collect “crops” from vehicles, homes, and such.



I rode around the rest of the bay, passing through the many nearby communities with unique offerings. It's like a ring-shaped mall of municipalities.

On the way out of the Bay Area, I went through San Jose. It turned out to be a city very full of concrete structures. I decided to get another smart phone there, as my previous one had significant shortcomings and was hardly useful. I bought a new one through craigslist, from an aspiring professional poker player. The phone had constant problems with the battery. Overall I've found that just maintaining usable electronic and mechanical parts has been a big challenge in traveling. Things break down and get lost more easily when you're constantly in motion, and you have less of a chance to maintain or find them. I've lost count of how many phones, laptops, bicycles, and toothbrushes I've gone through!

Then, after San Jose, onward to the coast. Heading out of the greater Bay Area, I got into the central coastal area, Big Sur.

### **Big Surreal**

The technologically active Bay Area contrasts with the agricultural interior of California. I didn't really go inland much at all. Basically just cruised down the coast, with slight detours to inland cities. There's a simply gorgeous highway, the 1, which runs much of the length of the California coastline. Because of its overwhelming appeal, this route draws travelers from around the world.

As I continued south, I ran into many other travelers, by bicycle as well as other means. This kind of set my





expectations high, as I became accustomed to meeting fellow travelers all the time. Later on, in more sparsely traveled roads in the interior of the country, I would go weeks or months without encountering another cyclist on the road. However, even then, there would be great encounters with people who lived in the place, and occasionally even with other travelers.

There are many charming cities along the northern and central California coast, including Santa Cruz, Watsonville, Monterey, San Luis Obispo , and more. By the way, Santa Cruz has a Bike Church, and San Luis Obispo has a big group bike ride. Group bike rides are taking off around the planet, they are fun and healthy social activities. Cycling in general is experiencing a renewed surge in popularity, just as astronomy is having a new golden age. Technologies and trends have cyclical waves of popularity, it's how culture evolves, as well as how light travels. We are all waves.

After the Bay Area, I went down through Monterrey, seeing the scenic wooden fisherman's wharf, and other areas that inspired John Steinbeck's books. Through Carmel, which has a lovely beach, and a self-awarefully funny artsy scene. In Watsonville, I found a large Mexican-American community. Same deal in the more relevantly named Santa Maria. I went through Pismo Beach, Lompoc, Vandenberg Air Force Base and other military bases, many different communities. Each one unique and beautiful. Cities and towns are like people, each has its quirks, some are more subjectively appealing than others, it's a pleasure to get to know them both at first and as the connection deepens, and so forth. I feel like I know some



cities better than I know some fellow humans! Do you live in a city that matches your personality?

The central coast of California, including the Big Sur area, is a natural wonder. Cruising along the winding, hilly road, with the cliff falling to the sea on one side and rising up high to the sky on the other, it feels like flying through a dreamland. The place is remote, beautiful, otherworldly.

A large number of bicyclists, motorcyclists, and other visitors share the road through Big Sur, and I got to know many of them in a surreal place. There's a camaraderie of the trail, and people would often stop and share travel tales.

The food around Big Sur is expensive. You can find a two dollar tomato and a four dollar avocado! And that's just at the store. If you want to go out to a restaurant, you'll pay a lot more, but the views are spectacular. Out on a balcony overlooking the sparkling sea, with sports cars and ritzy décor. And me an' my bike!

Riding along the coast, under the summer sun, felt glorious. One little cliffside town has a few stores and a hotel with a pool. On a hot sunny day, I got into the pool to cool off. A woman told me that it was only for guests. When she saw me getting back on my bike, ready to roll, wet with sweat, she said she now understood why I'd gone for a dip. By the way, riding a bike in the hot summer sun can actually keep you cooler than standing around, in spite of the physical exertion, because you get a breeze blowing away your sweat.



Carrying on down the road, the mountain started a somewhat rapid descent. I flew down the cliff, gathering speed. The wind blew fast in my face. The sun shone down upon me. All was well in the world.

As I flew down the mountain, with motorcycles in tow, I blew by a sign about a Henry Miller House or something. I wondered whether he was the “Death of a Salesman” guy or some other American icon. He always seemed to me like one of those writers whom you’re supposed to read instead of wanting to read. I rolled fast down the mountain, cruising right by the place.

What was my route-deciding algorithm? Follow your heart? The map? The wind? Some kind of previously half-made plan? I thought I’d just keep on going until I got somewhere more stable. However, that moment got me to rethink my route-making decisions. It was the curiosity.

I got to the bottom of the mountain, on momentum. Then, deciding that I was curious enough to check out the place, I turned around and climbed back up the hill. I rode to the Henry Miller House, and turned in. Looked interesting enough.

A charming old house where the author had lived, now converted into a museum. After taking in the garden for a bit, I walked into the bookstore. They had a whole bunch of his books on display, including *Tropic of Capricorn* and *Tropic of Cancer*. Browsing through, I was pleasantly surprised to find his writing surprisingly insightful and enjoyable. It resonated strongly with me.



Miller said of the Big Sur coastal area that “this is the face of the earth as the Creator intended it to look,” which seems like an apt description.

As I kept reading, getting more absorbed, a few other people browsed nearby. Two young women came and read by me. We got to talking, and got along. With the lesbian couple from San Francisco, we went for a hike in the splendid surroundings.

The world has many wonderful places. More broadly, the whole world seems wonderful. Anywhere you are, you can find awe. However, it stands out a lot more clearly in some visually spectacular places. Where nature puts on a show, through some combination of forces shaping a unique display. And experiencing that sort of stunning beauty can sensitize you to the ubiquitous marvels even in less obvious places.

The Big Sur area, with its intense scenery, showcases the glories of our planet, the wonders of our world. It attracted the sensitive soul of Henry Miller. It attracts travelers today. And it reveals the cosmic joy available in our world. On an earthly scale. How the winds and the waves and the rocks and the trees and the people and the vehicles and everything, we all grow together to create the world that we know and love.

After the Big Sur area, I kept on riding. The beauty continues. It evolves. It fades into the next ecoregion, the next biogeographical zone. We have notions of lots of different places as discrete, distinct. There are deserts and oceans and forests, and they are different. Realistically, however, they blend into each other, one into the next. For a while, as I rode



through the Northern California forests, I would see certain trees in recognizable patterns. Occasionally, every few days or so, I would notice a new kind of plant or animal. Maybe a banana slug here, or a tree with a bright red cylindrical flower there. But the overall ecosystem remained the same. Then, after a few more days, a few more changes. All of a sudden, enough time had elapsed that I could look around and see a completely new, different ecosystem. This is life.

Wow!

Everything in the world works like this. People vary, from individual to individual, and from group to group. Some people have slightly different sizes of ear lobe or shades of eye color or hues of personality or shapes of temperament. You can generally find someone very similar to yourself, but with slightly wavier hair, or a slightly higher or lower voice, or a slightly different baseline happiness. When you step back, you can see very different people belonging to different populations, easily recognizable. Same goes for plants or animals, bikes or car parts, planets or stars or galaxies or metagalactic clusters. Cool, huh?

After the rugged wilderness of the central coast, the route blended into small Southern California beach towns. I rode down to the sea, gladly.

Weeee! ☺



## **Dreamscape**

May – July, Year One

Southern California, USA

*After Northern California, it was time for Southern California. We make our way down the coast further to Southern California, including the LA metroplex as well as a big loop through the Mojave Desert. Meanwhile, Eagle nearly dies of dehydration. Riding through the hot desert in summertime! Near-death experiences, and the joy of water. Spaceships and mules.*

Southern California has lots of lovely places. The area receives plentiful sunlight, has beautiful beaches, and features the surrealism factory that is the LA-metaplex. Some of the cities and towns in SoCal are even more over-the-top than one might expect from media portrayals – places like Santa Monica, Santa Barbara, and Malibu. Still, plenty of down-to-Earth people live here too. And the beaches are fantastic, with amusement parks and surfers and babes. Like a dream.

After riding through small cities and beach towns, and accidentally riding over a mountain, I arrived to a surprising scene in Los Angeles. Stayed a while. Then, after a giant adventure through the Mojave Desert to visit the private spaceport, I returned to greater LA, riding down to San Diego.



Southern California is a place on Earth. That may not seem like much of a claim, but somehow it exists in the same world as the other places on Earth, yet without seeming quite similar. Through its unique blend of beaches and media, and its population and location, the area feels like an artificial bubble, which in a way it is. SoCal even feels like an escape from the central coast of California, which itself already feels like an escape from reality. Southern California connects with so much of the world through media, creating its own image, that it almost rises above the rest of the planet to its own level. Like a big, bright star!

### **The Surrealism Factory**

After the central coast, I kept going south, essentially just following the 1. On the way from Central to Southern California, I took a slight detour inland. There's a cute little Danish town, Solvang. It has a Hans Christian Andersen building with books, and lots of pancake houses. I continued to the charming town of Santa Ynez. There, I heard the sweet country song, "Heads Carolina, Tails California," stoking my imagination.

Then, making my way back to the coast, I could see a couple of route options. I picked the one that looked shortest and most direct on the map, and rode by streets with beautiful names like Camino Cielo ("Sky Road" or "Heaven Road"). The road kept on climbing, higher and higher. At a certain elevation, I came across some wild fennel. Kept riding. Got to an impressively engineered bridge, by now at very high altitude. Some people riding by in a pickup truck cheered me on, as I



biked over the epic bridge. Then a huge cruise down rapidly on the other side. *Oops!* I accidentally rode over a mountain.

In Goleta, I came across my first avocado trees. As an avocado aficionado, it felt fantastic to see and feel the beautiful trees in the flesh. The trees can grow to medium height, although the cultivated ones are kept short, to make picking easier. The fruits grow abundantly on the tree, often falling to the ground untouched.

The University of California at Santa Barbara here has such an upscale vibe, the students were lounging about in a pool and dining at nice restaurants. It felt like one of those TV shows about beautiful California students.

Around this far south along the California coast, the density of Mexican immigrants also starts to pick up, and I got to practicing Spanish. Up until then, my Spanish was really basic, barely competent for conversation. I had one of my first fledgling Spanish conversations in one of my favorite places: Carpinteria, a small town. Its name literally translates as “Carpentry.” And its charming beach sits right next to a long row of campsites, with smoky fires. The nearby streets are lined with shops and restaurants. At a Mexican place, “Oaxaca Fresh Mexican Grill,” I asked the Mexican waitress if I could try ordering in Spanish. *Claro que sí* (“Yes, of course”), she said with a smile.

There, I learned the word *sentarse* (to sit down), and more importantly got a bit familiar with the flow of the actual language. For the first time, I could have a conversation,





communicate an idea, in Spanish. And most importantly of all, I ate a burrito with *mole*. An alternative title for *Astrotripping* is “The Burrito Diaries.” You can learn to speak a language much more easily by actually speaking it. Reading and writing, studying in school, these can help to pick up the grammar and vocabulary. But to get a *feel* for the language often requires speaking it consistently, starting with a few useful phrases.

On the restaurant patio, a few cool youngsters also sat down with me, and we talked about travels and life. Just meeting people wherever I go has proven to be one of my favorite things in the world. I used to be more introverted. You learn a lot from other people. Each of us has our own life journey. Even if not traveling in the conventional sense, we go along the pathways of life, adventuring. I love camping, beaches, wood smoke, travel. Scientists love to be the first to find new evidence and ideas about our world. It’s important to discover your passions, the motivations that drive you to get up in the morning and go out there to succeed. What motivates you?

Carpinteria’s beautiful beachside campground has some upscale spots, with gigantic multiroom tents. Along with some fellow lightweight travelers, we jokingly speculated that some campers scold their children for misbehavior with no big-screen TV, only the small screen. However, like a lot of California’s campgrounds, the one in Carpinteria also has simpler hiker-biker sites, basic land where you can stay for a few bucks. Together with my companions, we simple travelers shared some warm food and conversation – the important things in life.



Then, as I was falling asleep, I heard some more people arrive, setting up a tent next to mine. We chatted briefly in the dark, and I found out that they were riding from San Francisco to Los Angeles, where they lived, moving much faster than I was going. With their support bases nearby, and with much faster and lighter road bikes, they could do the whole intercity route in only days, what took me weeks. In the morning, I finally got to see them, and we exchanged contact info.

Carrying on, I rode further south along the coast. Through a few small beach cities, stopping for some sunshine and burritos and conversation. Beautiful boardwalks and live music. Joy!

Southern California is much drier and browner than up north. I was entering an area of the planet especially suitable for astronomy. The desert Southwest and northern Mexico contain many spots with dry air and high altitude (little atmosphere to interfere with incoming light), and low population (little light pollution). Also, once the astro community got its foothold here, the added incentive of building on in the existing place made this into a space haven.

I rode through the almost-desert, and by the beaches. As I approached LA, I didn't find the state park where I was looking to go camping. So I wound up getting into the city before anticipated – a recurring condition. It's nice to make the extra headway, but it can catch you off-guard. Los Angeles offers a surreal welcome.



### **Bright Lights, Big City**

Along the beach, plenty of homeless Angelenos slept. I rode further on the busy highway for a little while, then went down to the beach. There, a strange circle of lights was moving in mysterious patterns. I watched for a while, in the dark night. Finally, silhouettes of people became apparent around the lights, engaging in some sort of dance or ritual. The whole scene seemed surreal, a good and appropriate intro to Los Angeles.

For all the flak that LA takes, I found it a really cool place. It's admittedly hard to get around the city, especially on a bicycle, and the city has plenty of ugliness to spare, yet it's also a really energizing city. It has tons of students, large populations of Mexican and Central American and Korean and Filipino and other immigrants, and space science and technology and food and art and more culture.

Riding into the heart of the city, through all the surrounding municipalities – Santa Monica, Manhattan Beach, Redondo Beach, and so on – I found some beautiful scenes. Manhattan and Redondo appear in Beach Boys songs. Riding into Santa Monica I thought of the song lyric, “All I wanna do is have some fun until the sun comes up over Santa Monica Boulevard.” After going to the beach I checked out town. The first store I walked into had some beautiful people buying water for like eight dollars.

I rode on to Venice Beach. Strong people exercised outdoors, vendors sold their exotic wares, and there's a large amusement



park on the beach. One freak show hawker loudly proclaimed “Snakes alive!” amid various other attractions, while showing a shallow container with a two-headed turtle valiantly swimming in opposite directions, yet getting nowhere fast. I guess we should be thankful to have the power of locomotion. Easy pet to own, anyways.

The very lengthy beach path made it easy to cruise along the coast. Cutting into town, I rode through a number of down-and-out neighborhoods, where practically every place was a church or a liquor store. While in the Los Angeles megaplex, I met a few characters. One guy I met while riding by the canal on the way out of town was a strong skateboarder, who could ride up the waterside path as fast as I could ride bike.

When I got into LA, I met up and stayed with the cyclists I’d met at the Carpinteria campsite. They lived in a huge housing co-op, with around twenty people. Lots of discussions and activities constantly flowing. And an avocado tree and a chicken coop and a campground in the backyard. By the way, which is which between a coop and co-op? And the neighborhood had burrito eateries and all the other necessary amenities. Cool!

One day while downtown, I passed by a huge crowd of people in bright blue hair and large swords and other outlandish costumes. It turned out to be an anime conference. They’re a lot of fun, if you haven’t been, with song and dance, exhibition booths, and tons of travelers to meet. It’s a subculture of people creating their own lifestyle in accordance with their



dreams and imaginations. We all have aspirations, it's just a question of pursuing them boldly. Whether riding a bicycle cross-country, or studying the stars, or dressing up in a Japanese-style costume – or pursuing any passionate interest – we can create new experiences with unpredictable yet often rewarding outcomes. Just find a way!

My second cargo trailer, the one that I got from the blind bicycle mechanic in Portland, Oregon, broke down around LA. I've found that I go through lots of parts while touring. Things break from wear after all those miles. Local shops couldn't work on the bike trailer, because it was made of aluminum, which is tough to weld. Finally, I found myself at a car mechanic in Compton. Why do car mechanics always act as my saviors? And firefighters.

The Hispanic mechanic couldn't fix the trailer either, but he was a very generous man, who drove back to his home, picked up an old trailer that he had but no longer used for his child who had outgrown it, and also even brought an extra sleeping bag. He looked at me earnestly, and told me that it was the Christian thing to do.

Again, I've met so much incredible generosity along the way. It has come from Christians, hippies, and Christian hippies. And other people, too.

### **City of Angels**

Los Angeles has a big Christian scene. I visited a number of churches. The black gospel music is amazing. So is Hispanic gospel. I went to lots of Mexican and Central American



Catholic churches. They had open doors and social warmth, with sweet wonderful music flowing out. I went in, and felt the joy of life. These services really resonate emotionally powerfully. I finally understood why people practice like this. Raising our hands, crying, smiling, laughing, we vibrated with love.

While in LA, I heard a lot of *banda* music blasting out of vehicular speakers, usually pickup trucks. This style of music, from the desert border region, kind of reflects Mexican country music. I fell in love with *banda*, and have become a complete devotee of the heavenly sounds. You can search YouTube for “Banda Sinaloense MS” for an example.

In downtown LA, the Black Entertainment Television network held a huge event. I went, surrounded in a sea of beautiful laughing smiling faces. They had gospel choir contests, and many other singing and dancing events. The music, the dance, the colors, the life.

These are the music of humans. These are the music of the universe.

And the food of the universe. In America, as elsewhere, cultural traditions of food and music reflect the harmony and truth and beauty of nature. Culture is an intuitive grasp of what astronomers look at in the orbits of celestial objects. The periodic gyrations of celestial or earthly bodies through space paint the story of energy flowing through time. One and the same. Amen.



In Compton, a traditionally gangsta hood, I went to a sweet barbecue joint. A whole crowd of people chilled idly out front. We chatted as I went in, where I ate some of the most delicious food I've ever tasted. And they were kind of impressed by my bicycle travels. We all have something special to give. Sometimes our gifts come from unusual sources, but we can then deliver even better surprises.

Just down the street, an air and space museum, seeming incongruous. They had one of the coolest social programs I've ever heard of. A flying program to keep kids out of gangs. They had a room full of advanced flight simulators. And out back, they had a huge fleet of airplanes. Underprivileged kids would come here and fly freely instead of joining gangs. The liberty of flight. Of the unknown. Of discovery. It's a lot more productive and fun than the old violent ways.

I went camping in Compton. There are still lots of gangs, and I got some menacing glares from drug-dealing gangsters. Like wild animals threatening to kill.

Now, though, the overgrowth of new life spreads through. Mexican immigrants are reproducing faster than gangstas. The neighborhoods are turning Hispanic.

I also met a large family of Mexicans in front of the old part of town, the neighborhood dating from back when LA was still in Mexico. At current rates, maybe one day it will rebecome Mexican!



Back in Compton, there was a burrito place down the street, with a map of America on the wall, on which I could see the route of my now lengthy travels. There was also a painting of black portraits, like Martin Luther King Jr. The place advertised Texas-style three-foot burritos (I regret not having got around to eating one). The juxtapositions of a shifting country.

Along a waterway, by a long fence, in the heart of gangland, a Mexican man astride a horse came riding by, music blaring in the background. I deeply admired his moustache. In that area, I stopped in at a Catholic church service. I could now make out most of the Spanish, although some of the people there also tried to help me understand. The story of Adam and Eve, in the Garden of Eden. Our origins. Our destiny.

I rode on.

The City of Angels has so many lessons. The intricate depth of people there bring vibrant life through many different manifestations. People adapt to the huge numbers, millions of people, all living together in one place. It transcends what our bodies evolved for. Yet with our minds and our technologies, we create ways to get along. And that takes on so many different colors, flavors, and shapes. Many surprise you. The glorious diversity of forms flowing through the metropolitan area reflect our origins in the evolving universe. Light and clarity come shining through, expanding from the simplicity of the past into a kaleidoscopic panorama. What do you believe?





Truth and beauty travel harmoniously, like the cosmos, like love, like life.

People in Los Angeles and elsewhere, we're rays of light intricately convoluting towards tomorrow.

All right! ☺

### **Leaving Los Angeles**

Unfortunately, a day or two after getting the new bicycle trailer, it was stolen. I was in Long Beach, which sounds like it has a nice name, but has some crime alongside the luxury. While I was camping on the beach, the police woke me in the night, and told me to move over to a location a little ways away. There, a group of homeless people smoked and cackled throughout the night. In the morning, the trailer was gone.

After that event, I switched to various rack-and-saddlebag setups. Each system has its pros and cons. Overall, the saddlebags seem more popular, and perhaps slightly more convenient once you get the configuration set up. I've since then gone through lots of racks and bags, mostly from mechanical failure. "Travel lightly" applies especially to bicycle travel, where every pound, and even every ounce, counts. You have to pack the minimum of *stuff* that accomplishes the most. Maximize the power-to-weight ratio.

After LA, I decided to do a big trip through the Mojave Desert, to go to the Spaceport for "Exotic Quest." I was quite worried about the desert, since this was my first time riding there and it was the height of summer. I nearly died of dehydration, and



water never tasted so good. Sometimes you have to go through danger and challenges to get to remarkable new places. Overall I loved the desert, and ever since then I've enjoyed going to other deserts. It's so peaceful and sunny and open and beautiful, especially the starry night sky. Oh my goodness.

On the way out of town, I would ride out through the outskirts, the edge. By the TV studios. By the artificial rivers. By the zoo. By a BBQ place, which smelled so good, and the people opening it up offered me free food if I stopped by on the way back when they were open and which I never got to since I wound up going around a different route on the way back and which I regret but which overall shows the generosity of humanity which is what brings us joy and happiness and love and truth.

At a small town in the desert, I stopped at a little Mexican joint. Got a burrito. A man and two of his daughters riding on three horses came by, getting burritos at the drive-thru, and eating while mounted. We greeted each other and rode off.

A burrito literally translates as "little donkey." At one point on the way out of LA, I went by a mini-donkey petting zoo. Makes you think. By the way, if you like *Astrotripping*, be sure to check out my children's picturebook *The Flying Burrito*, which shares the same theme of the dream of flight, at "[eaglegamma.com/writing](http://eaglegamma.com/writing)"! ☺

Also, out in the Mojave Desert, there's a small town with a building that has on its front lawn a spaceship next to a mule cart. The town sits at the historical intersection of space



industry and mining. As a somewhat accurate viral e-mail points out, modern rocketry retains ties with old-fashioned beasts of burden, in terms of the evolution of their dimensions. One mode of transportation paves the way for later ones. Likewise, telescope designs have built on each other, from Galileo's first device up through modern megascopes.

On a bicycle, I rode through the hot summer sun, out to the Spaceport.

### **In the Desert**

In the desert, I made my way through several gorgeous small towns, and tons of sparse, empty space in between. Having never gone riding through the desert before, it struck me as very novel, and beautiful.

At one point, the way where I rode happened to intersect Route 66. That classic mother road connects Chicago and Santa Monica, carrying the nostalgic strains of American folklore. I came across a road restaurant with a California gold rush theme, had a snack, and played an old song on the jukebox ("I Wonder Why").

Then, on a spur, I switched onto a service road, and rode the amazing roller coaster of curving ups and downs, away from all traffic. In great tranquility, trains went by on the track, the sun shone, life felt amazing.

Getting back into civilization... After several small towns like Santa Clarita, with Mexican populations and more burritos, I got to a big area overlooking Quartz Hill. A relatively large



stream of water flowed, rare in the desert, and it looked incredible. Water in the desert looks so magical, starkly contrasting with the aridity all around.

A young woman in a car at the overlook offered me some food and water and a place to stay, and we chatted. I had packed a few bottles full of water, more than I would usually carry, although still less than I would need. Simply carrying enough water to stay hydrated in the desert proved extremely challenging. Your sweat evaporates so fast in the dry air that you hardly notice how hot and dry your body gets. It can get dangerous.

The town of Quartz Hill itself is quaint. The houses have yards without lawns, which I found funny, having always associated yards with lawns. I did see at least one home where the owner was determined to have a lawn, and a sprinkler system was working overtime in order to keep the island of lawn growing.

In town, I went to a café with a garden, again without much greenery, just lots of sand. It reminded me of an empty zen garden. The waitresses told me about a mining ghost town in the outskirts. My curiosity was piqued.

With the rocky earth constantly bombarded by sunshine, sparkling gemstones dot the landscape. Maybe they weren't ready for jewelry quite yet, but they made the scenery wonderful.



This area, which locals call the high desert, actually does get some precipitation. I found it funny to see signs in the desert warning of flooding and snow.

A small desert town has a big cat museum, with dozens of exotic tigers and lions. Beyond this, the area basically just has housing and little shops and restaurants. Not many people live in the desert, mostly due to the shortfall of water. Many cities out west, including LA and Vegas and Phoenix, depend on huge amounts of artificially imported water. With such sparse population, you can buy plenty of cheap, sunny land in the Mojave. I daydreamed of building new ways to get water here and live in the desert. There would be lots of space to camp, anyways!

### **Space City**

As I carried on towards the town of Mojave, my water ran low. Like, really low. Headway was slower than expected. I was getting extremely thirsty, to the point of worrying about my health. The temperature was well into the triple digits. It was so hot and dry that I would sweat away all the water I drank, evaporating instantly into thin air. Despite the heat, the lack of water, and the sparseness, it felt amazing to have the constant warmth of the sun, all day every day.

Riding closer to town, I ran through most of my remaining water and food. Camping by the side of the road, my throat was so dry that I had a hard time swallowing. I ransacked my belongings for anything wet at all. Ah, toothpaste – this has water in the ingredients list. I tried a little dab. For the record,



this is probably a dangerous thing that hurts rather than helps. Going to sleep, I wondered whether I would make up in the morning. I woke up in the morning, which was a good start.

Pushing hard, I got close to the town of Mojave. A really tough slog. Thoroughly dry, exhausted, and hot, I pedaled hard and felt like I was barely moving. After rounding a corner, I could see a sea of windmills. Ah ha, the wind! No wonder I was doing “all the running you can do, to keep in the same place.” It can make a huge unseen difference, the wind. Sometimes I’m riding downhill, pedaling hard, and getting nowhere, due to a strong headwind. Conversely, some of my favorite rides involve standing up and cruising fast uphill, without pedaling at all, in a tailwind. Here, though, it was hard riding barely making any progress, until gloriously arriving in town, alive.

When I finally got into a building, a Jack-in-the-Box fast food restaurant, I repeatedly filled up my water bottles with ice-cold soda water, and guzzled it down. Water never tasted so good in my life!

Mojave. Place looked down and out. A huge corner store advertising burritos. A beautiful sky. A Spaceport.

I met some friendly, although struggling people. The town has a row of quick service restaurants, several shuttered businesses, and a handful more places of interest. The McDonald’s has a space theme, with comfy, starry blue



benches and photos of Voyager and SpaceShipOne and other highlights celebrating the place. One house in town has a lot of biblical quotes on huge signs out front, presumably the place of the artisan. The signs also adorn many of the other buildings around town, making for an interesting contrast between the high-tech space community and the old-fashioned Christian denizens.

I camped right next to the Spaceport. Spaceships adorned my view. Rain fell in the desert.

While in Mojave, I got a flat tire. The only store in town with a spare tire was the corner store with burritos. I fixed the bike and rode on, after a brief while in town.

Carrying on through the desert, I stopped briefly in various towns, including Victorville, Hesperia, Boron. Boron is a small mining town where they get the Borax for cleaning. Mule teams would carry the cargo into town. Now a large Australian company runs the big mine here. They converted the local laws to metric units, resulting in funny speed limits with fractional kilometer units, like 33 1/3 kilometers per hour.

Throughout the desert, I learned to survive a bit better, by taking more precautions and being more aware of surroundings and available resources. Even in the sparsest places, seemingly devoid of life, things thrive. And people find ways to adapt. In fact, often the adaptations lead to greater innovations than in more comfortable places. Necessity is the



mother of invention. We invent jackets when it's cold, ice boxes when it's hot, and hopeful beliefs in the desert. Several religions started in the deserts of Western Asia.

In the desert, you can see so many things. Like mirages, visions, dreams. The possibility shines, like a rocky gem sparkling in the sun. You can dream up a spaceport in the vast expanses of sand. In the empty spaces, you can see so many ways to fill the world. With flight, joy, laughter, life.

Often, excess resources can actually leave a kind of emptiness. In the desert, with its abundant space and deficient water, and lacking constraints on building, settlements tend to grow out, flat, somewhat desolate. By contrast, in bustling wet places with little reliable space, dense interesting cities grow high. Conversely, in the city so much happens that it leaves little room for dreams, strangling out new shoots with existing noises. In the desert, with nothing around to interfere, you can go for miles and miles while dreaming. And here in the Mojave Desert, some dreams take flight.

Deserts are so lovely!

### **Intersections**

After the Mojave Desert and the Spaceport, I went back to the coast, and rode down to San Diego. It felt wonderfully warm to ride down the road to the southwestern corner of the country – like a homecoming. Along the way, the route from LA to San Diego switches among highways and smaller roads and even unfinished trails. It goes through military areas, campgrounds, and beaches. When I arrived in the northern





parts of San Diego, I felt a sudden onrush of emotion, a surge of dopamine, as I realized that I had completed the first phase of the trip, and I rode across the United States of America!

Arrival feels like a great turning point. After setting out, with initial uncertain prospects, and going through all manner of mayhem along the way, it feels amazing to fulfill a dream. Each of us is on a journey through life, which contains many intersections. How do we navigate those intersections?

I spent a little while in San Diego. Very early on, I met Yuta, a fellow traveler who had come to the Americas from Japan to ride by bicycle. He too had started in Vancouver, although he was generally going on a faster and more direct route than mine. Yuta had previously studied astrophysics, which he called his religion with dry humor. Then, he made a bundle trading stocks, and started a big bike journey. I met him while he was changing the tires on his bike. I helped him a bit, despite my very limited mechanical skills. Neither of us was a very hands-on person, both more abstract. He got us some pizza. Then we rode together for a while.

We went to beaches, made sand spaceships on the beach, ate together, went to the amusement park and other tourist attractions, met some more travelers, and had an all-around good time. It was great to spend time with a kindred spirit.

Yuta was going straight through Mexico, and then down through South America. I had been deliberating on whether to



go next through Mexico or the southern US. The thought process was actually a continuation of my original trip planning, when I hadn't known which way to go, or if I would even make it beyond California. At the start, I thought Mexico, but in Seattle I stopped in a barbecue joint whose food and music changed my mind. On a beach in San Diego, I finally decided to go through the southern United States next, after a weekend in Tijuana. Yuta and I parted ways.

Through deserts, across borders, we fly through life with our own motivations and destinations. We give life to our dreams. We go on journeys of exploration and discovery. And it turns out that often we get our directions wrong. And arrive anyways.

Dreams give life form. And we flow through our efforts. It can become quite difficult to predict or decide where to go, or what to do. And even after making plans, we encounter all kinds of obstacles along the way. What we do – our reactions to the actual paths we travel – often matters more than the details of our grandest dreams. And how we go about living – lovingly, curiously, wonderfully, or otherwise – often matters even more than where we go.

A trip is a metaphor. Life is a trip. Traveling somewhere on Earth, reading a book, reading the stars. We travel through many intersections, making many choices. Which ones we take affect where we wind up. Yet, bigger, deeper forces also affect our movements. A massive metropolis like LA has far more intersections than a big open desert like the Mojave.



Regardless of where we are, though, or what we do, the journey itself is our development. The dream. Life.

Wow! 😊



## **Exotic Quest**

Mojave Spaceport, Mojave, California, United States of America

July, Year One

*At the Mojave Spaceport in the California desert, a space think tank funds research into gravity-based propulsion, without the need for any onboard propellants. The controversial astrophysics may be bogus, or may help us travel to the stars – and even through time.*

In the Mojave Desert. Big. Dry. Empty. Not a lot happens here. Like space. Yet, in both cases, the places could hold promise for our future. Both expanses hold abstract resources that attract hopeful, yet possibly naïve, explorers. Both could hold boom or bust.

The Space Studies Institute, at the Mojave Spaceport, conducts research into promising technologies that could enable our species to leave planet Earth. In a new initiative, the organization is funding research into “exotic” propulsion, which could send spaceships well beyond current limitations. However, some critics believe that the whole premise is built on flawed foundations.



The researcher leading the initiative is an intriguing, older professor. He has an experimental setup in a small, almost antique physics lab. Is he on the technological forefront of the future of our species? Or tinkering with toys? It depends on your perspective.

### **Dry in the Desert**

It's a vast, empty expanse that most people would probably rather avoid. Yet, some of the smartest minds now actively researching spacecraft technology congregate here. No, this isn't some remote science outpost in space. Not yet, anyways. Instead, at the Spaceport in Mojave, California – which has already launched historically important spacecraft such as SpaceShipOne, the first private spaceship – the Space Studies Institute (SSI) has announced a research project to develop spaceship propulsion of an entirely new breed.

The SSI, which collaborates with external partners including NASA's Ames Research Center, got its start with Princeton physicist Gerard K. O'Neill. His 1970s book, *The High Frontier*, became a space expansion classic. The organization's goal is to settle space this generation. To do so, they run research on technologies to access space resources, and thus to make space financially viable.

SSI research programs to date focus on advanced hardware demonstrations. Example technologies include self-sustaining closed environments, and zero-gravity developments. Now, the group runs its new Exotic Propulsion Initiative. SSI openly



acknowledges the edginess of its research vis-à-vis mainstream attitudes, at what it calls the “very borderlands of physics.”

Going to the heart of “NewSpace” – the movement towards entrepreneurial space exploration – takes science and technology to extremes in the quest to send humanity out into space in force. The basic science that SSI funds aims to demonstrate generally useful principles, for further development in the larger economy. This program falls somewhere in the middle of a spectrum: not a corporate R&D lab where results are expected to yield immediately marketable products, nor some purely academic ivory tower research.

Essentially, SSI wants to spread our civilization beyond the grasp of Earth’s gravity. To this end, the organization funds independent investigators to develop new technology. The latest foray, into propulsion at the limits of astrophysical possibility, could yield starburst or stardust, starting at a small lab in Orange County, California.

### **A Twinkle in His Eye, a Twinkle in the Sky**

The main thrust of the Exotic Propulsion Initiative is currently a research effort conducted by Jim Woodward (California State University). Woodward, a professor of history and physics, has conducted his personal pursuit of space propulsion here for the past couple of decades. He recently wrote a book outlining his views, *Making Starships and Stargates*, and now SSI takes up his ideas.

Woodward’s lab is a small space. It contains computing and mechanical equipment, for tabletop experimentation.



Woodward himself, an older man who talks of his health issues and visibly slumps, has a grandfatherly or avuncular air. Woodward now struggles with stage four lung cancer, among other health problems. He still pursues the research, although without much expectation of personally traveling to the stars through his invention. His hoarse voice lends to the tantalizing feeling of expectation for future possibilities.

Woodward acknowledges the non-mainstream nature of his work. “Fringe-y is I think a nice way to put it.” To him, the important thing isn’t how the research is thought of, but where it takes us. “What it boils down to is that if you choose to work on the problem, to figure out how to get to space quickly, then you haven’t got much choice.”

Conventional approaches can only take us so far. To get to even the closest stars requires a lot more propulsion than we can muster today. This leads to the need for extremes. “Ultimately, the holy grail is figuring out how to make traversable wormholes,” says Woodward. A wormhole, intimately connecting remote parts of space, would theoretically enable humanity to travel between distant stars without passing directly through the entire vast amount of intervening space.

### **The Woodward Drive**

The highlight of Woodward’s research is a device that some people call the Woodward Drive, and which Woodward himself calls the Mach Effect drive, after a colleague of Einstein’s who first formulated the controversial principle at



its heart. The drive purportedly enables space travel at a fraction of current costs, and extends our reach to distant stars well beyond any existing or immediately foreseen technology. Moreover, because of the way that the drive depends on gravitational effects – and because gravity connects space with time in modern theory – the drive even holds potential implications for time travel speculations.

Woodward acknowledges that in speculative matters, it's easy for people to fall for the hype. “[Richard] Feynman had it right. He said: ‘The first principle is that you must not fool yourself – and you are the easiest person to fool.’” For Woodward, following his inspirations, the key to exotic propulsion is reproducible experiment. “There’s almost no experiment. The only touchstone of reality is actually making something work.” Moreover, quality matters. “What experiment does get done, often has problems.”

In his lab, the Mach Effect thruster, or Woodward Drive, purportedly demonstrates the effect. It uses a stack of eight piezoelectric crystals. “When you apply a voltage, plus or minus, you make the stack expand or contract, depending on polarity. If you apply an AC signal to the stack of piezoelectrics, it’ll oscillate.”

As the accordion-like device gets longer and shorter, it’s clamped by an aluminum bracket against a brass disc, or “reaction mass.” Power comes in through liquid metal contacts. The oscillations are meant to induce temporary changes in mass, which Woodward could use to leverage his





current. Synchronizing a second current to push with the oscillations, the result should apply a unidirectional force with the input of power, but without propellant.

### **The Mach Principle**

Where does the propulsion for the propellantless device come from? Everywhere. As the electric current flows in and out of the piezoelectric crystals, which expand and contract, Woodward believes that the gravity of all the matter in the rest of the universe interacts with the device, making its mass shrink and grow. “And if you add a second force on the stack, so that you’re pushing in this direction with more mass, then pull it back when it’s a little bit less massive, then you don’t pull back as much as when you’re pushing the other direction because of the changing mass situation.”

Add up enough of these little one-way jolts, and you’ve got forward motion. Without burning any fuel. Instead, from imperceptibly tiny forces spread out throughout all of the rest of the universe. According to this interpretation of inertia, as the drive pushes on the rest of the universe, it’s the same as the rest of the universe pushing back.

The overall effect is to convert electricity into motion. The propulsion would make minute changes to the overall distribution of matter in the universe, instead of carrying its propellant with it. According to Woodward, this would happen within the constraints of the basic laws of astrophysics, because all of the gravitational oomph that comes into the device goes back out to the universe.



Essentially, when any object in existence experiences a force, the object resists that adjustment, with its mass. This resistance is called inertia. While mainstream physics does not offer a comprehensive explanation of inertia, the concept serves as a highly useful abstraction. But where does that resistance come from? At least some sources explicitly disavow the interpretation of inertia on which Woodward bases his invention. Yet, differing understandings of inertia fill the annals of physics.

The fundamental idea behind the Woodward Drive works as follows. Under the umbrella of “Mach’s Principle,” some interpretations of inertia have the resistance to force stem from the matter and energy within space and time, rather than being some property of the universe itself. Therefore, a clever design can use gravity to manipulate this inertial field, which spreads across the cosmos, as a source of propulsion. Voila! No heavy tank of gas needed, just use the distributed contents of the universe for fuel.

According to Woodward, and the graphs he produces, he can measure a difference in the motions produced by his manipulations of gravity and inertia. Whether the difference is actually attributable to the effect in question, or to experimental protocol, has been an issue of some debate.

### **Spurious Effects**

In his lab and in his book, Woodward attempts to refute possible sources of error. The purported changes of mass take place inside a vacuum chamber on wooden supports, with



weights sitting distributed around the apparatus. This design is meant to isolate confusing sources of force, noise such as vibration or radiation or even ionization, in order to demonstrate clearly his principle. The “gizmo,” as Woodward calls it, should push against a torsional bearing, revealing the amount of generated thrust.

Woodward’s theory depends on how spacetime works at large scales. Looking at the vast universe that he hopes to make reachable, the geometry of the universe itself affects the matter and energy at specific points within it, according to general relativity. “Spacetime is the gravitational field,” he says. “It’s flat, cosmologically speaking.”

The theory behind the Woodward Drive therefore depends on the nature of the universe. Moreover, it calls for some questionably attainable ingredients, such as a “negative mass” the size of Jupiter. These dependencies have made the drive a target of some considerable criticism.

Critics have called Woodward’s work everything from incorrect to naïve to fraudulent. Is it the brilliant prelude to humanity’s next venture into space, or an obvious misinterpretation of the mechanics of the universe? The answer depends upon whom you ask.

Donald Simanek (Emeritus Professor of Physics, Lock Haven University of Pennsylvania), skeptically considers the Woodward Drive another example of naïve misunderstanding of astrophysics, mere “pseudoscience.” Many thinkers and tinkerers come up with inventions that, unbeknownst to them,



violate fundamental laws of nature. These have included previous space drives, and Simanek thinks that Woodward has come up with another flawed take. “One of many such eccentric ideas,” according to Simanek.

“Neither of his patents I looked at ever mention the word ‘momentum.’ If you are going to accelerate a spacecraft without exhaust, you must address the issue of conservation of momentum, either to demonstrate that the momentum conservation law is wrong, or doesn’t matter, or explain how it is to be circumvented.” Woodward, for his part, maintains that his invention does conserve momentum.

Simanek, who runs the website “The Museum of Unworkable Devices,” which is “a celebration of fascinating devices that don’t work,” considers the Woodward Drive another pipe dream. “His patents describe a practical-sounding plan for electro-mechanical propulsion. There’s no indication that it has ever been built, tested, or implemented in actual propulsion.” He expresses doubt in the concept, yet retains an open mind. “I don’t hesitate to class it as an ‘unworkable’ idea. However, if someone actually goes to the trouble of a conclusive laboratory test, I’ll be interested in its outcome.”

What will come of the Woodward Drive?

### **Future Fantastic**

Gary Hudson (President, Space Studies Institute) says that SSI is aware of the doubters. “We have considered criticisms of his work, and feel that the best way to address concerns is by experiment, not by debate over theory.” What should we



expect? “I personally would consider success to be at hand if we can fly a self-contained small satellite with a Mach Effect thruster and have it change orbit in a fashion that is unambiguously shown to be due to thrust from the Mach Effect engine. The joke in the business is that some people won’t be satisfied until a propellantless thruster floats out of the lab on its own power.”

Hudson openly acknowledges that the current initiative, which includes Woodward’s work as well as other “exotic” projects such as laser propulsion, stretches the imagination. “It is outside of the mainstream as the physics and propulsion engineering communities may view matters,” he admits. Referring to two renowned aerospace engineers, he boldly claims: “Mine is the Burt Rutan or Kelly Johnson view of engineering. Take chances or go home.”

Hudson supports Woodward’s approach, without committing to its certainty. “The groundswell of interest in exotic concepts is reaching new heights, and if we can help push one or more ideas forward it is worth the time and trouble to take some risks.” He adds: “The upside of any breakthrough in high performance propulsion of the type that he and others postulate would be so stupendous as to make the minor risks of loss of funds or reputation trivial in exchange.”

The goal of the Exotic Propulsion Initiative is to make our expansion into space realistic. “I regard the opening of the space frontier to human settlement and exploitation to be my primary motivation. And anything that makes it easier, cheaper



and faster is good, as far as I can see. Mach Effect or equivalent advanced or exotic propulsion will likely be required for rapid settlement of both the Solar System and the stars. Without some breakthrough, we are condemned to a very slow expansion that will be paced, not by the imagination of and drive of humans, but by the laws of economics.”

### **The New Space Community**

For all its controversy, the Woodward Drive concept has received at least critical attention from a variety of sources with greater recognition, including NASA’s Johnson Space Center, and DARPA’s “100 Year Starship” project. The latter project, along with others now taking off around the planet, aims to launch our species into deep space.

John Cramer (University of Washington), who led the discussion on exotic propulsion at DARPA’s “100 Year Starship” program, also writes a column for the magazine “Analog Science Fiction and Fact,” and works at Brookhaven National Laboratory. Cramer freewheelingly discusses different theories of spacetime. He believes that many possibilities could take humanity to the stars, and that the Woodward Drive is one of them. Conventional drives, even including nuclear power, could come up short in delivering enough propulsion to cross the vast gulfs separating stars.

The Woodward Drive has traveled far and wide intellectually. It has received attention of one kind or another from various corners, ranging from the big American government agencies, and Lockheed Martin, through several national laboratories, all



the way to teams of gravitational physicists at the Russian Academy of Sciences, the Austrian Research Centers, and the National Scientific and Technical Research Council in Argentina.

Jim Peoples, a former FBI agent, backs Woodward. While talking on the telephone, he identifies aircraft flying by, over the other side of the line, by their sounds alone. Peoples wants to bring together better funding and organization to modernize research into the drive. Right now, Woodward works in his small lab, with a grad student, on older hardware and software. Peoples wants to take the experiment to the next level, demonstrating unambiguously whether the principle applies in practice.

A critical goal here involves getting our species' technological capacities up to a level at which we can travel relatively effortlessly among celestial bodies. This is practically impossible with current technology. The threshold defies all the combined skills and resources applied by humanity to date, remarkably enough. We've made it off the home planet, but we really have yet to grow our space wings. However, radically new techniques could reshape the playing field. Or they could just be so much space junk.

### **Making Humanity a Spacefaring Civilization**

Humanity now stands on the verge of transformative change. Many of the developments that Woodward, the SSI, and even Gerard O'Neill have proposed, derive relatively directly from science fiction – as have many previous technological



advances. Our evolving capacities will perhaps take us to new realms, new worlds. Have science fiction writers given us unfairly high expectations? Science fiction and reality have a very complex relationship, to say the least.

However, the Exotic Propulsion Initiative does come at a unique time in human history. Now, for the first time ever, dozens, hundreds of organizations of all sizes rush onboard to develop a wide variety of space initiatives. From private companies sending individuals into space, to new government-industry partnerships in technology development, and new incentive prizes and markets, we have the brightest prospects for space enthusiasts since the heyday of Cold War status contests.

Since that first burst of space exploration in the nineteen-fifties and sixties, and going back even further to the early dreamers who never had the advantage of modern science and technology, we have had our eyes on the skies. Soon, if things go according to optimistic expectations, we could have access to an exciting new environment. Now, are we finally within reach of the stars? Will the Woodward Drive take us there?

Woodward and the SSI seek methods to realize humanity's deep spacefaring dreams. The exotic propulsion group's game plan involves first making near-Earth transportation economically feasible. Then, building on this technological and economic foundation, we send out self-supporting spacecraft, powered by the Woodward Drive, to populate the





stars. Over time, our species thrives in space, establishing ourselves as a relatively permanent part of the cosmos.

Why should you care? Do you want to travel to space? Your kids, or your neighbors' kids, probably will want to. Even if you don't, it now seems like a highly realistic possibility that a branch of humanity, along with other life forms, will spread out to the stars, extending and expanding our reach.

Such a development would presumably result in plenty of surprises, including new materials and energies and cultures and biologies. This new space race dramatically alters our prospects and perspectives, as the original space race did, as did discoveries in biology and particle physics and other fields. Pioneering efforts often yield great rewards.

The new technology in the Woodward Drive, which employs a novel interpretation of gravity and inertia in order to send ships to the stars, could alter our species' prospects. In some headier moments, Woodward whispers questions that evoke a magically plastic sense of existence. Could we have a deep future in space? Could we even travel through time? Have we already?

Many possible futures stir amidst the chaotic fluid of speculative space technologies and their critics. What is possible? Where in the world will we go?

Hudson maintains a realistic attitude. "Sadly, the history of most advanced concepts is one of failure. This is true for both 'exotic' ideas that challenge mainstream physics and even



‘conventional’ engineering concepts and projects. We expect most of what we support will meet similar fates. But from failures are born a few successes and these will, in the future, open the space frontier to all humanity.”



## **An Impromptu Romp through the Mexican Desert**

Baja California, Mexico

August – September, Year One

*Crossing the border. Another rough start after crossing south into another country. Awesome tacos. Hitchhiking in Mexico. Deathly ill. Riding up to the peak. Cruising down through fantasyland.*

After returning to Los Angeles and then San Diego, following the Mojave Desert gambit, I was prepared to ride across the southern United States. First, I would go across the Southwest, then through Texas, and then to the Southeast. However, I wanted to spend a weekend in Tijuana first, before setting off on a big new adventure. To take a break, after six months of riding down the Pacific coast of the USA.

Went to TJ, and liked it a lot. Loved it. Went deeper.

So I kept going, deeper and deeper, like Alice down the rabbit hole. Until I came out into an altogether new adventure in wonderland. Riding across the Mexican desert!

### **Across the Border**

From that beach in San Diego, where I made my decision for the upcoming route, I rode south. South, through the stretch of



small outlying municipalities, which seem to specialize in selling cars on preposterously huge lots. South, to the largely empty parkland next to the Mexican border.

On the San Diego side of the border, things pretty much peter out between the metropolis and the huge patrolled border fence. A large treed area serves as a kind of off-roading park, although almost empty. I rode around the trails for a little while. A handful of houses dot the area, and US border patrol agents drive around in utility vehicles. Mostly quiet.

The Mexican side of the border, by contrast, is a huge fiesta. Loud music, kids riding bikes, lots of food and dancing and entertainment. Through the border fence by the beach, some kids on bikes and I waved at each other and conversed. Unlike the virtually empty American side, the Mexican side has bustling neighborhoods stretching right up to the border. People line up to cross over, many to go to work. And endless vendors supply those people with tacos, burritos, and whatever else you could want at an international border crossing.

With no clear signage in the American park area, I stopped at a house to ask directions. A man was gardening behind his hedges. I knocked on his wooden gate. He peeked through, and we talked through the barely open gap in the gate. When I asked the man how to cross the border, I didn't think to specify how or where. He told me of a quiet route that wouldn't invoke questioning – an unofficial crossing.

I tried to follow the man's directions, but never found the way. A little while later, a border patrol vehicle asked me where I



was going. I asked the border patrol back, where was I going, and I wound up getting directions to the official border crossing.

After going over the pedestrian bridge to the access area, I went to a foreign currency exchange booth on the American side of the border, to get some pesos. As I was wrapping up the transaction like a burrito, I heard somebody behind me call out my name: “Eagle!”

Surprised that someone would know me at the US-Mexican border, I turned around. There was Yuta! The cyclist I had met in San Diego had arrived at the border at the same time.

We went into the customs building together. Mexican officials with assault rifles processed the line of mostly Mexicans going home from work. An Asian and white pair of touring bicyclers obviously stood out. The customs official didn’t speak English, Yuta didn’t speak Spanish, and my Spanish was then quite poor and my Japanese primitive. The agent mistakenly assumed we were traveling together, and asked questions about where we were heading, which I tried to answer while translating between barely understood languages. Confusion reigned.

The official stamped our passports and gave us travel permits. Mine looked like it said 30 days, so I planned around that, although later on someone pointed out that it was actually messy handwriting for six months. Apparently you’re supposed to pay a fee at a bank after going into Mexico. That became something of a question.



After the border crossing, Yuta and I parted ways again.

Time to explore!

## **Welcome to Tijuana**

Right after crossing the border into Tijuana, I had some food, and it was much heartier – and cheaper – than “Mexican” food on the other side.

Mexico is a really happy place.

After eating, I went through a few different parts of the city. Tijuana has a kind of ramshackle appearance, which many people seem to hate, but I love it. Everything from the streets to the houses to the boardwalk really appealed to me. The people live in the moment.

On my first day in Tijuana, I experienced a lot of culture shock. My Spanish, which I had practiced along the California coast, faced a few major challenges in Mexico. And the whole country seemed utterly different than what I knew or expected, in everything from the way people lived in unfinished concrete environments to the food and the music and the ways of public life.

One of the first places I went, a *marisco* (seafood) *taqueria* (taco stand), had very friendly and polite and beautiful people eating and working there. They made some of the tastiest tacos I have ever eaten. When I tried to pay, they made it a gift.

Across the street, a man sat huddled on a set of front porch steps, naked, smoking a cigarette.



“It’s a free country,” said one of the *taqueras* (women making tacos).

“Is it?” I wondered to myself, not at all rhetorically. I had a lot to learn about Mexico.

Over time, I’ve formed the opinion that Mexico is actually in many ways a much more free country than today’s USA. (In other ways Mexico is less free.)

A police pickup truck came by, collected the smoking naked man into the bed, and handcuffed him to the railing before driving off.

Throughout the northern part of Mexico, as I would later find, heavily armed police and military forces patrol the cities and towns and outlying areas. The border has become the transition point for much of the illegal drug traffic into America.

I wasn’t sure where I’d stay that first night. I started to worry somewhat, as I didn’t even know how to find a safe place in Mexico. After riding around for a little while through the hilly city, I found a cybercafé, and looked through some online maps and info. After that, I rode out to the ocean, which is a ways away from where I was.

The ride itself felt great! Mexican roads are far rougher than their American cousins, and Mexican gas more so, and Mexican drivers yet more. Anyways, I made it.



On the *malecon*, or boardwalk, people joyfully partook in relaxed evening strolls. Restaurants and bars line the walkway. Karaoke pours forth, with popular *banda* tracks blaring loudly. I ate and drank and talked with people, including an Indian (native) family from southern Mexico. They gave me tamales – corn dough with filling, cooked inside corn husks. Mexico is a lot less multicultural than the US or Canada, so I met mostly Mexicans, and enjoyed the novelty of being the only obviously outside visitor.

That first night in Tijuana, I wound up camping on the beach, which was somewhat scary although very lovely. Although I was a bit afraid, as the city had a fierce reputation, and I had already encountered deadly cliffs without any warning markings, among other dangers, I also deeply enjoyed the music of the Mexican voices as they went by, talking and laughing and playing on the beach late into the night, as the waves crashed against the shore, and I drifted off to sleep.

The next morning, I woke up, which was a good start.

### **Deeper**

In the morning, as I went walking by the boardwalk, a car drove up with its loudspeaker blaring an announcement for tamales and *champurrado* (a chocolaty Mexican drink), which tasted heart-warming in the cool fog. I love how in Mexico so many vehicles blast out vendor messages. Even the electric company has its catchy jingle going.

Over the next few days, I explored more of Tijuana, biking around the wild untamed roads joyfully. The vibrant city has





plenty of open-air street markets, lots of seafood, and a bull ring, although it *is* tough to find a decent (and open) bike shop. I went to a bullfight, and despite the characterful ambiance, I cried at the savagery of the sport/art, and the crowd's alcohol- and nicotine- and testosterone-fueled reactions of fury. I guess it's comparable to eating meat. Traditionally a victorious bullfighter takes home the carcass for food, by the way.

I learned a few wonderful words in Tijuana. In Mexican Spanish, they say *¡Ándale!* for "Let's Go!", and *¡Órale!* for "Wow!" Of course, both words have lots of other meanings as well. For example *órale* can also mean "OK", or "oh, really." Mexican is full of nuance and humor, and really hard to understand fully.

My bike was basically functional, yet I had broken a rack, an aluminum thing that snapped under the weight of my cargo load. Around then I decided to see a bit more of Baja California, going down to Ensenada as someone had recommended, instead of going back right away to San Diego as I'd originally planned. On the way out of TJ, I went through the small municipality of Rosarito. There, I went into a bike shop, yet they didn't have the part.

However, the man working in the bike shop was very generous. While he minded the shop, I ran down the street to add a bit of credit to his phone – and some internet time for a youngster at the corner store – so that the bike mechanic could call his brother at home, and find out that they had a spare part there. The bike mechanic drove me home, and both brothers



did a fair bit of repairs together in the garage. They wound up putting together a jerry-rigged, Mexican-style storage solution: an old plastic crate bolted onto the bike. And the family invited me to stay the night there.

The whole extended family lived in a conjoined set of buildings. Many members came and went. The bike mechanic and his brother had got their start in business by doing bike work from home, before opening the shop. One of the family youngsters worked in the US, where he had acquired some American attitude. The women seemed extremely shy, like in a traditional society – which this was. Children grew and played. One active tyke got dubbed “aventurero,” adventurer. The household felt full of life and emotion.

In the morning, we had *panes dulces* (pastries) and coffee. Many Mexicans eat an enormous amount of sweet food, and drink lots of coke, and pour mounds of sugar in their instant coffee with powder creamer. It tastes good, but I suspect it contributes to some of the country’s health issues, such as obesity as prevalent as in the US.

We chatted for a while, and took photos. I neglected to get their contact info or give mine. Since then I try to be much more on top of that. If you meet people you want to keep in touch with, make it a habit to exchange contacts right away, before you forget!

Ready to rock ‘n’ roll, I went with the family to the outskirts of town, before continuing my ride south – deeper into Mexico.



I love the open road! ☺

### **Ensenada Man**

Riding down the 1, the big highway that stretches the length of Baja's 1,700 kilometers (1,000 miles), I got progressively more comfortable in Mexico. Waving and chatting with the people I passed by, learning the ins and outs of the place, the country really grew on me, rapidly becoming my favorite. Now I'm a Mexican patriot!

Pemex stations dot the highway. Pemex is the government gas monopoly, which makes up a big part of the economy and culture. Just recently, they have been allowing the first handful of private oil companies to operate in the country, eliciting a lot of controversy.

The newly built highway crosses the peninsula from north to south, where before only rougher roads ran. Wild dogs and cattle roam the streets. The sun burns down brightly & hotly. The people are deeply friendly, and live to ripe old ages. I really love northern Mexico, and am so thankful that places like this exist. If you ever get a chance you should go.

For my new route, I would go to Ensenada, where I wound up doing interviews for "Robotic Triplets." After Ensenada, I had options. I could keep on going south, or go southeast, and either way see some more of the beautiful Baja California peninsula. Or else I could still turn back to San Diego. For the time being, I kept carrying on towards Ensenada.



As I rode, I stopped at night to camp out on the side of the road. Alongside a little farm, I set up my tent in the gorgeous hues of sunset. Before going to bed, I noted that lying on the ground near me was a white object, a goat skull.

In the daylight, on the way into town, I stopped at a *taqueria*. They were all out. “You don’t have anything left at all?” I asked in Spanish. I learned much of my early Spanish from *taqueros*. “Well, I could scoop out this head,” offered the *taquero*, holding up a goat skull like the one I had seen on the side of the road. Mexicans, in particular *taqueros*, have a great sense of humor. It tasted rich, anyways.

When I finally arrived in Ensenada, the boardwalk there too was full of life, food, music. A band of youngsters was performing classics of American rock and Mexican pop. They were really good. All around me, smiling happy people ate and laughed in the sun. I had stumbled onto a *feria de la sardina* (sardine festival). Culinary students made many Mexican dishes featuring the humble fish.

I stayed for a little while, trying some of the delicious dishes with the fishes. While there, I tried to communicate with a Warm Showers host I was going to stay with. I found that the whole festival area was blanketed with wifi. Tijuana has a lot of wifi throughout the city too. In fact, in many ways Mexico actually has more widespread wifi and other technology than the US. (In other ways, such as drinking water and toilet paper, Mexico has far less infrastructure.)



I went and met Felipe, the host who had offered to put me up. He was a nanoscience graduate student at the university. Ensenada is kind of the academic hub of northern Mexico. It has a branch of UNAM, the country's biggest and best university. While there, I interviewed the observatory director and the lead astrophysicist for the "Robotic Triplets" story.

Felipe showed me around town. We went to the fish market and to *taquerias*. And we talked of bike travel, as he wanted to go on a trip of his own. Felipe taught me a lot about Mexican culture, including many important swear words. He laughed at my story of *tacos de cabeza de chivo* (goat head tacos). He also showed me some good places to go, on a map of Mexico. In stark contrast to the desert north, there are jungles in the south, and mountains in the center. I decided to carry on farther through Mexico, playing it a bit by ear. At some point along the way, I decided just to keep on going through Mexico, and then return to the southern US later.

With Felipe and some of his friends, we rode on a bus around town. I asked one of his friends a series of questions about tacos, which then still comprised much of my Spanish vocabulary. At least I was beginning to be able to have conversations. Switching subjects, one of his friends told me a bit about her house. "And there," I asked, "do you eat a lot of tacos?" They laughed.

On my way out of Ensenada, Felipe helped me track down and buy a bike pannier from a bazaar. Then it was off to unknown lands to the south.



Let's go!

### **Close Encounters**

Riding out of Ensenada, I went by a roadside stand selling bananas. I ate a bunch.

At one stop along Highway 1, around Ensenada, I wound up staying with another Warm Showers host. Roberto lived with his family, operating a taco stand at a scenic spot overlooking the ocean. On the other side of the highway, atop a high cliff, there rose to the sky a gigantic statue of Jesus. Christian iconography fills up Mexico, although with its own twists inspired by native religions.

That evening, in the paradisaical location, I chatted with Roberto and his family and some of the tourists who stopped at the highway spot. A couple who had come from Tacoma, Washington, sat down with me at the *taqueria*. I confessed to them: "Whenever I meet a guy from Tacoma, I can't tell whether he's a Tacoman or a taco man."

Roberto gave me a bucket and some soap to wash my clothes by hand. I looked out over the sea, in the glorious sunshine, and set up camp.

In a small town farther along the highway, I walked along the touristy beach. Rows of palm huts sold *cervezas* and *mariscos*. A big surfing contest was getting set to happen there soon. It looked like lots of *gringos* went there on holiday. With my evolving perspective from riding and writing, I actually now felt a little bit in between a Yank tourist and a Mex beachgoer.



More like a gypsy! More generally, I feel like I'm something of a hybrid – between the technical and the artistic, the serious and the playful, the reverent and the irreverent. Astrotripping through life. Do you feel at home where you came from? Or have you ever felt more at home while abroad? What is home?

Camping out one night on the beach, I locked up my bike against the fence of a house, along the sand. As I was getting ready to sleep, a man came by and spoke with me. He and another man had been talking in the backyard of the house. The one who talked with me took on an aggressive tone, and asked me what I was doing there.

I told him a bit about my travels, and that I'd figured it would be all right to camp on the beach there. He changed his demeanor, and told me that he would protect me, that I was safe there. Then he started asking a few questions: if I was interested in making money, and the like. I asked him what he was getting at.

“It's easy,” he said. “All you have to do is drive a car. You just drive a car to the US, and you'll get a lot of money. Then you do it again.”

Hm.

Declining the offer, I felt a little uneasy going to sleep that night.

I woke up the next morning, which was a good start.



Continuing to ride beyond Ensenada, I made my way towards Mexico's National Astronomical Observatory. Along the way, I stopped in a charming little town, La Misión, where my latest bike rack broke from overburden. Wound up getting it fixed by an American expat retired firefighter, and his local friend. The Mexican, who had been deported from the US and now was making flower pots out of old car tires, asked me if the telescopes I was visiting could read the future. A lot of people, in all walks of life, confuse astronomy with astrology. People have looked to the stars for stories and navigation for ages. With increasingly precise tools, scientists now measure stars' paths, as objects like those on Earth move, and create theories to explain those motions naturally. With these we can predict the future motions of the stars and other celestial bodies. This tells us about our home in space. However, nowadays professional space scientists don't view the stars as accurate predictors of daily human events, as astrologers would.

Anyways, time for adventure! ☺

### **To the Observatorio**

My next destination would be Mexico's National Astronomical Observatory. Merely to get there is a challenge. Located on a mountaintop in the middle of the desert surrounded by the sea, the place redefines remote.

I rode along the dirt roads bordering dry fields. Along the way, there are a handful of very charming tiny little desert towns. Each one has its own unique character. The towns share dirt tracks that makes up a good chunk of the Baja 1000 off-road





race. The towns also share an informal style of living, with plenty of kids racing around on motoquads, and delicious tacos.

My favorite little town in that stretch, San Vicente Guerrero, has a lovely park in the town center. There, numerous little taps provide potable groundwater, a highly welcome luxury at that point.

I got into town around the time of Mexico's national holidays, *Fiestas Patrias*. I camped out in the park, by the police station. The whole place turned into a long-weekend-long, non-stop party. Large *banda* groups played invigorating live music, and everybody danced the bouncy, sharply angular cowboy dances of the *norte*.

During the holidays, when the town seemed to swell in population, the traditional celebrations included a lot of shouts of *¡Viva Mexico!* The beer and tacos flowed freely. An early drunk stumbled out into the huge central dancing area, setting the stage for all the rowdy participants, and the king and queen of the ball.

I partook in the festivities, although I couldn't stay up as late or dance as well or drink as much as all the revelers. After wrapping it up for the night, as I fell in and out of sleep, the music continued to blast. I enjoyed lying awake tired yet lively, listening to the music. One of my favorite songs from this period is *Dos Mujeres* (Two Women); you can hear it and see all the Mexican cowboy dances online.



During the day, kids engaged in a traditional practice of egging each other, as well as eating lots of colorful treats. Fiestas happen in Mexico throughout the year, for any occasion whatsoever. A huge holiday only makes the festivities that much bigger.

Ready to switch back from fiesta mode to writing and riding mode, I got a convenient travel bag from one of the vendors lining the park, and took it to another stand where they modified it into a saddlebag. This complemented the saddlebag I had bought at the bazaar back in Ensenada. When I had started riding with a rack instead of a trailer, but before I got the saddlebags, I had just strapped my stuff onto the bike however I could. Now, I had a proper touring setup.

Then I carried on, ever south, towards the observatory...

## **Challenges**

One day, as I rode up a hill in the hot desert sun, *snap!* I heard and felt the bike shatter beneath me. Getting off to inspect, I found that the seat had broken off.

Sticking my thumb out, I hitchhiked. After a while, a truck came by and picked me up. We drove by beautiful cactus fields. At the first tiny little settlement, hardly even a town, we stopped and got out. No bike shop in town, of course, but a car mechanic had a bolt that roughly fit the seat.

Right next door, parked in front of a church, a couple called me over. In the back of their sedan, a small child looked at me. From the trunk, the family offered me cold water, which was



the first in ages and incredibly refreshing, as well as ham and cheese sandwiches with tomato and avocado. “*Tacos americanos*,” I joked.

Later, after a game of pickup soccer with local youths who gleefully encouraged each other to pass the ball to the gringo, I set up camp. A tent pole broke. I fixed it. Lying in bed, I felt increasingly sick, eventually vomiting the sandwiches. The first few challenges of many to come in the unforgiving desert surrounding the observatory.

After throwing up that night in my tent, I started to feel better. I thought I would be OK for the ride up to the *observatorio*. Jajajaj.

Along the way, my tent had degraded, as had my bicycle gear. In need of a replacement, I had tried buying a tent from people I had met in small towns. The Baja desert does not have a lot of sports stores. On the side of the highway, I came across a vendor outside his pickup truck, with his wares on display.

“Do you have any tents?” I asked him in Spanish.

He found a couple of tents. I asked him how much he wanted. One was too expensive. Another one seemed closer to what I wanted. I haggled with him. Finally, we settled.

When I got to the tiny town that’s the last bit of civ before the observatory, I’d run out of pesos, not having planned for spending this much time in Mexico. The town didn’t have any ATMs, so I rode to the next town, Camalú – singing the town



name to myself to the tune of Olivia Newton-John’s “Xanadu” masterpiece.

In Camalú, I had some really warm interactions with many locals. An older man told me about living there, and I was glad to understand his difficult speech, and his difficult life. When I went into a grocery store, a boy asked me to buy some food for him and his family, which I did. I then stopped to do some writing, and met more friendly locals.

When I went camping in the desert town, I was setting up my tent in the wind, at an abandoned lot, near where some musicians were rehearsing. When I opened the tent I had bought, I found that it was missing an important part!

A driver in a pickup truck pulled over, and asked me what I was doing. I explained. He warned me of the *delincuencia* (crime) in the area, and that it was unsafe to stay there.

The man drove me to the police station. Inside, the cops, less than enthusiastically, let me set up a tent in the courtyard. The station was a complete mess. I combined parts from the old and new tents, to make a provisionally serving shelter. I had an all right night’s sleep.

Stocking up on groceries before tackling the climb up the mountain, I asked locals for guidance. I wasn’t even sure how to get up there. I got conflicting directions. According to some people, a road I had selected didn’t even go up to the top. And the towns in the area seemed to have conflicting names, showing up on one map one way, and on another map another



way, and the people speaking of it with a name not appearing on any map.

The people there also warned me of a range of dangers. Apparently the peak held wild animals, including most dangerously cougars. Also, it would be hard to carry enough water. I bought a big jug of water, to strap onto my bike in addition to all the water bottles I was already carrying. I still hoped that I wouldn't run out of water, or get eaten by a cougar.

People had warned me a lot about the dangers of Mexico, especially the border regions and drug trafficking areas. In one of the towns I went to, right at the turnoff to the observatory, I saw a newspaper with a gory front-page picture of a highway sign, where a few people had just been executed. As I left to ride on, I passed that exact sign, looking very much like it did in the newspaper photo.

I set out on the road up to the mountaintop. Time for adventure!

### **Up the Mountain**

Time to make my way up to the observatory. I got going, and the road started off with a gentle slope. It rolls up over beautiful scenery. Sweetly rolling hills. Lovely little vistas.

At some point on the way up, there was a tiny little village, with an *abarrotos* (grocery) store. I stopped in, refilled my water gratefully, and had a bite to eat. They offered me some fresh fruit from the tree outside, and we talked.



It turned out that another bicyclist had come by recently. He was Japanese. Yuta! Yuta had also apparently been to the same *taqueria* that I went to in the little town at the base of the mountain.

Then, as I kept on riding up the mountain, it became steeper. I rode and rode, and had a wonderful time.

Ready to call it a night, I looked for a place to camp. The empty fields to the sides of the road were fenced off. I thought I'd camp next to the fence, ready to call it a night, but first go a bit further just to see if the fences didn't stop up ahead. After all, the material type of the road changed a bit, so it was a reasonable guess.

As I carried on, I could see a figure up ahead. That was funny. I hadn't seen anyone else for miles, pretty much the whole time.

As we approached each other, we greeted one another. The person was on foot, a somewhat unusual-seeming Mexican man. I said hi, and asked how he was. He pulled out a small bird from his coat, which he said had died. I felt disturbed going to bed, instead of the peace I had felt up until then.

The next morning, I woke up, which was a good start.

That camp spot had a lot of sharp, cactusy plants. I caught myself on one, by walking less carefully than I should have. A huge chunk of the plant came off, sticking into my leg. It hurt, and I struggled to remove the thing. Later on, I would get



similar plants stuck in my leg in Arizona and Texas, among other places. There's always a catch.

As I rode on, I felt very sick. I had relapsed again after a brief respite, from that hitchhiking-sandwich incident. This time it came back far worse than before. I had diarrhea, which dehydrated me and made the water situation worse, on top of being unpleasant and forcing me to stop at regular intervals. I often felt like death.

Climbing up, under the hot desert sun, dry, sick, up the steep mountain, proved really challenging. It was a trial by fire, and I felt quite concerned about health and safety.

Further up the mountain, I ran into another little pocket of people. A relief! There was a tiny little getaway, with a few buildings and a swimming pool. I cooled off in the pool, and again filled up my water bottles, gratefully. There were a few other people there, and we chatted about travels and bike riding. Then I kept on going, towards the peak.

After a long day of climbing, the sun started to set. I thought of camping, but decided to carry on a little further. I could see the sunshine coating some areas of the mountain, while other areas got shaded. I wanted to make it to one last sunny section, and camp in its wonderful hues.

Out of the blue, a few dogs stood staring me down. They looked kind of wild, very defensive. I stopped.



After a lengthy stand-off, unsure what to do, I rode towards them. It was hard for me to go by, on the lonely mountain pass, without much room and without much speed. But, I pedaled hard and got the dogs off, and moved on. By the time I got to a campsite, alas the sun had already set.

The higher I got, the harder it got. I was getting sick of being sick. At a certain elevation, at least the climate cooled off where the pine forest started. The little streams of water and shade flowing from the trees proved very refreshing.

After significant struggles, I got to the park area that encircles the observatory, and went into the office building. They radioed up to the observatory, to say that I was on my way.

I kept on going, and it got even harder towards the top. Pushing and pushing, I struggled as mightily as I could to get up the massive mountain. I rode through a grueling stretch, going by a flock of California condors swooping about the cliff.

Finally, seeing from a distance the dome of the telescope, I took heart. At last, I made it to the gate. I stopped. I looked around, surveying the incredible panoramic view. It felt amazing to look out over the many miles down below. I had made it. To the top. To the Observatorio.

I stayed at the Observatorio for the next few days, touring and interviewing for “Robotic Triplets.” I stayed sick throughout my time there. But I was extremely happy to have arrived. It felt glorious, joyful, wonderful. Full of life!





*Astrotripping: A Cosmic Joyride*

Eagle Gamma

*¡Órale!*

Wow!



## **Robotic Triplets**

Observatorio Astronómico Nacional, Sierra de San Pedro Mártir, Baja California, Mexico

September, Year One

*Up the Sierra San Pedro Mártir, to Mexico's Observatorio Astronómico Nacional. A new international project searches vast troves of data indirectly for tiny transneptunians. The three new robotic telescopes seek kilometer-size objects beyond the planets.*

They're out there. Orbiting the sun outside the eight planets, the minor planets known as "transneptunians" include Pluto, famously demoted to dwarf planet, and over a thousand other planetoids. However, many billions, maybe even trillions, of smaller bodies spread throughout this remote realm of our Solar System, too small to see.

A new project, the Transneptunian Automated Occultation Survey (TAOS II), now gets underway at Mexico's Observatorio Astronómico Nacional. The effort brings together top astronomers from the United States, Taiwan, Mexico, and beyond. The installation of three robotic telescopes aims to pierce the veil outside of the planets.



The transneptunian objects hold lots of secrets about our Solar System. Their number and size offer clues to explain how planetary systems form. And they may hold the key to our future. Currently, astronomers know surprisingly little about the area of space between the core planets and distant stars. An account of our cosmic neighborhood must accurately describe these mysterious missiles.

### **In A New Light**

What exactly are transneptunian objects? Any small bodies orbiting the sun beyond Neptune. Carrying information about our origins, they may also form our future homes, according to prominent astrophysicists such as Freeman Dyson. Since the recent discovery of the first handful of transneptunians, knowledge has exploded to over a thousand. However, the vast majority remain unknown.

Known transneptunians range in size from around 30 to 2,500 km (20 to 1,500 miles) across. The largest, including Pluto and Eris, are somewhat smaller than our moon. However, TAOS II hopes to find much smaller ones: more like a few city blocks.

In order to pinpoint such precise targets, the project uses an innovative set of robotic telescopes. New sensor and storage technologies enable the processing of massive volumes of data. New astronomy techniques allow the devices to analyze incoming light.

Mauricio Reyes (Universidad Nacional Autónoma de México) leads the Mexican contribution. “Transneptunian objects, like all bodies in the Solar System, except the sun, are bright



because they reflect light originally coming from the sun. The farther they are, or the smaller they are, the less light they reflect.” Existing telescopes cannot collect enough light to see countless transneptunians.

Instead, the triplet telescopes observe transneptunians indirectly. To measure the miniature items, the instruments detect distant starlight. Every few days, a given star gets slightly dimmed by an object passing between it and the Earth. Each occasion, or “occultation,” lasts for only a fraction of a second. The more transneptunians there are out there, the more frequently they will pass in front of stars. By watching enough stars for enough time, it becomes statistically apparent how many transneptunian objects there are, and where.

Michael Richer (Universidad Nacional Autónoma de México), acts as Director of the Observatorio. “The shape, and the duration of how the dropout happens tells you enough information with three telescopes to figure out how far away these objects are and how big they are.” New insight arises into the flight of the transneptunians. “The idea is in the crudest sense that you have three telescopes to tell between birds flying in front of a star.”

### **High Technology**

Optically, each of the three telescopes has identical properties, including a 1.3 m (around 4 ft) diameter primary mirror, with a Cassegrain reflector. The focused image has a diameter of 154 mm (around 6 in). The system records images so fast that it



practically shoots video footage – 20 frames per second – on more than 10,000 stars simultaneously.

With tens of millions of pixels per camera, at a couple of bits per pixel and twenty frames per second, the researchers estimate that traditional CCD sensors would take over 250 terabytes (TB) – per night. Custom CMOS sensors by tech co e2v cut this down to 2 TB, by selectively recording subapertures containing stars.

Matthew Lehner (Academia Sinica, Taiwan) serves as the overall TAOS II Principal Investigator. “In terms of practical data analysis and archiving, we’re expecting to get close to a petabyte per year of raw image and light curve data.”

The three telescopes sit together in a compact array. Before starting to build the telescopes, the designers performed many analyses over several years, including running Monte Carlo simulations – complex numerical calculations.

If the telescopes sit farther apart than around 500 m (1,600 ft), then they see the same object along different lines of sight. If they sit closer together than 150 m (500 ft), then atmospheric effects result in “correlated variations,” negating the advantage of multiple telescopes. Therefore, they must sit in the sweet spot between these two distances.

The triplets sit too closely together to serve for stereoscopic or interferometric studies. Reyes notes that the redundant telescopes are “an important element in order to rule out the false positives that may be due to, for example, some fast-



moving clouds that pass in front of your telescope, or some bird, or some electronics glitch, which is something that has hindered other efforts that have been done with a single image.” While space garbage moves too fast, and exoplanets are too far, the technique is so subtle that it requires the triplicate measurements for sound observations.

### **Succulent Desert and Pine Forest**

The Observatorio sits at a unique position atop the Parque Nacional Sierra de San Pedro Mártir (Mountains of Saint Peter the Martyr National Park). This pine forest at the high point of Mexico’s Baja California peninsula offers especially excellent viewing conditions, often billed as one of the best astronomical sites in the northern hemisphere.

At around 3,000 meters (or 10,000 feet) above sea level, and 100 km (or 60 miles) inland, the remote location lacks in convenience what it has in astronomical conditions. The site has many clear nights, low humidity, little light pollution. The Mexican government moved its devices here in the seventies. One of them, at 2.12 m (7 ft), is the largest optical telescope in the country.

The route to the observatory goes through long stretches of dusty, dry, red desert. For most of the way, the hot and arid climate yields a scattering of succulents such as cacti, yuccas, and agaves, which look like giant pineapple tops or artichokes, and whose flower stalks look like immense spears of asparagus. Tiny little lizards dart about rapidly.



At a higher altitude, pine trees become more frequent, contributing to a fresh, cool breeze. Occasional herds of cattle graze by the side of the road. A few small squirrels pirouette around the rocks. Around three quarters of the way up the mountain, a large flock of California condors swoop about the cliff.

A telescope dome stands out high atop its mount, the white and blue edifice visible even from well outside the observatory limits. Brightly painted orange buildings provide workspaces, including a warehouse and machine shop, while a larger building houses staff and facilities. A variety of curved white pods look like they belong in a classic science fiction movie. Several white pickup trucks drive around the facilities, along with white Volkswagen Beetles.

In addition to astronomers, a team of engineers, mechanics, and drivers ensure the ongoing operation of the observatory. The personnel have catering and entertainment, as well as the incredibly scenic location. With the tranquility at the observatory, and the revolving population, it feels like a remote astronomy retreat.

### **Building Up**

TAOS II brings new infrastructure to the national observatory, including telescopes, buildings, roads, and power. The three new telescopes share some features with the previously built instruments, including the housing dome design, and they sit nearby. The new devices, however, have full automation, with



a central control station in a fourth building to monitor all three telescopes.

Because the telescopes are robotic, only a handful of new employees arrive, mostly to do maintenance tasks such as cleaning. In a role reversal, people now help machines to do astronomy.

Liliana Figueroa heads engineering at the Observatorio. The site currently has diesel power generation, and microwave internet, she says during construction. “We’re going to construct three buildings. We’re going to make the access roads, because right now there are no roads. And we’re going to bring electric and fiberoptic connections to the place.”

To get to the construction sites requires a pickup truck. With dangerous terrain, a professional driver helps, and the ride still feels iffy. The impossible-looking route feels as treacherous as it is beautiful. Sudden cliffs with sharp rocks defy common sense.

Wildlife roams the grounds freely, including the ever-visible cows, as well as squirrels, birds, coyotes, deers, and an ecosystem of other animals. Out over the horizon, countless thousands of pine trees mesh with the succulents and dirt trails.

The telescope sites have amazing locations for viewing the stars, and some of the most stunning vistas in the world, stretching to two seas. Every day sees clear blue sky and sunshine throughout the day. At night the stars shine brightly,





feeling palpably immediate and present and encompassing. It's easy to see why astronomers love this place.

Hiking where the new instruments will go feels like walking in the wilderness. Figueroa's team will transform this mountain pine forest into a futuristic citadel. Here, robotic telescopes will watch for transneptunians.

### **How the Solar System Got Its Planets**

The point of TAOS II is to tell us about our planetary niche. "Why are we building it? To learn about how our Solar System formed," says Richer. "That's one of the fundamental unknowns."

As chunks of rock and ice made planets, gravity stretched out the dough into the Kuiper belt, which wraps around us starting at 30 times the orbital radius of the Earth. Transneptunians now return inward in the form of comets. Importantly, they bring back frozen material in a state similar to when the planets were born. The comets from beyond Neptune may even have seeded biological life on Earth.

Astronomers create models of planetary system formation. Evidence from observations of the transneptunians provides validation. "What there is now is a constraint on any theory of formation because all of these theories have to predict what the Solar System is like today."

What we learn about our Solar System also applies elsewhere. "There are planets that we know around other stars that our current theories don't explain," says Richer. "It's



understanding your backyard in order to figure out how distant communities work.”

Lehner speaks of Sedna – a transneptunian planetoid – as a big puzzle. Its unique movements mystify astronomers, and it has become the subject of many competing hypotheses. He also highlights exoplanets. “We don’t know how exoplanets happened around other stars. Before the first exoplanet was discovered, theory said there are very few, because it’s hard to form planetary systems. But lots of stars have them. A lot of questions remain to be answered, and this is a small part.”

### **Past and Future**

The project had a predecessor, TAOS I, designed as a test for the current phase. It operated several smaller telescopes at Taiwan’s Lulin Observatory. Between 2005 and 2013, the predecessor collected over 27 billion observations, without detecting a single occultation. Lehner notes that events were not necessarily expected at this stage, on the statistical basis of the transneptunians measured to date.

The absence of detections by TAOS I limits the possible number of transneptunians. The way in which Kuiper belt objects get perturbed into cometary orbits implies tens to hundreds of occultations detectable by TAOS II. Observations from the Hubble Space Telescope (HST), down to 30 km (19 mile) diameter objects, reveal a density of comets that supports this theory.

The three main differences between TAOS II and its predecessor include size, speed, and location. The increase in



mirror diameter from 50 cm to 1.3 m will allow the astronomers to look more deeply, and see more stars. TAOS II will record at 20 Hz, revealing details that completely eluded its predecessor, at only 5 Hz. And the clear and bright skies at San Pedro Mártir provide much better viewing conditions than Lulin.

The robotic triplets will revolutionize observations, notes Richer. “Every night, three hundred nights a year that are clear, these telescopes will be observing a predefined set of fields, to look for occultations of a predefined set of stars. They’ll do this for six years. This scale of project has never been contemplated before.”

Moreover, major astronomy projects often yield surprises. “When you can look at the universe in a different light, you’re almost guaranteed to find things that you hadn’t found before.”

One possible way forward focuses on getting a clearer picture from space. NASA has sponsored research into the detection technique. Lehner notes another option at the Atacama Large Millimeter Array (ALMA), to “put telescopes on the grid, measure shadows as they move across the sky, and help constrain the size and orbital characteristics much better than TAOS II.”

Looking beyond Neptune, the three new robotic telescopes at Mexico’s Observatorio Astronómico Nacional open our view to new worlds.



## **Across the Desert, Across the Sea**

Baja California Peninsula to Sea of Cortez, Mexico

October – December, Year One

*From the desert to the sea, many misadventures make for a magical winter in Mexico. After leaving the Observatorio, Eagle rides through the desert of Baja California. Along the way, we meet a troupe of capoeiristas traveling by bicycle. Eagle runs into broken electronics and a stolen bike. Then, after hitching a ride for a sailboat crossing, it's time for the mainland!*

Following the touring and interviewing at the National Astronomical Observatory, I had to decide on a new course. Would I go back up to the US, or continue south through Baja, or turn off to the east? The ensuing route took me into a surprising series of events. I wound up going south, further into the Baja Peninsula, traveling through a good part of the alternative route that I'd envisioned when previously contemplating where to go after the first six months.

The route first took me through both states on the peninsula, Baja California in the north and Baja California Sur in the south. As I was preparing to cross a very large section of especially sparse desert, I encountered a troupe of people who practice the Brazilian performance art *capoeira*, on a



pilgrimage to their South American mecca. We spent an enjoyable little while traveling together.

Then, carrying on to the bottom of the peninsula, I wound up getting into a handful of trouble with the trip: riding, writing, the whole deal. Disaster after disaster seriously threatened the course of my journey, soon after I had been feeling so high. Yet, a few fun decisions had me sailing across to the mainland, and carrying on in a new and exciting light.

### **Going Down the Road Feeling Good**

While at the observatory, I talked with many of the support staff – warehouse and site managers, for instance, good fellows with lively humor. At one of the catered meals in the dining hall, they asked me if I had ever tried *pozole*, traditional hominy stew. “¿El rojo o el blanco?” (“The red or the white?”) I asked to their surprised delight, referring to the two different varieties I had tried in my travels. They teasingly asked whether I wrote for astronomy magazines or gastronomy magazines.

I asked their advice on routes. They generally pointed me southward, towards the splendors further down along the Baja California peninsula. This agreed with what I’d heard elsewhere.

At least one of the observatory staff suggested that I take an unpaved and unmarked track down a different side of the mountain than the route I took up. It would’ve been difficult, especially considering the sad state of my bike and supplies. I decided to survive, and just go back down the main access



road. The kitchen staff kindly invited me to take a bunch of food with me, so I had a good haul, which included many fine peanuts. Ready to rock & roll!

I rode down, back on that same road that I came up. I had been longing for this ride intensely, because of the immense effort of getting up the mountain in the first place, and knowing that now it would be *puro descenso*, pure downhill.

The miles went by waaaay faster on the way down, of course. On the first night, I slept along the 60 mile route, as planned. I had a great view, and was riding high on the excitement of visiting the observatory and learning all about the robotic telescopes. All seemed well.

When I woke up the next morning, and looked outside my tent, I felt like I was in a magical fantasy land. There were puffs of cloud all around me, billowing up and around my encampment. Looking out over the ledge, the foamy clouds seemed to roll on forever to the infinite horizon, like an endless sea. In all directions, the clouds surrounded the mountain, with bits of land popping up like little islands.

I started to ride down through the clouds. Along the way, I felt like a quixotic spaceknight tilting after imaginary dragons. I dreamed up a story of a freelance dragon hunter, who would go to risky extremes in pursuit of dragons, only to come up short, not get paid, or experience some of the other challenges



that I had been confronting in my astrophysics travel adventure writing.

When I finally arrived back on *terra firma*, the dry hot desert reminded me of “regular life.” Oh yeah, every day brings the opportunity to travel through incredible locations with stunning geography and society! I went through a small town that had a huge open-air market. Walking in the sun among the stalls felt so fun and wonderful. On the dry desert land, vendors sold clothes, foods, electronics, toys, and pretty much everything else you would find in a shopping mall.

I ate some delicious tacos, notably some of the greasiest *carnitas*. A very fat vendor was frying up a huge pot of the fatty pork. A fat cook is a good sign. I also bought a pair of shorts to replace the ones that recently broke. I refrained from getting a new set of headphones, which actually cost considerably more there in the desert market than they did in upscale San Diego.

After the incredible high of riding up and then down San Pedro Mártir in Baja California, it was time to decide what to do next. I had a few options. I originally thought I’d turn around and go back to San Diego, maybe after a side trip through the northern border towns of Tecate and Mexicali. At that point I still thought of this as a brief detour from my jaunt across the Southwest.

Life is an adventure. Live for the rainbow, not the pot of gold. Or both. There’s no clear and obvious instruction manual, and things often don’t go as expected. Whether you’re in the



middle of a remote environment and culture, or trying to understand our incredible universe, sometimes it helps just to immerse yourself in the mystery, interact with what's there, and then roll with the flow.

Around this time I decided to just keep going south. I don't know where the exact turning point was, but it became obvious that I would get more out of my time by spending lots of it in Mexico. I love this country so much.

*¡Ándale!*

Let's go!

### **Can You Really Be Down in Mexico?**

So I kept riding down the Baja peninsula. Unlike the American California, the coast of Baja California does not get a big highway running alongside many populous beaches. Instead, the much smaller highway, which was only built recently and replaced a rough dirt road, curves inland and runs through almost empty desert. Tiny little towns dot the route, so sparsely that signs warn drivers how long until the next gas station.

Some of the towns are very charming. They often have central parks – looking kind of funny in the desert, where they have dry earth instead of lawn. A few nice towns have underground water sources, providing fresh drinking water in a place where it was otherwise hard to find. The locals here are friendly, and I also met a few migrants from other parts of Mexico. In some towns I wound up camping at fire or police stations. In





general, I tried to experience the regional flavors, eating new foods and learning new words and exploring this wonderful part of the world.

As a funny American country song asks, “Can you really be down in Mexico?”

Near the Pacific Ocean, after the town of El Rosario – different from El Rosarito, Santa Rosa, Santa Rosita, and so forth – a very lengthy stretch of empty desert has practically nothing. As such, this charming little town serves as a “last chance” before crossing the desert. It has a couple of grocery stores, a few *taquerias*, and a smattering of dwellings. Many travelers stop here. One restaurant in town serves as a landmark for the Baja 1000, the major off-road race across the peninsula.

Before setting out to cross the empty desert, I girded myself. It would be a death match, and a chance to learn and grow. I stocked up on groceries – tortillas, beans, tomatoes, grapefruits, and such. I also had a snack at the Baja 1000 place, which had a live ram in the yard. While there, I did a final checkup on e-mail, and found magazine interest in “Robotic Triplets.” Later, that interest fell through. At the time, though, I felt great, as I wrapped up and prepared to ride across the desert on a high note.

However, on my way out the door, I caught a glimpse of bicycle bits that didn’t seem to be mine. I looked around, and saw one bike and then another, and another and another and



another. A whole mass of touring bikes and their bikers were coming in!

Despite having hoped for a simple and clean exit from the town to get out onto the road, I was excited and happy to cross paths with such an adventurous group. We talked for a little while, and found out the basics of each other's trips.

The troupe of riders were *capoeiristas*, people who practice the Brazilian martial art/dance/sport of *capoeira*. It looks kind of like break-dancing. The troupe I met were traveling together by bicycle, with their teacher Mestre Acordeon. Mestre is a title like "Master." *Capoeiristas* traditionally adopt performance names: Acordeon means "accordion," and students had names like Pirata, "pirate." From the San Francisco Bay Area, where they had their academy, the group were riding down to the bay in Brazil where the Mestre had launched his path.

As we stayed and talked, I realized that it was getting late. The weather got wetter – for some reason I seem to get rained on an awful lot every time I go into the desert. After some deliberation, it seemed to make sense for me to stay another day or two, then ride out with the *capoeiristas*.

### **Camping and Capoeira**

We camped behind the restaurant, with permission, in the yard with the ram. The little tent city felt really warm, a fun communal camp. We talked and ate and went on little outings and made merry. The group of around a dozen *capoeiristas*



had developed complex social dynamics over the course of their travels to date. I enjoyed the company.

Together, we rode off into the desert. Camping was really pleasant, with fires and music and group cooking and playing around. I got to try my hand – and foot, and torso – at *capoeira*. The taste and smell of woodfire-cooked rice and beans and vegetables with wheat tortillas was incredible, and will long be a favorite memory. Some of the sunsets were visually as remarkable. I really cherished the time together with these great people.

*Capoeira* was invented by Brazilian slaves, according to legend, who wanted to learn self-defense under the guise of innocent games, without getting into trouble. So they came up with a ceremony that looks like dance, but also teaches personal combat maneuvers. It has low, flowing movements, with a lot of kicks, and is very rhythmic. Like making love, I observed. And Mestre Acordeon concurred, noting that “you should be ready to fight anybody you would make love with.”

Each round of combat, called a *roda*, features a circle of *capoeiristas*. In the center, a couple of combatants spin and flip around each other, with stylized movements. A *capoeirista* can tap into the ring, and a cycle of matches flow from one bout the next without pause.

Music often accompanies the *rodas*. A few simple instruments create a kind of earthy droning sound, with accompanying chants. The *capoeiristas* practiced their instruments and songs during downtime. Between riding, we would stop at little



houses or other establishments that occasionally dot the sparse landscape, which allowed time to eat, fill up on water, and of course practice *capoeira*.

Along the way, some of the *capoeiristas* also got travel sickness, like what I experienced on the way up the Sierra. It makes it extra tough when you also have to ride across the hot dry desert. Having the *capoeira* support vehicle helped, allowing the wounded warriors to ride out a few days in peace and quiet.

We had a lot of great times together, more than I have room to recount here. At one scenic camp spot, we climbed up huge rocks jutting up from the desert floor among a maze of succulents, and took stunning photos. At another site, we ate and drank among unique plants, the *cirios* (Boojum trees), in a house made out of the tall surreal trees. We met many lovely residents along the way, finding that women in this desert often live to ages of over a hundred years. It seems like a little piece of heaven.

During this stretch, I would sometimes stop separately from the *capoeiristas* at various desert points to write. I propped up my laptop on my bike, and typed in the middle of nowhere. It felt incredibly peaceful to have so much tranquility and space in which to write. Very different than writing in a crowded, noisy café!

One of my favorite towns, San Ignacio, is an oasis in the middle of the desert. After miles and miles and miles of cactus, cactus, cow, cactus, cactus, cow, it felt extremely refreshing to



get to this palm-filled wonderland. My tire had blown out along the highway, so I hitchhiked into town. At a security checkpoint in this drug war zone, I think all parties involved were a bit perplexed: me, the pickup driver, and the Mexican military.

Then, getting out at a gas station, I walked the exotic roads, through luxuriously wet palm trees, into the heart of town. There, a thriving community lived under the tall trees, which put out an enormous amount of golden date deliciousness. The people made date pie, and sold bags of dates, although you could also just collect as many as you wanted for yourself, as they filled the area. The town square has a huge and ornate Spanish colonial cathedral, where locals and visitors meet and talk.

Several people came to talk with me, including a couple of kids on bikes. They liked my bike touring setup, and enjoyed hearing my travel stories. I liked their company, and was happy to share some of my experiences. Later on, I wound up playing soccer with a whole horde of local kids, including those two. As we played, and again later on, they all joyously yelled out “¡Águila! ¡Águila!” (Eagle! Eagle!)

To replace my broken bike tube, I went to a few of the general stores. None of them had a tube for my bike, but I learned of a man with the Mexican nickname “*el Negro*” (literally “the black”, although it refers more to a dark brown complexion). I found my way to his house with the help of local youths, through winding cobblestone streets. In his yard he had a



number of spare parts, and under the glorious sun he helped me to get rolling again.

While still in town, I went to a *tortilleria*. There, a group of women hand-made both corn and (wheat) flour tortillas. There and at the *abarrotes* (grocery) place across the street, I bought some tortillas, beans, pineapple juice, and other goodies, and had a snack. Eating the fresh hot flour tortillas with beans and drinking the cold pineapple juice under the golden sun felt incredibly good.

The town also had a bookstore, one of relatively few in Mexico. The place, *Casa Lereé*, has a lovely garden, where I sat and wrote. The garden has an irrigation channel of water flowing through it, and an old tool shop, and inspiring words on the walls. Up to here, the mill of fate, from here on, your choices.

It was again very bittersweet to leave the protected sanctuary of San Ignacio. After stopping for a swim in an incredibly beautiful lake overhung by palm trees – where I got a ride with some children on a paddleboat, while observing the wonderful diversity of life – I finally rode back into the cactus-filled desert.

The next night of camping, among the spiky succulents, scared me. My bike wasn't properly set up for riding in that area. It still had fenders from rainy Cascadia. The thin and balding tires were no match for some of the spiky plants in the desert. I got a lot of flat tires, sometimes a few each day. Eventually I ran through my supply of patches and tubes. Luckily for me,



the *capoeiristas* had a support vehicle with a number of parts from sponsors, including tubes of the right size. I also got roadside assistance from a pair passing by on a motorcycle, who had some tools.

At another point in the desert, riding with the *capoeiristas*, we stopped at a little roadside food establishment. The bathroom was an outhouse, and the sink was a bucket of water and a basin. Some of the *capoeiristas* spontaneously started a *roda*. Over by the building, I noticed a younger girl sitting on the porch, reading a book.

“¿Que lees?” (“What are you reading?”) I asked.

She showed me the book, which was a Spanish version of the *Bhagavad Gita*.

We talked for a little while. She was a sweet girl, and we got along well. I told her about back when I had read that book, years ago. She told me about a kind of steam therapy, and where you can do it in Mexico. She also handed me a few aromatic sage leaves, which continued to give my bike a pleasant scent for some time thereafter.

“*Con permiso*,” one of the *capoeiristas* interrupted, to invite me to carry on as we returned to the road.

“You two knew each other?” Pirata asked me on the way out.

### **Back into Civilization, Sort of**

After some extremely long days of riding, including one of over a hundred miles (160 km), it felt great to hit civilization



again. My supplies were running extremely low. I had gone ahead of the *capoeiristas* to get into town and replenish my supplies. The first sizable town was Guerrero Negro, “Black Warrior,” which sits in the southern state of Baja California Sur. Riding in under the burning desert sun felt glorious. A long and arduous quest sometimes yields great treasures.

While there, I wound up running into a worker at the local salt plant – the biggest salt plant in the world – who was enthusiastic about biking, and I stayed with his family.

Baja California Sur (BCS) was my Waterloo. After all the fun and enchantment of the northern half of the peninsula, in BCS everything went wrong. My laptop died, I think from overheating in the desert sun. Both my phones died – one my fault for dropping in a toilet, the other from hardware failures in the tough environment. And my bike got stolen. It felt like being in a Mexican country music song!

Things degrade. There’s a fundamental lesson in physics. Whether we’re talking about the basic structure of the cosmos, or the finely polished optics in telescopes, or the parts of a bicycle, it’s hard to maintain order. It takes efforts of one kind or another to renew and improve. And change is part of the process. It’s interesting to watch as my bicycle cycles through parts until the same device has essentially none of its original parts. The same turnover happens at telescopes, and even in people. Amazingly, humans can be more resilient than steel, as I noticed when my body got stronger but my bicycle got





weaker from the thousands of miles. We create new order out of the disorder. We constantly evolve.

There were still plenty of bright spots. Along the way, I met a number of locals and some other bicycle tourers, including a Taiwanese rider traveling around the world. He was experiencing some burnout from being on the road so long. We talked bike travels and life, and we camped and rode together for a little while. I helped him with some Spanish, and later when we ran into each other again many miles later in another town, he invited me to stop in at his hotel room and shower.

Onward.

Rode through Mulegé and Loreto, pretty towns. After Ciudad Insurgentes and Ciudad Constitución, two small desert towns with tasty food, there's a lengthy ride down to La Paz, the southern counterbalance to Tijuana. Beyond La Paz are the touristy Cabo San Lucas and San José del Cabo, and the sea.

From the empty desert, I arrived at La Paz a day earlier than I thought I would. Oops.

A police officer at the city entrance was surprised to see me riding in on a bike amid the vehicles. The town has a scenic *malecon*, or boardwalk, overlooking the ocean. I tried camping on the beach, but the tide seemed deadly, and anyways the soggy wet wood of the support column that I tied my bike up against collapsed.



So I went to a nearby park, locked my bike against a tree, and went to sleep. In the middle of the night, I heard some juvenile cackling and voices. I thought of getting up to dissuade them, but felt tired and just went back to sleep. In the morning, my bike was gone.

Without my bike, I spent a little while walking around La Paz by foot. I met some cool people, and explored pretty parts of town. One neighborhood had huge rows of interconnected buildings forming a close community. The sidewalks strafed right and left through the lovely canopy of greenery. Again, it felt great to have some variety from the desert, much as I love the desert. Often the best adventures and personal growth come out of challenges. We sometimes need a negative push to propel us to positive highs.

When I reported the bicycle theft to the local police, well, first of all the police building was an outrageous bureaucracy. Then they suggested that I go instead to another municipal building, where I filed a report with a different type of bureaucrat. There, they asked me a long series of questions, including some that wouldn't be asked in Gringolandia, like religion (there are some differences between the countries). Another bureaucrat wrote down descriptions of everything I said. Anyways, I got the accurate impression that I would never hear from them or see the bike again.

Ready to cross to the mainland! Without a bike, it would be time to do things differently. It would be a change of pace, a new perspective. As good as it is to focus on one way of doing



things, and improve at it, sometimes it helps to step back, and try something different.

I actually felt kind of good about the bike theft. The thieves probably needed the bicycle more than I did. Anyways I had been getting sore and bored with all the riding in the desert. And I relished the chance to walk and bus and see more of Mexico in a new way. Often, as in astronomy so in life, it's the serendipitous little advances, which happen after some kind of failing, that offer the biggest surprises and opportunities. The loss of the bike turned out really well!

### **Across the Sea of Cortez**

Instead of taking the ferry as initially planned, I decided that without my bike I could go across the sea more simply, and then explore mainland Mexico in a different way. So I crossed on a sailboat.

By foot, I went to some of the local marinas, to hitchhike on a boat. By asking around, posting a notice on a bulletin board, and then finally radioing in over the local network, I got a berth on a small yacht that was going around the world. The captain, a Vietnam vet and retired Lockheed Martin engineer, also had onboard a retired restaurateur. She (the restaurateur) found out while we were docked that her cancer test had come back negative, and we celebrated. We all go through challenges and changes in life.

We stayed at the marina for a few days while preparing for the crossing. While I was going for a run in the neighborhood around the marina, I heard somebody call out my name.



Somewhat taken by surprise, I turned around and saw a man in one of the yards, behind a fence. It was Carlos, a driver who had picked me up one time when I was hitchhiking! We had also crossed paths another time, so this was the third time we had run into each other, throughout the Baja peninsula. I started to dream of a story about a hitchhiking traveler who forms a close bond with one of his drivers.

Back onboard the boat in the marina, we crew got to know each other, and we also socialized with crew from some of the other boats. A young Spanish woman I had met in town got on a different boat, to continue on her journey, and we crossed paths a few times in the marina. On the sailboat I was on, a previous shipmate left before I embarked. Living together in such close quarters can heighten any tensions, and this makes it even more difficult to deal with challenging personality clashes as they arise. Even close relationships can suffer under such strains.

In exchange for getting a ride on the boat, I helped with various tasks including sailing, cooking and cleaning, and night watch. On night watch, my role was to stay up all night, monitoring the bobbing lights on other vessels, as we made our way through the water and the night. I got some reading done, and felt the mystery. In general, you can make your way through many kinds of adventures by giving one kind of effort or another: pedaling hard on a bike, doing labor for a vessel, working to earn money for a ticket, or pretty much any way you can imagine. Travel, around the planet or in the journey of



life, is the exchange of energy. You give yours and you get to push through the environment.

We sailed across the Sea of Cortez, also called the Gulf of California. Along the way, we went by a whale shark (which is a shark, not a whale). I dove off the boat and swam with it. It was amazing to move in the water parallel with the great beast. A school of manta rays sentineled back and forth, flying in formation like a fleet of fighter jets.

Further on, many dolphins accompanied us for long stretches. The dolphins made the crossing much more enjoyable, as they played alongside and around the boat. The beautiful creatures were very personable. This sea boasts one of the richest marine ecosystems, and feels like a little piece of heaven.

Whether traveling through complex parts of Earth's biological and cultural realms in person, or voyaging through complex stretches of space's diversity of stars and galaxies through the lens of a telescope, there is so much to discover. We know very little of what exists, which means that there's a lot left to learn. It can be scary, exhilarating, fun, and evoke the whole range of human emotions – and that's still just to start. You have to leave the comforts of home to find your desires.

Across the desert, across the sea. We made it to the Mexican mainland!

*¡Órale!*

Wow!



## **Drugs and Beaches**

Sinaloa, Mexico

December, Year One

*After crossing the Sea of Cortez, arriving on land again. Writing on water. Scary encounters. Social breakdown. New views. A space book. Riding by bus. Cybercafés. Sinaloa!*

We sailed to the mainland, our crew of three, arriving at a little port town called Altata, in the state of Sinaloa. Sinaloa is a big drug trade state, notorious home to some of the most violent traffickers in Mexico. After cruising along the coastline for a short while, we got to a point where the social situation onboard the boat had become tenuous, and I left. Thereafter, I made my way through the Mexican mainland by various means, mostly a mix of buses and other public transportation services.

The new perspective I gleaned from traveling in a different way proved very fruitful. I feel like I came out of this transitional period much stronger, with a clearer focus. I reimagined the voyage, the book, and even the worldview. Now *Astrotripping* took shape as a concept.

After I got more comfortable on the mainland with my new MO, I delved ever deeper into the heart of Mexico. And after a



while, I felt like my own heart turned Mexican, more fully than ever. I went through some of the most historically important and currently interesting regions of the country, and got to meet a lot of incredibly cool people. Starting with those Sinaloenses...

### **Sinaloenses**

Arriving at the Mexican mainland after crossing the Sea of Cortez, we anchored off the coast. A small local boat greeted us, the skipper a restaurateur on the sea. We gringos would stay on our sailboat at night, and take a little skiff out to land during the day. I wrote much of my draft of “Exotic Quest” onboard the sailboat. While anchored here, I also swam in the coastal waters.

After we got to shore, we spent a bit of time in the small town of Altata, Sinaloa. Sinaloa is a state notorious for its drug gangs, undergoing a period of intense violence. People warned me about this area, one of the most dangerous in a dangerous country. The drug trade was definitely flourishing – while in Sinaloa, I regularly got spontaneous offers for *mota* (marijuana).

My body felt compressed from all the time in a cramped space on board the boat. I decided to go for a run. Alongside the *malecon* (boardwalk), vendors sold all manner of delicious seafood. Behind the *malecon*, the place had some ramshackle houses, a few small *abarrotes* stores, and street vendors of the charcoal-grilled chicken for which the state is famous.



At one point I felt like I was running through a shantytown, with trash lining the streets and stray dogs barking madly. I ran away from where the dogs were barking, and heard a loud roaring engine charging up behind me.

My heart started to beat faster. I was far enough away from any public area that I worried about having little recourse other than whatever I could do for myself. Thoughts of drug gangs and ferocious dogs instilled some level of fear. The roaring engine caught up to me, and I took notice that it stopped instead of going by.

I turned around and saw a teenager of the Mexican desert sitting astride the motorcycle. We looked at each other for a bit. I wondered what he wanted.

He said, “Why are you scared?” I explained, in my mediocre Spanish, that I had just arrived and didn’t know much about the area beyond what I’d heard, and the dog-barking and engine-roaring had worried me.

He told me that they were good people there, and curious about me. We exchanged some more words, and then I kept running. A few moments later I heard loud footsteps coming up from behind me, and the roaring engine. Somewhat stunned, I turned around again. The motorcyclist pointed to some younger kids, who were running towards me. He said: “They want to run with you.”

So we ran. My fear and trepidation turned into exaltation and joy. Up and down the dirt roads, we ripped through the streets





of Altata. Smiling, laughing, whooping gleefully, we tore up the town. As we went by, people joined in. Kids of all ages, from teenagers down to small children riding alongside on trikes, and even dogs ran along, as we raced up and over hills, winding our way through shortcuts, zigzagging through town. Everywhere we went we brought wonder and joy, shining with smiles and laughter. It was one of the happiest times of my life.

Delving into the unknown takes courage. People often ask me if I get scared. By wild animals, drug traffickers, gangs, police, weather, and a million other disasters. And yes, I do find a lot of fearful things in my journey. Yet, it is important to manage our fear, in order to conquer our desires.

Likewise, space is a big scary place. Yet, in looking at it with open eyes and an open mind, we are able to unearth deeply beautiful new discoveries. We live in an uncertain and unsafe world, yet we have tools to explore it. Let's go forth with confidence.

We sailed on to Topolobampo ("To-to-to-to-to-lo-bampo," I sang to the tune of "La Bamba"). This charming seaport has some great hills for running, and at one point a wedding parade shut down the whole main part of town. Here, some of the budding tensions on the boat finally burst, and we parted ways.

### **New Ways on the Mainland**

I had a bag of some groceries with me, from the boat, and I was hungry. So, the first thing I did ashore was to go to a



family restaurant, and ask them if they could make something with it. They put together a tasty *caldo de verduras* (vegetable soup). I ate half and took the rest with me.

As I was sitting and digesting on the lovely patio, a man pulled up on a nice-looking bicycle, and walked into the restaurant. Thrilled with the success of the soup, I said to him in Spanish: “I’ll buy your bike.” He laughed, and told me that he couldn’t. “I’m a postman, and this bicycle belongs to the government.”

Next I decided to go to the nearest city of substantial size, Los Mochis. I walked down the street to the bus station, and bought a ticket. A lady and a child were sitting at the station, and after we spoke, I gave them the soup. Then, I got on the bus.

What a ride! Mexico has a highly developed bus system. Buses service places large and small, and will stop anywhere along the way to pick up or drop off passengers. They play great music, and vendors sell everything imaginable, and people talk to each other and have a great time. It was bittersweet to get off the bus, as I had enjoyed the ride so much.

Exiting in Los Mochis, though, it was totally worthwhile. When I first got off the bus, I was greeted with a beautiful new mass of choices. Immense, seemingly endless open-air markets filled the streets. Vast arrays of food filled the place, along with the wares of the other merchants. I ate some really delicious tacos, of *borrego tatemado* (grilled lamb). *Borrego* tacos turned out to be one of my favorite Mexican foods.



Another delicacy, which I only had there in Los Mochis, was chicharrones but made with beef instead of pork. Los Mochis is a beautiful city, most famous as one end of Mexico's last remaining train, which traverses the incredible *Barrancas del Cobre* (Copper Canyon). By the way, it's in part due to the absence of trains that buses are so popular here.

Mexico's Secretariat of Tourism runs a big publicity campaign highlighting *Pueblos Mágicos* (Magical Villages). I think they should scrap the whole program and just call all of Mexico a *País Mágico* (Magical Country).

After walking for a little while around Los Mochis, I encountered a woman, and we talked for a little while. I explained how I had been traveling by bicycle, and would now continue on foot. She seemed surprised, and told me a bit about the town and herself.

I realized that without my bicycle I could enjoy walking and busing quite a lot, although I would want to reduce my cargo load. A bicycle makes a great mule for carrying weight, even when you're not benefiting from the relative speed advantage of riding. And even with a bicycle, it can be a constant struggle to reduce your load to a minimum.

In Los Mochis, I rethought my travels and writing. I decided here to focus exclusively on the space theme, with which I was having relative success, meaning not quite as much failure. Meanwhile, without a functional laptop, I went to cybercafés to write.



I still had my broken laptop with me. After having taken it to a number of places in Baja California Sur that couldn't fix it, I took it to several more in Los Mochis that also couldn't do anything. I wound up selling it for parts in a small desert town, after hitching a ride with a teen on a quad.

Without a working laptop, I would write in those cybercafés for the next little while. Mexico has a lot of little places that let you rent a computer by the hour. In a country where not so many people have their own computers, the cybercafés do thriving business and have become welcoming community hubs.

I had tried to buy a replacement laptop in La Paz before crossing the Sea of Cortez. However, it had a malfunctioning keyboard. So I continued to look for a replacement machine to write *Astrotripping*, while going to the cybercafés. I met some great people there, one more example of how problems become opportunities.

Anyways, I got to quite like Los Mochis. Despite its relatively small size, the city seemed dynamic, endlessly fascinating, beautiful. Like many parts of Mexico, the place is very lively with public activity. In Mexico, practically everywhere has loud music, live or recorded. Live bands go house to house, and play in public areas. Storefronts have huge speakers, including even pharmacies and accountants and everywhere. Life is a big fiesta. An average day in an average city in Mexico is like a huge party in a huge city in America. ¡Mi tierra!



¡Órale!

### **Soaking up the Fun**

One day, I found a town square there in Los Mochis. I sat down to read. A book on artificial life that I had found in a sharing library in a marina in La Paz. After a little while, some people in an assortment of clown suits and related attire started assembling. A parade was getting ready to march. One clown came and talked to me. He told me about his past problems including drug abuse, and how he had found redemption in Christ.

A few more people came by and we talked. As it started to get dark out, a man came and sat next to me, a retired school teacher, and asked me about the notes I was taking. We talked a bit about my travels, and he invited me to stay at his place. A bit later, a friend of his came by, a retired gas station attendant. We decided that it would make more sense for me to stay with the latter.

Walking through the streets of Los Mochis, we stopped by a beer store. We picked up some *chelas*, and greeted the *gasolinero's* friends. He showed me back to his place, where I had a shower and then we ate. With the older man sitting and smoking aromatic cigarettes and sipping on beer, and the grainy radio playing, I felt transported to a different spacetime. Later, he started asking repeatedly that I pull down my shorts, if I understood his Spanish. You don't always get what you want.



Los Mochis has a number of beautiful parks: both small city parks where local communities gather, and larger areas with huge trees and other amenities serving a wider region. At one of the latter, with a cool set of outdoor gym equipment, I got in some good exercise. Later, I went camping in the park. I met some friendly people in that park, and had a chance to do some bigger-picture planning, dreaming. Between bouts of action and adventure, I believe that it's important to have downtimes to read, think, relax, enjoy life. These periods heal and strengthen you for the next round. Like iterations between theory and observation in astronomy. Or fallow fields for farms.

After some time, I decided to skip the *Barrancas del Cobre* (Copper Canyon), the famously lovely train route inland that many people recommend, and instead make my way directly down the coast. Then, I would cut in towards Mexico City, getting a chance to see some critical central parts of the country while getting more writing done. I really deeply wanted to see the southeastern jungly side of Mexico, and Mayan ruins, and more glory, including the states of Chiapas, Oaxaca, and Yucatán. Better to save it for next time.

A big Christmas parade went by that same park. I had previously seen trucks driving by with banners advertising the parade for some time. "*Jesus es Buena Onda*" ("Jesus is Cool", literally "Jesus is on a good wavelength"). Christianity is really big in Mexico. I spent more time in Los Mochis, going to a Christmas Village. They had an artificial snow mound, with kids sliding down, and an artificial ice rink. I



found it funny to watch Mexicans skating, and wondered where they got the ice skates, which they presumably only used once a year. Also, I found it funny to see the Christmas snow pile sitting in front of palm trees and the blazing sun. So much better to be down south in winter! Anyways, I had a wonderful time meeting many people. You can find good company while traveling, so it doesn't have to be isolating to be away from your old home.

Los Mochis has many good food vendors, including *tortillerias*, and eating fresh hot flour tortillas in the sun with all the natural beauty all around, I realized why in Mexico not all streets have signs and not all places have clocks. It doesn't really matter what time it is or where you are, because you're having fun! Figuring out exactly where and when you're at only helps when you're trying to do something else or get away.

I love Mexico. I love the freedom. I love the happiness. I love the food and the music and the colors. I love the feeling of life. With all that energy coming in from the sun, the country bursts with festive activity year-round. The economy has not developed along the same lines as in colder countries – because the ecology already provides such a bounty of wonder. Why bother exerting yourself technically to produce market value when you're already immersed in fulfilling biocultural value?

Each country has its unique pros and cons, as does each city or town or human. Mexico is one of the most fortunate, in my



opinion, sitting in a location to fill its people with sensory and social warmth. Worth visiting, worth living.

I love Mexico!

### **Norteños**

Carrying on from Los Mochis, I took a series of buses, stopping in several small towns. I loved the places: Guasave, Guamúchil, and more. Each town had its own unique quirks. Overall, the people were gregarious, the food delicious, the views astounding. Lots of *taquerias* offered *birria* (a red stew), made with goat or other meats.

In one of the towns, while enjoying the parks and walking through the old streets, I came across a *fruteria* (fruit store), with people talking outside. I was going to pick up a few items. One man had a large watermelon, which he was cutting up. It had fallen to the ground and got smashed, and he was offering free chunks. I ate some and talked with the family of owners, who asked about my travels, and they gave me some more fresh fruits for the road.

People are often extra friendly towards visitors, and visiting a foreign culture gives you a chance to practice humility. You get to experience another lifestyle, which requires putting aside many of your background beliefs and habits. It can feel uncomfortable, especially for some people, to sacrifice your usual way of doing things in order to get along, yet it offers great rewards in terms of learning different and sometimes preferable outlooks on life.





While I was trying to get to the bus station, it started to rain heavily. I kept walking. Deking through the streets, water pouring down. Huddling under the shop overhangs, I wrapped up my few remaining belongings and myself, as well as possible, and hurried to the station. After stepping into a puddle and getting completely soaking wet in the downpour, I gave up on staying dry, and just soaked up the fun.

Got on the bus to Culiacán. I got out and didn't know the city. Not knowing my way or having any electronic devices or maps, just semi-randomly found my way.

Culiacán is considered *norteño* (northern), part of the country heartland, home of *banda* music, which I loooooooooooooove. Culiacán is also home of some of the most infamous and deadly *narcotraficantes* (drug dealers). This place is fiercely proud.

I found a little park, drank some water from a questionable tap, and where the water made contact with my throat I later felt swollen and gross. I found a grassy area, and was going to camp, but it seemed someone homeless lived there. (By the way, there seem to be few homeless people in Mexico. Despite the relative poverty, the country seems to provide greater social services.) Walked a bit farther, found a bigger park, with a view including a body of water and a big bridge. As lightning and rain came crashing down, I set up my tent and went to sleep, police sirens wailing constantly along the nearby road.

I woke up the next morning, which was a good start.



I walked around the city a bit, exploring. Culiacán has a long river flowing through it, which was that body of water I had slept by. Along one side of the river lies the commercial center of town, with somewhat American-style shopping. The city is home to the Coppel department store chain, which brings an American shopping experience to Mexico. Culiacán in general has a more conservative feel, somewhat like Texas.

Along the other side of the river, I crossed into an older part of town. The rough cobblestone streets led through charmingly beautiful neighborhoods. Families lived here, ranging from children through aged faces that bore the history of the place.

I stopped in at an *abarrotes* place, and picked up some familiar and some new foods. I sat on a doorstep across the street, eating in the sun. The shopkeepers had seen me from inside the corner store, and brought out a big cup of *agua fresca*, the sweet flavorful water that refreshes on hot days. It felt lovely, warm and welcoming.

In between the two sides of the river, a chain of long narrow islands stretches. Bridges connect the islands with the two sides, making it into a kind of independent third option, a new intermediate ecosystem, where people gather for entertainment. In general it's easy for us to see two polar opposites, while neglecting the middle ground. For example, at the border between Mexico and the USA, straddling both sides, a cultural bridge metaphorically links the communities into a kind of island chain. Some biological species link



together two other populations on opposite sides. It's part of the continuum of life.

That night in Culiacán, I found a beautiful place to camp at the end of one of those islands. From a distance, I could see a water fountain, with jets of water shooting up with rainbow-colored lights, in sync with music. Later, I would see the same concept in a popular spot on the Strip in Vegas. Good ideas travel well.

Along the riverbanks, I dried out my sleeping bag under the sun. A police officer asked me if I was sleeping there. No, Sir.

I finished that book I had found at the sharing library in the La Paz marina, a book about artificial life, and I left it back at that first small park I had found, for someone else to pick up. If you're interested in the topic, I started a synthetic life project, LifeFLOW ([worldsowisdom.com/life/](http://worldsowisdom.com/life/)).

Also along the river, people were dancing, playing card games, walking a pig, eating hot dogs, admiring nature, and falling in love. Like anywhere, I think, that river serves as a microcosm for life in the cosmos. There are some gorgeous views, and some gruesome too. There's also a lot of variety. And you can make of it almost anything you want, if you have the vision and take action. Much of life is about attitude.

From Culiacán I would go to Mazatlán. There's a funny *banda* song contrasting the different lifestyles of the two Sinaloan cities: Mazatlán is all chic and Culiacán is a drug haven.



Mazatlán would now be a good change of pace. In fact, on the way out of town, that view was confirmed.

I decided to hitchhike from Culiacán to Mazatlán, so I walked to the side of town facing my next destination. At a gas station along the way, a couple of youngsters sat selling homemade wine outside, and gave me some local guidance. As I got to the outskirts, around where an intercity bus station was located, I held out my thumb for a while. I didn't get any rides, and it was getting dark.

So I asked someone nearby about the bus. One going in my direction was coming by. In Mexico you can just get on or off a bus at any point, you don't actually have to go into the station and buy a ticket and wait in line. So I paid and got on the bus, and walked to the back. I went into the onboard washroom.

When I came out, people were looking at me. What was up? I was asked to get off the bus. After all that camping without a shower, I had begun to acquire an odor, which bothered some of the other passengers. Oops!

That night I camped out near the bus station. I thought I would clean up and try again *mañana*. As I was walking the next morning, a car pulled up to me.

“What are you doing here?” A man and his wife spoke with me in Spanish.

I told them a bit about my travels.



“You shouldn’t be here,” he said. “This is a dangerous place. You should go to Mazatlán, it’s more suitable for you. Here’s some money to get a bus ticket and a *torta* (sandwich). They make really good *tortas* in that place over there. But don’t stay here any longer, it’s very dangerous.”

The *torta* place was closed, but I finally got a bus to Mazatlán.

Back to the beach!

## **Mazatlán**

Ah, Mazatlán!

This is where we were originally going to sail with that boat out of La Paz, and it still struck me as a good destination. Mazatlán has a reputation as a visitor magnet, which it deserves.

The gem of a city is on the coast, and gains many of the benefits of a beautiful seaside location. It attracts large numbers of tourists, both from Mexico and from abroad. It has lots of fresh seafood. It has plenty of charming quirks, from the city planning that stretches up a rock jutting out into the sea, to the public transportation. In the 1960s, a local started building golf cart-style *Pulmonias* out of old car parts, which function as unique taxis.

The bus station, where I arrived, is quite a ways outside of the main area of town. I went to a little hole-in-the-wall restaurant across the street, and got some burritos. At this point I could probably roll a better burrito than most professionals, on either



side of the border. Then I took the long walk into town, soaking up the sun. It felt fantastic, after all that rain. I had arrived.

Walking around town, I went through beautiful open-air markets. People strolled through the streets, stopping at stalls. A portly cop stopped me and asked to see my papers. His more attractive female cop partner seemed more laid-back. I guess that as a bicycle traveler I looked out of place in this more touristic area. I explored more of Mazatlán.

Later, I found a cool place to camp out on the beach, right towards the end of a stretch of sand underneath the *malecon*, the boardwalk which had a lengthy row of market stalls. Many people would walk by on the lovely boardwalk, some seeing me and stopping to chat. Mexicans are so friendly, they are very warm and happy and generally outgoing in greeting people.

The coastal city has lots of seafood. In the open-air markets, they sell shrimp and coconuts and other deliciosity. Eating a coconut under the sun is one of life's great pleasures, if you ask me. However, the one I had in Mazatlán from a surly salesman was actually less tasty than one in Tijuana, where a group of jovial vendors provided a *blando* or *suave* (soft) coconut with plentiful coconut water.

While I was walking close to the central area of the Mazatlán but a little off the beaten path, I encountered a seafood *puesto* (stand) geared more toward the locals rather than the tourists. Some customers were sitting around eating a meal of oysters



and huge scallops and more. I inquired about the price. It was well out of my range. An older gentleman there let me try some of it, and I have never eaten seafood that rich and enormous.

At that point I'd been struggling financially, with some magazine story arrangements falling through, and after the losses of the bicycle and electronics. It's really tough to make a living writing while traveling. So please buy copies of *Astrotripping* for all of your friends and family and enemies and everyone!

In writing and riding, you have a lot of the same pressures as with any job, however you have less time and stability and support to deal with them, and you *also* have to deal with the unpredictable rigors of publishing and adventure. In particular, writing is difficult, dealing with a large and mature industry in an artistic area. Still, it can produce valuable insights, and life-changing experiences. I think that if you have a very strong passion, it's worth significant cost to pursue it. On the other hand, you could instead pursue a more reliable career and just engage in your passions as a hobby.

Exploring further, I went to a town square. A younger girl bought me a local treat! Another time, when I was on a cobblestone street way up on top of the city, I crossed paths with another group of girls and they gave me some treats. Mazatlán seems full of generous girls!

Around the same elevated part of town, at a big book store in an old stone building, I stopped to look at the posters on the



wall. Another younger girl was there, looking at a poster for a writing contest. We talked for a little while – it was exhilarating to have a fairly fluent conversation in Spanish finally. She was a student, who lived in Mazatlán, and later went to Mexico City to continue her studies. We were both interested in writing. However far you travel, you will find elements of the familiar, with which to relate.

A way cool place along the Mazatlán boardwalk was an exercise area. It had a bunch of gym equipment, including a really tall rope that I climbed up. My favorite part, though, was a series of vertical ropes, hanging in a line leading from the boardwalk out to the ocean. I climbed up on the high platform, and grabbed the first rope. Then, stretching further than I was sure I could, I swung from rope to rope, Tarzan-like, out to the ocean. It felt so exhilarating to fly through the air towards the water. Then, at the last rope, I held on until it swung me back towards the boardwalk. Reversing course, I swung from rope to rope until I landed back upon the original platform. Oh my goodness.

That was one of the most free, fun feelings in my life. The feeling of flying, moving more fluidly through air with the help of ropes or a bicycle or wings, or a telescope or imagination, releases a lot of the physiological and psychological pressures of being constrained to walk on the ground. Our technology and techniques free us, to fly out into the wild beyond. Big telescopes do the same for our minds that bicycles or ropes do for our bodies, by enhancing our eyes and letting us fly through the great vast depths of space on a





journey of intellectual discovery. This is the basic metaphor for life: travel.

I explored more of town, meeting and eating. Really lovely place, Mazatlán. Much nicer than Culiacán, jajaja! Meanwhile I finished another book that I'd found at the marina library, some old nineteen eighties science fiction, and left it at the outdoor gym. By the way, Little Free Library is a concept that assembles a few books for people to read, it's worth doing.

One day, after camping on the beach, I heard some music. A large family hired a *banda* group to play live music, as the family danced on the beach. One cover song, which I also heard a recording of blasted from a nearby Pemex gas station, was a silly catchy song called "*El Mechon*" ("The Lock" [of hair]). There people laugh and play on the beach, making it more of a lively party scene than just a place to relax.

Anyways, after recharging in Mazatlán, I was roughly ready to charge forth into the heart of the country. I would first carry on down the Pacific coast of mainland Mexico, about which I still knew little. At some point, the exact place to be decided later upon learning more, I would curve inland, towards the big important cities. I went back to the bus station, and got a ticket for the next state south, Nayarit. It would be the beginning of a new adventure.

*¡Ándale!*

Let's go!



## **Into the Heart**

January, Year One

Interior of Mexico

*Into the central core of the country. Avocados and tortillas. Through the big famous historical cities. Missing avocados. Finding even more joy. Lovely times.*

From Sinaloa, I was ready to continue deeper, into the heart of Mexico. In spite of all the troubles in my travels, I had found ways not only to survive, but to fly!

Somewhat ignorant of the geography of the country, I decided on an approximate route down the coast just a bit farther, then at some point to go inland towards the big central cities of Guadalajara and Mexico City.

I wound up getting to Guadalajara surprisingly quickly. Then, I spent a fast yet fulfilling period in the state of Michoacán. There, I ate a lot of ripe avocados. Afterwards, I made a hasty jump over to the capital, Mexico City.

### **Old Mexico**

After the surprising challenges and pleasures of Sinaloa, I looked forward to discovering a new state. At this point, the map of Mexico was basically a blur to me, consisting of the



mainland blob and the finger of the Baja peninsula. I would learn as I made my way down the coast. The coast seemed like a good starting point, as coastal areas tend to draw interesting crowds. And the route planning is easier.

The bus I rode on went all the way to Guadalajara, the big old city in Jalisco, with a stop in the intermediate state of Nayarit, the destination for which I held a ticket. On the bus to Tepic, the main city in Nayarit, I fell back into the plush, comfy seat.

Mexico's advanced bus system is Janus-faced. You could get to go on either a rowdy rollicking party bus, or a rich and luxurious ride. This upscale bus had plentiful space and an embracing ambiance. It also had vendors getting on and off at stops, including one pit stop at a very cool convenience center that sold all manner of goodies under bright neon lights, feeling like some alien planet, especially in my state of fatigue.

Onboard, the bus screens played a bunch of movies, one after another, which were quite entertaining. A classic of Mexican cinema featured a female maid-turned-wrestler, who concludes: "Mejor ser campanera que campeona." (Better to be a countrywoman than a champion.) Also, we watched an overdubbed Australian movie, *Red Dog*, the adventures of a traveling dog who winds up finding a suitable companion in Red Cat.

When the bus pulled in at Tepic, Nayarit, at night, I was half-asleep, and in no mood to get out. Also, *Red Dog* was getting really interesting. I looked out the window, and saw what looked like an OK college town but fairly similar to what I'd



already seen, and just let myself drift off back to sleep. Guadalajara, here we come!

### **A Gay Old Time in Guadalajara**

Guad turned out to be a gay old time. My first night in town, I got hit on before I even found a place to stay. The guy, a young makeup professional, offered to get me a hotel room. I felt hot! I declined the offer, although we bumped into each other again later that night. Reiterating his offer but this time in a more amicable instead of romantic manner, we went to a hotel. After the first one was full, he took me to another, and talked to the counter girl. She pulled some strings, we got a room, hung out and had pizza and soda, before he left. It was the first time I'd slept in the comfort of a bed in ages, after so much camping.

Throughout my stay in GDL, I stayed with a few Couchsurfing hosts. Pretty much the whole town was gay. Went out clubbing, which was *great*. Many if not most of the people I met complained about how conservative the city was, which surprised me. The place did have a ton of really old traditional cathedrals. I found out that the city has a huge conservative side, so it's about half gay and half conservative. Jajaj!

Guadalajara stretches out quite far geographically, encompassing many different and exquisitely beautiful neighborhoods. From on top of an apartment building where I stayed, my host and I looked out and could see all around us the whole city, panoramically. Visible religious buildings, including traditional church steeples as well as unconventional



groups that my host described as cults, dot the landscape. The central part of town has huge long rows of stone walkways, with cathedrals, history seeping out of its veins. It also has shops, restaurants, *taquerias*, and lots more cultural artifacts. This area of the country, I learned, represents much of what outsiders know about and associate with Mexico, including tequila and mariachis.

At *Mercado Libertad* (Liberty Market), a large public market with multiple floors each stretching on seemingly forever, an adjacent square was the birthplace of *mariachi*. Inside the market, vendors sell food and clothing and other items. The city is famous for its *tortas*, especially *tortas ahogadas* (drowned sandwiches), soaking in hot red chile sauce. The markets also served many other specialties, including *birria*, and fruits including a lot of varieties I never even knew existed. And tequila comes from its nearby namesake, a town also in the state of Jalisco.

At least Guadalajara was in some ways affordable. In the Baja California desert, they shipped all their fruits and everything up all the way around from the mainland, making it even more expensive than the US at times. By contrast, in GDL you could sometimes find tacos for like ten cents apiece.

At one of the places I surfed, my host and a few other people and I got high, and we watched cartoons. I said, half-wittingly, “*estoy regañado*” (“I’m messed up”). We also went out exploring... dancing and eating and making merry!



A lot of people in Guadalajara speak fluent English. To the point that I would start speaking in Spanish to practice, and they'd just answer in English. Also, a lot of the modern crowd in the city have American-style money from American-style design jobs, and spend it at American-style shops and restaurants. I got the impression, anyways, that part of Guadalajara was kind of like Gringolandia. I could easily imagine myself being somewhere in America – even more so than in some heavily Mexican towns in the US itself. Is home a place, or a way of being? Does the person make the place or does the place make the person?

In a very Americanized neighborhood, I ran into a couple of young Australian girls, who were studying abroad. We went to the supermarket. Across the street was another shop, an old government grocery store. The prices and selection at the latter were outrageously poor.

Guadalajara is a big and exciting city. The *Tapatíos* (Guadalajarrians) who live there are generally very friendly, in keeping with the national character, and the city is extremely scenic. I would have enjoyed spending more time there, and I highly recommend visiting. Anyways, at this point I was actually a bit pressed for time, as I wanted to get to Mexico City in time to do interviews for “New Gravity,” and I still also wanted to see a lot of the in-between areas. In particular, I had a possibly irrational desire to see Uruapan, Michoacán.

*¡Rocanrol!* ☺



### **Uruapan Avocados, Michoacán Militias**

Uruapan is a tranquil city in the state of Michoacán. It is known, within Mexico and internationally, as an avocado-growing area. In fact, Uruapan and the surrounding areas produce the vast majority of the world's avocados. The avocados grow abundantly in quality and quantity, and are actually affordable. I joked with some Mexican friends that back in Gringolandia, you had to buy avocados on layaway.

My passion for avocados goes back at least as far as California, and probably before. When I got to Goleta, near Santa Barbara in Southern California, I got to see my first live avocado tree. Then, in Los Angeles, I stayed at a house where I actually had an avocado tree growing up to the window where I slept, which I could even reach out and touch. In San Diego I went so far as to try doing seasonal work picking avocados, however I never made this dream a reality.

When I told people that I planned to go to Mexico City through Michoacán, they warned me about Michoacán. Even many Mexicans warned me about the dangers of the place, pointing out that militias had set up checkpoints, sometimes fronting as police. The state is another drug trafficking hot spot, and has seen its share of violence. Still: avocados.

Meanwhile, I had occasionally noted a *taqueria* or other establishment throughout my time in Mexico, invoking the name of Uruapan in the title. From all this, I built up the mythology of Uruapan, and had even tried to visit the fair city. In fact, at one point I came extremely close, and almost made



it into Uruapan, before canceling. I later found out that it was a different Uruapan in a different state. The dream was still alive.

So I got on the bus from Guadalajara. On the municipal bus on the way to the intercity bus station on the outskirts of town, I had a few fun conversations with fellow passengers, stretching across vast topic ranges – I love travel conversations! When you’re thrust together for a brief time, you often delve far more deeply. We cruised through the glorious city, and I got off at the imposing bus terminal. Then, I took a bus into Michoacán.

### **La Linda Michoacán**

From the state of Jalisco, I would travel to Mexico City. The intervening state, Michoacán, has immense natural beauty. However there were whole regions of the state controlled by drug gangs, with their roadblocks. But I determined to go, in particular to Uruapan, avocado capital of the world.

Due to upcoming interviews for “New Gravity,” I had a very short time in the state. In the few days of transit, I tried to get the most out of Michoacán. I especially enjoyed Morelia, the historically important state capital, where I would’ve loved to stay longer. Sadly, I still didn’t get to Uruapan. One day.

Getting into the state, I arrived in Morelia. On my first day in Michoacán, I found myself in a neighborhood focused around the bus station. I got off the bus, at night, in a place with a fearsome reputation, and decided to urban camp!





I woke up the next morning, which was a good start.

Walking around a bit, I saw a long line of *puestos*, vendor booths. I started to walk down the street, figuring I'd have a quick stroll before busing into the center of town. I walked, and walked, and walked. The street market seemed to go on forever.

At the open-air market, I ate many foods. A lady had a big metal tray of *moronga* (blood), which she made into a tasty taco. Among all the fruit and vegetable vendors, I loaded up on huge numbers of avocados, and all kinds of produce. Bags and bags of beautiful stuff, and affordable too. I also picked up some fresh corn tortillas made on a *comal* (a traditional griddle), which were hot and flavorful and soft, in the golden sunshine. Oh. My. Goodness.

After practically exploding from deliciousness, I headed to a cybercafé. In the brilliant sunshine, the twisty streets, the crowds of happy people, I wanted even more than ever before to live in Mexico. A crowd of young girls came in to the cybercafé, all giggly. I connected with a Couchsurfing host, and then had the challenge of getting there.

The sun is a star that fuels life here on Earth, and therefore plays an important role in this story.

Walking back out into brilliant sunshine, I looked around. The twisty, hilly streets held no indication of which way to go. The neighborhoods had a confusing layout, with lots of



iconoclastic districts. Instead of buses running simple routes, there were the *combis*.

The city of Morelia, Michoacán, is serviced by a network of minibuses called “combis,” basically converted vans, which run on idiosyncratic routes. My host had given me some directions and recommended a taxi, not really expecting me to find the place. I decided to go on the minibus system instead. After a few missteps, including getting on one wrong *combi*, I found myself on what I believed to be the right route. The wild ride went through many beautiful neighborhoods, and with the assistance of local passengers I got off at a stop that seemed right.

A little kid was trying to get into a building, and I helped by ringing the bell that the kid couldn’t reach. Right next door, my host was looking out, as surprised as I was that I got there.

Then, we and a group of the host’s friends had a great time exploring all the historical landmarks, and messing around. The sun shone brightly.

### **Historical Adventures**

Morelia is where the history of Mexico was crafted. Revolutionaries with local ties threw off the shackles of European oppression, and formed a new hybrid identity, blending their Spanish and Native and American influences into the wonderful country of Mexico that we know and love today. I sometimes imagined the founders of the country assembling the necessary resources: a constitution, an anthem, a militia, fifty million corn tortillas...



Wandering through the historical city streets, full of intricately beautiful architecture, we youngsters passed under the hundreds of arches lining park-swept neighborhoods, into a small “lover’s lane.” The charming alley had inscriptions on the walls, which I read aloud in my now all right Spanish, impressing the Morelians. Here, we posed for photos, before heading into the classical halls of learning where we goofed off some more.

Michoacán has a major sweet tooth. Some of the famous local specialties include *paletas*, a kind of ice cream sticks, which are also widely sold throughout Mexico and in Mexican neighborhoods abroad. I commented to my Morelian friends that seemingly every town and city in Mexico has a *paletería* called “La Michoacána,” or “La Monarca,” or “La Monarca de Michoacán.” (The monarch butterfly is a symbol of the state.) They were surprised and delighted, like the licker of a *paleta*.

We also went out for tacos – especially *pastor* tacos, roast pork on a spit – and we made some Mexican food at home. I again surprised my hosts, this time by making some quesadillas that passed muster for authenticity. I love Mexican food, it’s one of the most unique and important culinary traditions, a national heritage.

People eat well here. The small corner store had fresh bread – a legacy of the French colonization of Mexico is ubiquitous delicious rolls. They also sold cheese, vegetables, and all the makings for a pleasant meal. At a little outdoors eatery next door, a musician came by and serenaded listeners. I wanted to



spend considerably more time in Morelia, but felt the pressure to get to Mexico City.

One more way that I may have surprised the people I met in Morelia was with my knowledge of Mexican history, which I half-jokingly mentioned having picked up from navigating city streets. Practically every Mexican city has streets named after the heroes of the revolution, and the famous dates and events. Miguel Hidalgo, Benito Juarez, Niños Héroes, 20 de noviembre, y más. And in Morelia, I got to see many of the landmarks where these national icons gave birth to Mexico.

On my last day in town, I went for a run around Morelia. Flying through the sunlit streets, blazing a path of joyful gratitude for how fortunate I felt to visit. I had a delightful time, and it was really bittersweet again to leave. So many places in Mexico grabbed my heart, and made me want to stay. However, with time running tight and a new gravity coming, my very kind and considerate hosts helped me get back to the bus station, where I hopped on a bus to Mexico City.

Time for adventure!



## **New Gravity**

Institute of Astronomy, Mexico City, Federal District, Mexico

January, Year One

*At the elite Institute of Astronomy, theoretical astrophysics research finds that gravity may need its first major overhaul since Newton and Einstein. This goes to the heart of the universe – and everything we know.*

Gravity. The most important, yet least well understood, fundamental force in the universe. Determining the primary shapes and orbits throughout the universe, gravity plays a key role in astronomy. This cosmic glue creates the planets, the stars, the galaxies, and the metagalactic clusters. And it turns out we may have it wrong.

The signs of demise come from massive astronomical observations. Looking around the universe for astrophysical systems whose behavior divides the evidence between the existing theory of gravity – general relativity – versus a new explanation, case after case reveals observations that match a new theory.

In distant realms, where objects fall into extreme behaviors, celestial systems do not follow existing theory. Traditionally, speculations such as mysterious dark entities have filled in the



gaps. Now, a group of researchers in Mexico City believe that enough astronomical evidence has mounted to contradict conventional explanations, and open new possibilities.

### **Newton and Einstein Were Wrong**

One of the most important concepts in the 21<sup>st</sup> century may be our physical theory of gravity. Since Isaac Newton came up with a universal theory of gravity, Albert Einstein updated it with general relativity, to account for how matter and energy interact with space and time. Notions of gravity remain essentially unchanged since then. It turns out that universal gravity may not be so universal, nor general relativity so general.

When astronomers see the amount of matter in large systems such as galaxies, they can calculate the expected motions according to existing gravitational theory, and see that the predictions are wrong. So far, the standard hypothesis for this discrepancy is that some mysterious elements – so-called dark matter and dark energy – exert gravitational force, but somehow don't interact electromagnetically. So we don't see them.

Yet, after many years of expensive efforts, we still have no empirical evidence for the existence of dark entities. Researchers with access to new data from modern astronomical devices conclude that the reason is simple: gravity does not behave according to conventional theory.

Now we have new evidence that fits with modifying gravitational theory, but not with dark entities, according to



Xavier Hernandez (Institute of Astronomy). Only institutional inertia retains the old theory, he says. “Dark matter is too big to fail.”

The revelation calls for a new theory of gravity. Such a subtle idea should thoroughly explain phenomena across a broad variety of scales. From metagalaxies spanning millions of parsecs, down to extremely tiny subatomic particles, a new theory will succeed where even general relativity falls short.

Sergio Mendoza (Institute of Astronomy), who collaborates with Hernandez, believes that dark matter could still explain shortcomings in general relativity – if they were small. “Things are quite coherent when you do that. But, the modern idea that we have about dark entities, these are not small corrections, these are major corrections to the theory.”

### **From England to Mexico**

Mendoza traces the dispute over the nature of gravity farther back than modern astrophysics – all the way back to Newton, and his contemporary René Descartes. “Descartes had an idea that the whole cosmos was filled with an obscure fluid, which was in the whole cosmos to support planets not to fall. Planets stayed in orbits because of the vorticity of the occult fluid. Those vortices made planets rotate and retain stable orbits, that’s how gravity worked. So dark entities were postulated much longer ago. Three hundred years.”

According to Mendoza, because of the Catholic Church’s influence, which went as far as faking experiments, occult fluids languished in continental Europe long after England



went looking for more scientific answers. In the face of uncertainty, some seekers look for succor. “Whenever you don’t have an explanation, people think it’s good to have a mysterious entity to explain it.”

Much of the success of astrophysics comes instead from finding deeper explanations. “Newton worked against all that. Nature had a mathematical meaning, and you could explain things using forces, rather than obscure or occult entities.”

In the seventeen hundreds, an astrophysicist in Mexico, Andrés Guevara y Basoazábal, continued with Newton’s investigations into logical rather than obscure explanations of gravity. An early heliocentric proponent, he studied to become a Jesuit priest. Then, with other Jesuits, he got expelled from New Spain to Italy. Afraid of religious punishment, this thinker refrained from publishing his popular astronomy writing, and instead sent his book back to Guanajuato, Mexico, where a librarian hid it.

In the 1980s, the rediscovery and publication of *Pasatiempos de Cosmología* (Cosmology Pastimes) caused a stir. The playful yet philosophical book takes a look at the world from humanity and Earth all the way out to the center of the universe. Mendoza pulls out a copy, with handwritten and typeset copies side by side. “It’s always society trying to oppress new ideas and not let them flow.”

### **Astrophysical Evidence**

From England to Mexico, astrophysicists have vied with questions of mysterious entities versus parsimonious forces.





Mexico City, one of the world's most populous cities, offers a dizzying array of possibilities in its complex web of life. The Institute of Astronomy sits at the famous national university. Riding on the crowded Mexico City subway while discussing theoretical astrophysics and general relativity with Hernandez, a leading expert in the field, offers a challenge for the prefrontal cortex.

Ever since the first early clues came in, that something was amiss, the theoreticians have found a pile of evidence in the stars. It started with the galaxy rotation curves. Each galaxy rotates at its own rate, which depends on its contents. According to conventional gravity, stars more distant from the galactic center should rotate much more slowly than stars nearer the center. They don't. The observations disagree with the math.

The astrophysical evidence could point to either invisible dark matter, or a flaw in the theory of gravity. Hernandez, who points out that he has never even set foot in an observatory, wanted to find the simplest possible test case, to distinguish between the two options. So, two stars, a "wide binary" system, publicly available data, proved just the thing.

As a pair of stars rotates around its combined center of mass, we can compare the observed rotation rate with expectations. And it turns out that gravity acts according to a new theory, rather than existing theory. This case is so simple that it doesn't even allow for alternative explanations such as dark matter. Incidentally, the same scenario, binary stars, that now



violates classical gravity, first proved the very same law of gravity within its limited context of validity.

Chris Allen (Institute of Astronomy) has evaluated much of the observational evidence bearing on extended gravity. She says: “I have looked at many stars, from the SLOAN survey, and other less broad, more detailed surveys.” After looking at a variety of types of astronomical data, she agrees that the stars don’t act in accordance with conventional gravity. “Much to my surprise, they tended to behave as modified gravity predicts.”

More examples came pouring in. All cases so far support a new theory, and not standard gravity.

Globular clusters, which group several thousand stars on the outskirts of galaxies, agree with the new theory, not with dark matter, says Hernandez. “There, you’d need a hollowed-out dark matter halo which is dynamically unstable, and makes absolutely no sense.” The Bullet Cluster, historically the textbook case in favor of dark matter, has two galaxies colliding into each other and producing a shock wave – which, it now turns out, wouldn’t even be statistically possible under conventional gravitational theory.

“The need for dark matter disappears like aether,” says Hernandez, alluding to the long-dispelled hypothesis that the universe is full of an invisible substance. Other obsolete scientific metaphors pop up, like epicycles, the speculative cycles-around-cycles to explain shortcomings in archaic circular cosmologies. Hernandez, who first came into the



research looking for dark matter, now criticizes the idea as a “completely *ad hoc* hypothesis,” often falsely presented as proven, “perverting the course of research.”

Alejandra Jiménez (Institute of Astronomy), points out the relevance of novel astrophysical evidence. “This decade, new evidence came to light through observations made possible by today’s impressive telescopes.” And in all of the above cases where the evidence sides with a new theory of gravity, the key occurrence happens after crossing the exact same threshold.

When distances among celestial objects become long enough, when mass becomes small enough – in short, when space becomes sparse enough – gravity appears to act with more force than we thought it should. All systems above the threshold of acceleration act according to conventional laws, and all systems below the threshold of acceleration act according to modified physics. It seems like the team have found a fundamental behavior of nature.

### **Pieces of the Puzzle**

When the theoreticians investigated further, it was amazing how the pieces fit together. Subtle harmonies kept resonating. A new, “extended” theory of gravity makes all kinds of seemingly disparate behaviors in the universe understandable, in the context of modern astrophysics.

Hernandez asked himself: “What force law do I need, to explain the rotation curves of galaxies without dark matter? I was extremely impressed, you need exactly and precisely the square root of the Newtonian solar system force law. Then I



started thinking, what if there is a more complicated underlying general theory, and it's only the fact that we're looking at small ranges of parameter space that hides it?"

The leveling out of the gravitational force beyond a certain threshold of mass and length, which is the critical feature of extended gravity, lines up extremely well with the way that galaxies actually rotate. The acceleration threshold, called Milgrom's constant after an antecedent astrophysical researcher, may reflect a basic fact about the nature of space and time.

Below that specific acceleration, gravity appears to exert force according to a different rule. At around a billionth of the gravitational acceleration that we feel on Earth's surface, this effect only becomes apparent at extreme scales. Thus, astronomical systems make great case studies.

Moreover, when the researchers stretched out the idea and calculated what other phenomena it would predict, they found several astonishing outcomes. Deep connections consistent with current observations kept popping out of the equations. The theory holds an elegant beauty far beyond competing explanations.

The astronomer Johannes Kepler first described orbital properties. Kepler's laws of planetary motion connect mathematically with Newton's laws of gravity. Likewise, the so-called Tully-Fisher law, which explains galactic rotation curves, connects mathematically with the extended theory of gravity. Beyond the new gravitational theory's threshold, a



different force law takes over, which yields a galactic rotational velocity no longer dependent on distance. The previously mysterious flat rotation curves develop naturally out of the theory!

In another elegant twist, the new theory supplies just the appropriate complexity to explain the evolution of the early universe. Previously, this mystery tore apart astrophysical theory, requiring all sorts of improvisational suppositions to describe the formation of cosmic structure. Now, the universe arises from simple math.

Mendoza found the modified theory much more effective. “Curiously enough, the first proposal I did in order to construct a relativistic theory of gravity in this modified regime, when I applied it to cosmology, it was the first very little step, but it could reproduce the accelerated expansion of the universe that we are seeing nowadays. Without introducing dark matter, and also dark energy.”

The Mexican researchers’ extension to gravity complements the first “extension” coming from relativity, when Einstein supplanted Newton. Hernandez started working with Mendoza, who had independently begun investigating gravity without dark matter but from a relativistic perspective.

Taking the two constraints of the extended theory – the extremely low acceleration threshold, and the existing extremely high relativistic velocity – as orthogonal axes, the four different resulting options now explain observational gravity. How force acts depends on scale, filling the four



quadrants: classical gravity, general relativity, modified classical gravity, and modified general relativity.

Those two gravitational constraints can also divide astronomical objects into four categories, fitting the four quadrants: relativistic black holes, a classical Solar System, or modified classical wide binaries, for example. Many systems fall along the intersecting lines of the two constraints, while no known system exists at exactly the intersection, under modified general relativity. Yet, intriguingly, the density of matter in modified general relativity matches the observed density of the entire universe.

### **There Is No Dark Matter**

In replacing conventional gravity, we lose the *raison d'être* for dark matter and dark energy, and gain a more parsimonious understanding of the universe. And because the low-acceleration regime also applies at subatomic scales, it potentially implies future technological innovations.

In one example where Mendozza views a dark entity as having served a purpose, 20<sup>th</sup> century French astronomers deduced the presence of a missing planet from anomalous orbits that deviated from Newton's predictions. This turned out to be Neptune. However, a second similar deduction, for the inner planet Vulcan, proved false. Instead, Einstein found the cause of orbital changes as a different force law, general relativity. "So something to learn about this dark matter of planets, yeah, it might be sometimes dark stuff there. But sometimes you



need to modify gravity, in order to explain these new phenomena that you are observing.”

Mendoza first became interested in modifying gravity while a student. “When I was finishing my PhD, I used to go to the library in Cambridge, and start reading articles of the *Astrophysical Journal*. I don’t know why. I found relaxation by doing so, rather than going for a walk or whatever. I used to go there and just read articles. And once I found an article about the Pioneer anomaly. The Pioneer anomaly shows that the Pioneer, this space probe that they sent in the 70s, they had anomalies in their motion. There were many, many theories at the time.”

Leading physicists, including many who were originally responsible for the notion of dark matter, now believe that extensions to gravity can explain observations of movements through space just as well as dark matter, at the very least. As new data come pouring in, the balance tilts. Growing astrophysical evidence narrows down the theoretical possibilities. Chris Allen looks to the upcoming Gaia space mission, which will unambiguously distinguish binary stars, revealing whether they rotate according to conventional or newly modified gravitational theory.

Xavier Hernandez agrees on “the very clear Gaia results, which three years from now will make it clear and unavoidable that classical gravity does not apply in the low acceleration regime.” Additional lines of evidence from new and planned astrophysical devices will eventually answer this question, one



way or another, beyond dispute. When asked how confident he is that gravity needs extension, Hernandez says: “I’m absolutely certain.”

What will we wind up with? We are at a turning point, where a major new theory needs to account for current observations. For such a new idea, extended gravity is gaining ground on dark matter. Next comes a full theory. The phrase “paradigm shift” recurs.

### **An Open Question**

The astrophysical evidence currently presents a failure of general relativity, the prevailing explanation of gravity. This is big, because general relativity is one of the pillars of modern science. General relativity, together with its sister quantum theory, comprise the gem of modern physics. Any deficits imply the need for a new breed of astrophysics, to explain the newfound anomalies.

Astrophysical theory can be quite abstract, yet since its foundation has drawn on a very strong empirical basis. Yet, for all its achievements, general relativity is not set in stone, notes Hernandez. “Many people have assumed that general relativity is a definite ultimate. Forgotten the crucial aspect of science, which is that theories have to be tested, and if they fail then maybe they’re wrong. And that’s what happened. General relativity is just an extraordinary approximation which works well in a certain regime. But the evident failures in the low-acceleration regime are not evidence for dark matter, but evidence for the end of the validity of that theory.” Even the





biggest theory can be wrong. “Once you no longer allow for that possibility, then you are no longer doing science.”

Now, modern observational astronomy is catching up, providing ways to test the theory of gravity. Bringing doubt to the theory, which is how research should happen, introduces scary yet exciting possibilities. Science, even a topic as basic as gravity, remains an open question.

Mendoza says that many recently observed astronomical systems are “impossible to explain with dark matter.” Traditional astrophysics holds true, but only on smaller scales. “Gravity works fine where you have tested it, at scales equivalent to the masses and sizes of the Solar System. But once they differ a lot, when they are more extended, then gravity needs to be rephrased, rebuilt.” In short, general relativity is dead. “It’s quite simple, mathematically speaking. It’s an equation that doesn’t solve your problem.”

### **The Big Idea**

Now, Mendoza wants to fix gravity. “From my own point of view, what we are doing with this modification, it comes from a fundamental level. You have the observation that doesn’t match Kepler’s third law of motion. So what do you do? You need a new theory at those scales. So let’s build it.”

Mendoza still takes inspiration from Newton and Einstein. “Standard gravity is OK where it has to be OK. It just was not constructed with these new observations.” He elaborates: “Normal general relativity was built with the notion of the orbits of seven planets. Now we have millions of dynamical



observations of different objects. It's a completely different story. It would have been great if everything would have worked, but no, it doesn't work." If the earlier theoreticians had access to modern observations, they would come to the same conclusions. "Why? Because I followed their steps."

Hernandez adds: "We have, so far, very definite proof of the need to modify gravity, and a good picture of what you need. The really big thing is going to come when a fully consistent picture emerges. I think that the most important thing that we're missing is a new fundamental principle to explain why this change of regime occurs." The explanation must be consistent across all astronomical scales, from Solar System to cosmological. "That would be the new theory."

A complete theory will integrate the mathematical physics with human experience. "What exactly that means in the end, I don't know. I don't think we have a complete final theory of gravity," says Hernandez. "Ultimately, I think that means that we have to keep a bit of a more modest expectation. The theory we learned, handle, and even the ones we construct later, will only ever be approximations to a more complex reality."

Goodbye dark matter and dark energy. Goodbye Newton and Einstein. Hello to a new theory. Hello to distant possibilities. Maybe the unification of quantum mechanics with gravity. Maybe new technology. Maybe new insight into how the entire universe behaves. And maybe new mysteries unforeseen.



## **Chilangolandia**

Mexico City, DF, Mexico

January – February, Year One

*Mexico City is mind-blowing. From the time of arrival, throughout the stay, including a few brief side trips, the city constantly amazes with its deep intricacy. Mexico City offers a plethora of adventures. Eagle finds some monumental camp spots, meets a lot of people, falls in love, explores the area, learns about theoretical astrophysics, then reluctantly leaves Mexico.*

From Guadalajara, after my too-brief passage through Michoacán, I got into Mexico City. DF. Chilangolandia.

Whatever you call it, Mexico City is one of the biggest and most exciting cities on this planet. Everywhere you go, the city is thriving with busy life. Commercially, socially, throughout the networks of transportation and communication and culture and every aspect of life, this place reverberates with motion, actively humming in many beautiful ways.

DF has intricately interwoven neighborhoods, relatively good metro (subway) service, a bus system that even confuses some locals, and many wonderfully sweet people. I spent a while in the capital city, exploring and experiencing it as much as I



could. Along the way, I had chances to meet interesting fast-paced folks, eat out and engage in a variety of cultural activities, visit some important astronomy research sites, and fall in love – with the city and with a creative Mexican lady, Avril.

Together with Avril, the two of us also made a few forays outside of the city itself. We went to nearby destinations of general interest, as well as going on a more adventuresome trip up to a mountaintop observatory in a neighboring state.

While in and around Chilangolandia, we had a lot of fun times and I feel like I grew as a person. It made me exuberant to be in Mexico City, with so much to see and do. There were some close calls along the way, but those make for the highest highs. Mexico City is the core of an amazing country, the largest and most important city right in the center of the action. By the way, did you know that there's a whole country where everyone's Mexican?! ☺

### **Into the City**

When I first got to Mexico City, I arrived at a major transportation hub. I came by intercity bus, and arrived at the terminal near the *Observatorio* metro station. The station is named after the nearby former home of the National Astronomical Observatory, before it moved up to Sierra San Pedro Mártir (location of “Robotic Triplets”). The old observatory itself is now defunct. When I went by it the following day, a guard stationed outside said that it was closed, and that on weekdays it served as a museum.



Right next to the bus terminal is the metro station, with its full complement of food stalls. In Mexico, vast numbers of food vendors congregate around metro stations, and pretty much any other active public area. The people love to eat. The food stalls in Mexico City serve different fare than elsewhere in the country, with the correspondingly huge range of quality that one would expect from one of the most populous cities on the planet.

That first night getting into the city, it was dark and I was tired, so I decided to urban camp! I found a small patch of greenery amid the throbbing city, right in the nexus of all that traffic by foot, car, bus, metro, and with so much movement going on all around.

I woke up the next morning, which was a good start.

After grabbing some tacos and tlacoyos, made with blue corn and filled with huitlacoche and all kinds of cool stuff, I got on the metro. A tlacoyo is like a taco but in a different shape and with different fillings, traditionally. Huitlacoche is a corn fungus that Mexicans eat like mushrooms. The food was delicious, although I confess a preference for the foods of other regions of Mexico, especially the northern desert.

Mostly ignorant of the city, I wasn't really sure where to go, so I rode the metro in a random direction. It felt so exhilarating to ride the crowded metro in a massive city where everything for me was new.



A couple of cute girls got on the metro. I chatted with them, and we got along well. One was called Azul (Blue). The three of us got off at a really busy metro station.

Off the crowded train. Into the crowded streets. Stimuli everywhere. Lots to see, lots to say, lots to hear and feel and integrate. A brisk walk through all kinds of urban scenery. Lots of old buildings, and lots of new American shops. Everywhere people. Mexico City has seemingly endless stretches full of people flowing by, everywhere you look or walk or think. More than twenty million people live in the metropolitan area, and many more come to work and travel.

The people kept on coming. Everywhere, more and more people. There are more people in this city than in many entire countries. Really fun at first, then later somewhat exhausting. Then later fun again. Lots of shops, restaurants, museums, architecture, and of course vendors, in the variegated streets.

We kept on walking, then went to an outdoor market and shared some foods. They commented on how much spicy salsa I liked (*bien enchilada*). I told the girls about my travels, and they told me about Mexico City, and their artistic inclinations. We talked about psychedelic substances, and while I had known that the sixties rock group the Doors got their name from Aldous Huxley's *Doors of Perception*, I learned that Huxley got his title from a William Blake poem:

If the doors of perception were cleansed everything  
would appear to man as it is, Infinite. For man has



closed himself up, till he sees all things thro' narrow  
chinks of his cavern.

Currently, astrophysics sees no theoretical limitation to the scope of the world.

As much as we break free of our constraints, through telescopes or adventure travel, we live through our growing yet limited awareness.

While getting acquainted with the city further, on several subsequent days, I made my way through the maze of streets and neighborhoods. I walked through many of the sprawling open-air markets that fill the city. And I ate *tacos de cabeza de borrego* (lamb's head tacos), and other street foods.

One night, I slept at a national monument. Really noisy. I especially remember some kind of repeating electronic sound, I think it was a street crossing signal. Lots of people, everywhere.

I woke up the next morning, which was a good start.

The locals have a few names for the city I was exploring. DF stands for *Distrito Federal* (Federal District), which is basically equivalent to calling the city of Washington "DC," for "District of Columbia." (After drafting this, the city reorganized so that it is no longer officially called *Distrito Federal*.) A slang word for a resident of Mexico City is "Chilango" (boorish person), hence Chilangolandia. It can also be called the Capital. Another abbreviation is CDMX, for



*Ciudad de Mexico* (Mexico City). Many people just say “Mexico,” which can be confusing when you don’t know whether they’re referring to the city or the country.

Anyways. Big place. Can’t see it all. Enjoy what you can. As in the cosmos, so in the cosmopolis.

I love Mexico City! ☺

### **City Ways**

Early on in Mexico City, I had plans to visit and interview a theoretical astrophysics group at the country’s big university, Universidad Nacional Autónoma de Mexico (UNAM), for “New Gravity.” They graciously put me up at a hotel for a few days, while I went to the research institute. There, I also had the opportunity to give a talk on astronomy communications.

In order to put together the talk, conduct the interviews, and write up the story, I would need a new laptop. I had still been making do with just the cybercafés, writing up my notes as I traveled through the Mexican mainland.

On a budget, I went to the *Plaza de la Tecnología* (Technology Center), a big complex full of computer vendors. Many of these vendors had started off selling on the street. They then got an “upgrade” by moving into this marketplace. Hucksters on the street out front hawk their products, selling all kinds of wares from pirated software to jerry-rigged machines.

I walked through the narrow, confusing hallways. Conspicuously gringo. A lot of the salesmen tried to pull me in





with hard sells. I considered some of the options, and came close to getting a small laptop to use with my previous hard drive, which I'd salvaged. However, the computer wouldn't boot up.

So, with time running short, I finally found a vendor who seemed slightly more trustworthy, and I bought an old laptop that would fill the bill. When I got back to the hotel, the laptop couldn't connect to the wifi network, the sound and video didn't work properly, and the battery didn't hold a charge.

On a return trip to the market, I found an empty area. A vendor from a nearby stall told me: "Oh, they closed down."

It turned out that I had gone to the wrong part of the maze, misremembering. After a few more return visits to the laptop provider, including one when I got angry in Spanish for the first time, and after several hardware repairs, we finally got the computer in roughly usable condition.

UNAM's *Ciudad Universitaria* (University City), the campus area, offered a pleasant welcome. Two of the researchers I met there very kindly showed me around the city-within-a-city. They even showed me points of interest elsewhere in DF, guiding me around to treasures I wouldn't otherwise have known. The campus has lots of murals, including the work of Diego Rivera, and is a World Heritage Site. It reminded me of 1960s San Francisco. UNAM also had student-police confrontations resulting in student deaths. And nowadays lots of students smoke pot on the lawn, like the hippies in Haight-Ashbury in SF.



Together with the theoretical astrophysicists, we walked around the huge nature preserve right there on campus. There remain some older structures that once hosted some kind of ancient ceremony, and now hold music and light shows. We climbed up and down a large stone ring. It had amazing ambiance, and would make for an awesome show.

The university even has its own metro station, with a gorgeous mosaic mural, and of course lots of food vendors inside and out producing wafts of enticing aromas. I came and went a few times for the “New Gravity” interviews. On the way out for the last time, I walked off campus and felt rejuvenated, full of inspiration and energy.

### **Life Cycles**

After visiting with the astronomers, I stayed a while longer in Mexico City. I met some people through Couchsurfing, which turned out to be quite an excellent way to learn about the locale. Wherever you travel, I highly recommend at least going to an event even if you don’t couchsurf.

At one place, we exchanged knowledge of Mexican vs. gringo dance styles, foods, slang, and more. Latin dances are sexier, and when the person showed me video of the traditional Colombian style cumbia, my first response was video of pole dancing, provoking laughter at the comparison.

Another place I stayed was in an apartment complex so huge that it practically constituted a city-within-a-city. Navigating the hallways of the many buildings within the compound was



as difficult as navigating the streets outside. We talked of travel in the US and Mexico, and in neighboring Guatemala.

Mexicans in the big cities often work long hours, and aspire towards a lifestyle with many American attributes. In DF as in Guadalajara, I met people fluent in English. And bicycle riding is quite popular, too, although I met few fellow touring cyclists. Some of the locals were quite shocked at places where I'd camp, or for that matter that I rode by bike from Canada to Mexico!

While in Mexico City, I went on a few runs. Running has a way of making me feel more comfortable, at home, anywhere, anytime. It felt glorious to run in the sunshine, through different neighborhoods. Some areas I recognized from metro rides I'd taken, although having a different perspective on foot. At one station on the blue line, a lady at a *puesto* sold *tacos de borrego*, delicious.

The metro itself can be an adventure. The first few times it was wonderful fun, figuring out how to enter and where to exit, and enjoying the ride. Thereafter it became something more stressful when simply trying to get someplace.

To get exercise, I also used some of the gym equipment they had in public parks. A lot of Mexican parks serve as big neighborhood gathering places, even more so than in the US. They often have amusement rides, live music, food vendors, and also exercise equipment.



While climbing up a huge metal chain in Mexico City, my grip slipped. I slid down hard. Pain shot through my hands. Blood came out. I went into the nearest place, a hair salon, and applied some antibacterial gel. My fingers swelled up, and remained swollen and painful for a long time.

Sometimes things don't go exactly the way you want. Still, it's important to keep going, climbing higher. You can't reasonably expect perfection, which means you must reasonably expect a few slip-ups along the way. And we heal, and improve for the next time. If you want to get far, in travels or in astronomy or in life, it helps to have the kind of resilience that comes from tenacious experience.

Throughout Mexico City, you can find anything and everything. I'm pretty sure that whatever you can imagine, if it exists on Earth, you can find it here. With this density of people, you get enough of a crowd for any taste or interest.

One cool activity, which exists in a number of cities although DF seems to do quite well, is called a *CicloVia* (sometimes written differently). Basically, the place closes down one or more main streets to vehicular traffic, and huge throngs of people bike along it en masse. In Mexico City, numerous big streets have *CicloVia* events on a regular basis, and at these rowdy happenings you can even borrow a bicycle for free.

Still without a bicycle, and feeling a bit nostalgic about the situation, I went to a *CicloVia*. I went to one of the free rental stations, and got in line. I got to talking with the woman next to me, and we discussed our respective travels. She was a local



resident, and had enjoyed spending time in Barcelona, Paris, and elsewhere.

We rode together for a while, she pointing out local landmarks, me recounting my ride to Mexico, both of us yabbering on about philosophical nonsense. I had met Avril.

Being back on a bike again, although in very different conditions than before, felt liberating, and it was joyful to ride together with Avril through the sun and have beautiful conversations.

We returned our bikes, and walked down a row of landscaped sidewalk running between the streets for many blocks. As we walked, we asked silly questions to which we could only offer silly answers, such as: How does time flow? What meanings could life hold?

Afterwards, we walked for a while more, then grabbed a bite to eat. We held hands. We kissed. We played. We parted. After a few dates, I wound up staying at her place. Later, we wound up going to the neighboring state of Puebla together, and visiting a giant radar dish (“Birth of a Giant Telescope”) and hundreds of vats of water (“Flying High”).

For our first date, we went to a *lucha libre* (Mexican wrestling) event. *Lucha libre* is huge in Mexico, and fun. It looks kind of like American wrestling, which probably borrowed heavily from *lucha libre*. It’s the sport with the colorful masks. *Lucha libre* also serves as a kind of social



storytelling, with *tecnico* (technical) good guys fighting against *rudo* (rough) bad guys.

Avril asked me if I was with the *tecnicos* or the *rudos*, and I felt torn between the two. To this day, I believe that it's important, for me anyways, to bring together a mix of the valuable characteristics of both sides. By way of example, I believe that systematic astronomical inquiry is good, and fun-loving adventure travel is great. Technical artistry in harmony with unfettered freedom seems to bring about wholeheartedly excellent results. Which are you: *tecnico* or *rudo* or both?

For Valentine's Day, we went to Hooter's, and I told Avril that I love her.

### **Pyramids and Canals**

Together with Avril, in DF, we went to a number of open-air markets, and got to know each other better. From Mexico City, we also did a few side trips, seeing pyramids and canals.

The pyramids at Teotihuacan are eerily beautiful remnants of an earlier civilization, which predates the Mayans and Aztecs of the area, then mysteriously disappeared. We drove to the archaeological site, walked about, and joked about the ruins originally being from an *oficina turistica* (tourist information center). Vendors sold gadgets to make roaring jaguar sounds. Walking around the grounds, we felt a connection with the people who had lived here in the past, and we took in the current beauty, told stories, and ran up and down the pyramids.



The pyramids were designed and constructed in such a way as to reflect astronomical information. For example, they were adorned in brilliant paintings of stars (as well as jaguars and snakes). Pyramids contain symbols pointing towards cosmology and calendars. At a similar Mesoamerican pyramid dedicated to a similar feathered serpent, as the sun makes its way through the sky during the equinox, it casts a shadow in the form of a slithering snake. The entire urban grid in Teotihuacan is laid out at exactly 15.5 degrees east of North, in alignment with their universal worldview.

Beneath one building, archaeologists accidentally discovered a secret tunnel, containing many surprises (as so many finds are accidental). The site included mysterious metallic spheres a few inches in diameter, and a miniature mountain landscape several stories below-ground, with liquid mercury lakes. The tunnel walls and ceiling were coated in a glittering material, giving the impression of the night sky. Figurines, with shining eyes and mirrors, gazed up at the celestial realms.

Avril told me the story of the founding of Mexico City. Apparently, Aztec (Mexica) legend had it that an eagle would eat a snake on a cactus, and at that location would be founded the city. Lo, the wandering people found an eagle eating a snake on a cactus, on a small island in the middle of Lake Texcoco, at Tenochtitlan. So the Aztecs founded their capital there, which later grew into Mexico City.

Avril pointed out as we drove by the water that it was a perversely Mexican trait to see a point in the middle of a lake,



and settle there, instead of at a more accessible part around the edges. I dunno, it made sense to me. In the course of these travels I've discovered that inside my gringo exterior I have a Mexican heart. And Mexican taste buds. Do you ever feel like you resonate more with a culture other than the one where you grew up? Some people are more "at home" at home, while others revel in an alternative home – which could be a city, a country, or a whole climate. Or even a different planet!

On another trip, we went to the canals of Xochimilco. It's kind of like the artificial land system at Tenochtitlan (the Aztec/Mexica island city – these place names all make great Spanish pronunciation practice, by the way!). Xochimilco has an active community built on artificial islands made on canals, who live in a way like their ancestral population. Getting there was a fun adventure of its own, which required going on multiple different transit systems including metro and light rail, through different neighborhoods to the outskirts of town.

The so-called *chinampas* form an ancient system of land-on-water, with attractive houses, and houseboats that go gliding by. We hired a *trajinera*, a boat like a Venetian gondola. The gondolier may have given us the special gringo price. I joked that Avril should have got the boat while I hid, then we could get onboard together.

Vendors sold all kinds of products from onboard other boats on the water. "A diez, a diez" ("one dollar, one dollar"), Avril and I laughed to each other, mimicking the common refrain





heard everywhere in the country, from the metro cars to the strip clubs.

One vendor sold the ubiquitous *elote* (fire-roasted corn), grilling right on his boat on the water. We bought a couple of cobs. He asked us if we wanted them spicy. Sure. They turned out to be outlandishly hot, like way spicier than usual even in Mexico, and we struggled to breathe.

We also had brought a bunch of chocolates and other treats onboard, and enjoyed some sweet time with the sun and water. It was very romantic, and a highly recommendable location if you ever go on a date in Mexico City.

We went back on land, and wandered around town a bit. Plenty of cute little shops in this charming district. We had quesadillas, including a gigantic one filled with *flor de calabaza* (squash flower). We also had some *borrego* tacos, really tasty, which helped me convince Avril of their merit. I try a lot of foods that *lugareños* (locals) eat less often. More generally, people seem to see more of a place while visiting than while living there.

Going on a trip of any kind, leaving behind your prejudices and predispositions, allows you to see the world more clearly. Like how looking deep into space beyond the known nearby parts of the universe sheds light on space more generally. We learn about life on Earth by looking out into space. We have a blind spot for “home”, wherever that may be. It’s easier to see clearly when you look at something freshly. Like backseat driving. And it’s easier to overlook the obvious, what you



thought you knew all along. Like looking for the pair of glasses you're wearing.

We drank lots of Coke, seemingly the national drink of Mexico. We kept walking in the glorious sunshine. We shared ice cream, walked and held hands, and enjoyed a wonderful day.

On the way back to town after our road trip, we stopped at a country restaurant to get some *pulque*. *Pulque* is a sour, fermented beverage, made from agave, like a precursor to tequila. Although it didn't taste the greatest to me, it was worth trying. Trying new things is generally something of a gamble, which can yield lemons or big payouts. No risk, no reward. True in travels. True in astronomy. True in life in general.

Back in town, another night, we went to a hipper place, an upscale *pulqueria* that had dancing and better drinks. It felt wonderful to dance to a mix of English- and Spanish-language tracks, under the bright lights, with so many lovely people.

While in DF, we had the opportunity to go dancing at many places, to see cultural and historical marvels, and to eat treats from pistachio sauce to stomach soup to our own homemade *tortillas de harina* (wheat flour tortillas). About the latter, which we joyfully ate with avocado, tomato, beans, and cheese, we joked about opening a *tortilleria*, "La Norteña." We could have *banda* music, foods to eat with the tortillas, and two different sides catering to both authentic and gringo preferences. To this day I retain a healthy fascination with *tortillas de harina* and their derivatives.



Meanwhile, I had been deliberating on whether or not to go to the neighboring state of Puebla, to visit a couple of observatories for potential stories. Both “Birth of a Giant Telescope” and “Flying High” would cover advances at the two mountaintop research sites. After getting an informal go-ahead from a magazine to go through with the Large Millimeter Telescope story, I thought it would be worthwhile to take the plunge. Without a bike or a contract, I was set to go to Puebla, whatever it would take.

Time for adventure! ☺



## **Heading Up**

February, Year One

Puebla, Mexico to the United States of America

*On a side trip, the biggest one, from Mexico City, we go on a somewhat spontaneous jaunt up the mountains of Puebla. There, a big adventure to see two telescopes. Buses and metro and more transportation. Churches and food. Romantic times. With Avril, we stay at surprising hotels, visit cathedrals, and eat mole. Then, a rush to the border. Universal revelations.*

While in Mexico City, I wanted to do another astronomy story nearby. I learned from the theoretical astrophysicists at UNAM that I could go to two major research devices in the neighboring state of Puebla. However, I did not have a magazine gig or a bicycle, and the logistics would be difficult.

I had decided to go anyways, though. Ready to go alone, I tried to convince Avril to come too. Together, we took a chance, got to the observatories, and got the stories. While in Puebla, we also took the opportunity to do some touring around. A good time was had by all.

Then, after some surprising twists and turns, it was time for me to leave Mexico and go back to the USA. The challenges continued, but finally I found a way out, only to regret leaving.



## **Puebla Mission**

Puebla is a more mountainous, less populous state, without much in the way of infrastructure. Without a bike, I wasn't sure how I would actually get there. Maybe it would be possible to swing a ride with some of the observatory staff going up the mountain anyways, although that seemed a tenuous basis to plan a trip around. The regional bus system looked daunting, with complicated routes into the state and still no clear way up to the observatory itself.

I invited Avril to go up to the observatory with me. It would be a fun adventure and a chance to develop our relationship while researching an interesting story. At first she was reluctant, with her own pressing work needs to deal with. We talked about the idea for a little while. Meanwhile, we carried on in DF for the brief remaining time before the point of no return. Finally, I won her over.

It would be much simpler to drive to Puebla with Avril, who had a vehicle. However, one day in Mexico City, as we were driving around town, some officials pulled us over and said that her holograms were out of date. Apparently, in Mexico they use some kind of advanced verification system for environmental testing. If my Spanish was good enough to understand. When the green police interrupted us, we had been having a lesson on the finer points of using the Mexican slang word for "fuck" (*chinga*).

Without a car, we still faced the transportation dilemma. Together, Avril and I tackled getting to Puebla by going



through a complex series of maneuvers. First we took the Mexico City metro out to a remote station, which connected with a long-distance bus terminal. From there, we rode a bus to the state of Puebla, staying the night at a cheap hotel. We chose a hotel across the street from one advertising hourly rates. The next morning, in the small hotel breakfast room, we discussed the just-announced arrest of a top *narcotraficante* right nearby. Then we coordinated just in time with observatory staff, who kindly picked us up at the hotel and drove us up to the telescopes.

The whole Puebla episode wouldn't have happened without this somewhat intricate sequence of efforts and events. Often in life, it seems like you have to do everything you can, and take a few risky chances, and pay careful attention, and still not have a clear-cut route to success, yet go for it anyways, and then *still* depend on having a few events fall in your favor. For this reason – the huge unpredictability of doing outlandish things under adverse conditions – it really helps to be adaptable. I think that having an open and firm-yet-flexible attitude may be the most important component to succeeding on the road, and in space science, and on the road of life.

Maybe.

We toured the twin observatories, seeing the Large Millimeter Telescope (“Birth of a Giant Telescope”), and the High-Altitude Water Cherenkov Gamma-Ray Observatory (“Flying High”). We also went to their institutional HQ in the mountain town of Tonantzintla, where I interviewed key astrophysicists.



The ride up in a pickup truck sure beat the pants off riding a bicycle, as far as ease and comfort go. Atop the mount, we could look out over the amazing horizons. I love climbing to the peak. In some ways it does feel a lot better doing it by your own physiological efforts. Yet however you do it, there's a thrill of accomplishment to match the views. Anyways, Avril enjoyed the drive up, and seeing the telescopes, and she commented on what it must be like to go up – and then come back down – one of these huge beasts of a mountain on a bicycle. Each way has its pros and cons.

In talking with the astronomers, a clearer picture came to light of curious minds playing on the edges of knowledge and ignorance. Often, building a telescope is a big gamble. These things take relatively huge amounts of time, money, and energy. And then they run the risks of failing to complete construction or failing to perform technically well. And even then, of the handful of big telescopes that do get built and then operate, astronomers don't actually know what they'll see until they look at the pictures – or else why build the things in the first place?

Oh, and by the way, in case it's not already obvious at this point from the previous stories, research astronomers generally don't look through eyepieces anymore, instead using purpose-built imaging tools. Nowadays the images are compiled through electronic circuitry into a picture you can look at on a computer – or perhaps more commonly, into numbers and graphs and other simple mathematical forms that could reveal valuable surprises.



Astronomers here in Puebla, echoing what I've heard many astronomers and other scientists say, go into a search hoping to find something big, with generally optimistic expectations due to careful planning, yet without a specific understanding of what exactly to look for. Often, the greatest discoveries come as a surprise even to the discoverers. A quip on this topic is that a more common word upon discovery than "Eureka!" is "Oops!"

That sounds very much like adventure travel. You go in with cautious optimism and lots of planning. Yet, it's often only when you get lost that you truly get found. What are we looking for anyways? We start out with a sense of our desires, yet along the journey we often find out that we had different questions. Through steps and accidental missteps, we traipse along our trails, towards our destinies.

Anyways, to do cool things, like understanding the cosmos, or on a much smaller scale climbing up a mountain: plan carefully, try hard, fail, adapt, learn, succeed, and move on. Simple!

### **Aftermath**

After touring the telescopes, when Avril and I came down the mountain, we went to the cities of Puebla to celebrate. There, we walked by some of the breathtaking local cathedrals. The state has some of the most numerous and some of the most elaborate churches on the planet. Ornate architecture, intricate shapes dripping and pointing and filling the visual field with gold. Here, we said jokingly, a breathtakingly beautiful church





only slightly less glorious than the biggest ones could be an “*iglesia de barrio*,” an arbitrary neighborhood church.

Our first night in town, we went looking for a hotel. Walking around the heavily built, touristic main square, we went into an information center. Avril asked the agent for hotel recommendations, and I heard him suggest the Ritz for a few hundred. The word “Ritz” struck fear into my wallet. Avril seemed to like the idea, and I hadn’t realized that we were going to have such a romantic evening. I was running low on cash and a bit worried.

As we walked through the maze of charming streets, with Avril seeming to know where we were going, we got to the place. The exterior seemed nice, although it didn’t strike me quite like my impression of the Ritz. We went in, and the interior had some interesting features, although it seemed seedier.

*Oh.* The price was in pesos. This was not *the* Ritz. It actually turned out to be a kind of discounty place. The room was small and full of problems, and I think the coffee in the lobby was the worst I ever drank. We laughed about the experience.

As we walked through the old-fashioned city streets, I admired the *tlapelarias* (hardware stores). Avril found that funny, and asked why. I feel like they are so full of possibility and wonder. I love hardware stores, and the ones in the old architecture there looked fantastic. Even though I’m not really good at building things with my hands, I love to dream up wild ideas, imagining the many incredible combinations. It’s kind



of like writing: you've got all these different words or parts or building blocks available that do different things, and you can put them together in so many ways to create very startling and useful and beautiful products. When I watch skillful people assemble a telescope or a skyscraper or even a bicycle out of basic components, using parts like you'd find at a hardware store, I find it almost magical. And just seeing the parts can inspire new dreams.

We walked the dazzling streets. We rode around the region on a series of buses. We went to magical lands, talking, looking, having wonderful times. Puebla is a gorgeous state.

While in Puebla, we had *mole poblano*, the national dish of Mexico, here in its place of origin. It combines cocoa and chile and sesame and many other spices, and is often served on chicken with rice and other accompaniments. We also tried other regional specialties. The state is conservative, famous for its food and churches – which makes it a bit funny to have the high-tech telescopes, in juxtaposition with traditional lifestyles.

Then, after the countryside of Puebla, back to DF! We took another complex series of transportation services back to the city.

With time running short, we would only have a few days left together. Officially, I had six months in Mexico, which was coming up at the end of February. I had been deliberating on how OK it would be to overstay the legal permission, or skip



paying the fee, among other questions swirling around leaving Mexico...

### **Bittersweet Departure**

After the excitement of the adventures up to Puebla, Avril and I returned to Mexico City. Here, with time running out on my paperwork, I considered staying on a bit longer anyways, although decided against it. Due to the vagaries of travel, however, I wound up leaving the country a day or two beyond the deadline.

At Avril's place before having to go, we bittersweetly spent our remaining time together. On our last day, we resolved to stay up all night.

We went for a rich *pozole* in Coyocán – the highly historic neighborhood formerly home to Aztecs, Conquistador Hernán Cortés, Soviet Leon Trotsky, and artists Diego Rivera and Frida Kahlo. Pozole is a spicy red dish with corn, which according to legend Aztecs traditionally made using human flesh – a practice now widely deprecated. We added plenty of cream to ours, making it thickly luxurious.

Then we went to a classic *tequileria*. The old building was full of fresh young faces. We drank fancy tequila. That evening, we walked by a traditional aboriginal dance troupe. We ate sweets, and we had fancy coffee drinks with whipped cream and liquor. We ate organ tacos like *sesos* (brains) and *ojos* (eyes), which we and the *taqueros* found interesting. We went dancing at a gay cowboy bar, the only open place we found, and had a fabulous time. Throughout the night and into the



early morning, we had fruits, pastries, and fun. We gorged on pretty much anything we could, going to great excess. We wound up falling asleep anyways.

The next day, waking up later than expected, it was time to go. Before heading out, we went and had fruit cocktails with everything the *puesto* expert could muster, including papayas and bananas and other tropical fruits with cream, and all covered in chocolate and nuts and everything else. We also got *champurrado* (kind of Mexican spiced hot chocolate), with pastries, *and* coffee, and practically everything else. The coffee came from a vendor riding on a bike with an add-on component on the front, like a wheelbarrow, which held all his wares.

Finally, satiated, supersaturated, we left. Flying back would be way faster than an epic bus ride all the way back to America, and time was of the essence. Avril drove me to the airport. She was OK with driving around town without her environmental permit, although not doing a big out-of-state trip. It was very sad for both of us to part ways. Such sweet sorrow, as the poet wrote.

At the Mexico City airport, I went to a few of the airlines' desks. I could have flown pretty much anywhere. I love that freedom. The flexibility. The possibility and wonder. If you could fly anywhere in the world, where would you go?

I chose to fly back to San Diego, California, as it would make for a convenient point to wrap up Year One and start Year Two. Also, I had only seen a small part of what I wanted to see



during my first time in the city – I had enjoyed San Diego, and wanted to spend more time there. Especially, I missed the beaches. With a bit of luck, I would be back on the beach by the weekend.

### **Airport Blues**

Mexico City has a fairly neat although limited airport. After checking out a few options, which cost me some important time, I found out that I missed the last decent option while investigating and I'd have to wait until the following day to get a reasonably priced flight to the US. Often you're better off just going with a sufficiently satisfying option instead of researching exhaustively. So I slept in the airport. It felt awesome.

Because of the extra night spent sleeping in the airport, my legal permission to stay in Mexico technically ended before I got out of the country. And when I went out of my way to find the department in the airport where they dealt with customs issues such as paying the entry fee – I had decided to pay it, because of how much I love the country and to express my thanks – the Mexican bureaucrats kind of looked at me skeptically, as if to ask, "Why are you bothering to pay this?" Truly, after my own heart.

I had a special feeling on that flight back to the US. My heart was overflowing with many feelings. It had been a full year since I started this adventure. A lot had happened. I had traveled by bicycle down the Pacific coast of the USA. I had made my way through the heart of Mexico, and Mexico had



made its way through my heart. I had visited research sites and written up a stack of astro articles. I had met so many incredible people, and even fallen in love. I had eaten my way through the continent. And all of this was still only the start of the trip!

I thought back to those first few pedals, in wintertime in Canada. I thought back to crossing into Mexico half a year later, instead of turning east. And I thought of leaving Mexico City, of leaving Avril. I thought of the future, and who knew what it held?

As I jotted down some handwritten notes in a little booklet that Avril had given me, I felt a kind of awe. So much. We live in an almost unbelievably intricate world. So much is possible.

Astronomers have cracked the codes of orbiting bodies out to distances of billions of light years, far beyond what our inherited brains would have otherwise believed. Simple mathematical patterns describe the growth of vast cosmic structures.

I felt, on that airplane, like maybe we're beginning to crack other codes, even more subtle than the astronomical marvels that our telescopes and minds reveal about space.

And, while it's only a humble step, I feel that freeing yourself from the chains of convention, and taking a plunge of your own out into the unknown, can reveal some really surprising, fun, sometimes scary, generally challenging, always amazingly



beautiful possibilities. So go ahead, follow your heart. Live your dreams.

I looked out the airplane window, and wondered.

### **Back in the USA**

After overstaying my travel time in Mexico, I flew back to the USA. Actually, I flew back to Tijuana, then got on a shuttle bus to go across the border. In TJ, I had a last glimpse of the glorious Mexican lifestyle, land that I love, then got on the airline's shuttle bus.

The bus across the border was crowded with Mexicans. I now felt partly like a Mexican inside, and could kind of speak the language, but still looked gringo on the outside. As we got off the bus and crossed the border by foot, we went through the US customs and immigration station. The Mexican citizens got asked a fair number of questions. The border agent waved me through with a smile.

I have found that border agents, police, and other officials vary quite a lot individually, as far as professionalism and other traits. Overall I think that legal bureaucracy is an unfortunate although understandable part of travel and life, and that being courteous and clear in communicating with people who already have their own challenges can be the best way through, regardless of your opinion or politics.

The next plan on my itinerary would be the Southwest of the USA. To go across the entire southern part of the country, as



I'd planned to do before my Mexican gambit. First I'd fly back to San Diego, then head east.

When I got back to San Diego, I remembered a whole lot of things that I wanted to do there, which I hadn't gotten around to doing the previous time. Just stepping onto an American street seemed funny at first. They're so much broader and emptier and colder and cleaner than Mexican streets.

My first coherent thought in America was essentially: "I want to go back to Mexico!"

Then, in the gray and rainy weather, a passerby spoke. The person made some unusual sounds, strange. After a few seconds, the sounds formed themselves into coherent recognizable patterns in my mind. Ah, yes. English. Apparently I understand it.

Where was home, anyways?

I now believe that home is a state of mind. When you feel comfortable in your surroundings, when you know and accept and belong, then wherever you are, you can fully and fairly call home.

Home is our universe, our world.

We live in a really big place. Usually we only see, or experience through any of our senses, a relatively tiny part of it. Yet we belong to a much, much, much, much, much bigger system. We come from, and are in, and are going to, the cosmos. *We are home.*





Astronomical tools have helped us to find our home. From the Big Bang, where we were apparently born, to our current place and time on planet Earth, for however long this lasts, all the way forward through whatever vast changes we face in the future, we live here. Home. This universe. The one that we're reading and writing and doing and being with. Existence.

Every person belongs to the same family, lives in the same structure, and does the same activity. Yet we've all got our own styles.

By the way, I love America, and I love Mexico, and I love planet Earth, and I even love the universe, although it's so psychedelically huge and challenging and intricate. Hope you do too!

*¡Ándale!*

Let's go!



## **Birth of a Giant Telescope**

Large Millimeter Telescope, Atzitzintla, Volcán Sierra Negra, Puebla, Mexico

February, Year One

*In the traditionally conservative and religious state of Puebla, the world's largest millimeter-wavelength telescope gets built. The construction of the Large Millimeter Telescope sets a new high in Mexico, as it looks at the deep, dark cosmos.*

Atop an extinct volcano, near the highest point in Mexico, sits a sizable new addition to the global astronomy community. After an almost two-decade gestation period, the Large Millimeter Telescope (LMT) redefines observations in its wavelength. The results will tell us a lot about the cosmos, from the dimmest planetesimals to the most luminous galactic cores.

With its unique design and construction, and its prime location, the device creates a new spot among the greatest scientific instruments. The innovative telescope is the largest in the world of its kind: a single-dish antenna operating in the wave range of one millimeter. It is also the biggest scientific project in the history of Mexico. As construction continues towards final dimensions, the telescope now gets underway with scientific research.



The construction process, fraught with challenges, has already cost over \$100 million. To build a 50 meter diameter telescope on an untouched mountaintop requires unprecedented techniques. When the project took its first steps towards laying the foundation stone in 1998, the site lacked even a basic road. The only access was on the back of a mule.

It took until 2006 to finish the civil engineering. Tests performed between 2007 and 2011 led up to the LMT's first light. As astronomy starts, expansion will bring the primary mirror to its final size over the next two years, at which point the project becomes a fully operational observatory.

### **On the Mountain**

Standing atop Volcán Sierra Negra, at an ear-popping altitude of 4,600 m, the LMT makes for an impressive beast. Currently only the inner 32 m operate, yet placeholder panels fill out the full size of the reflector. Driving in a 4x4 pickup truck along the steep and windy dirt road that now climbs up the mountain, the telescope becomes apparent from far below. It stands out incredibly against the snow-capped volcano, like a geographical feature.

The surrounding hills sport many palm trees and agaves. Puebla, a beautiful mountainous state near Mexico City, is famous for its churches and food, including Mexico's national dish, *mole*. Old stonework buildings dot the landscape. The route to the mountaintop intersects a smattering of life: horses, donkeys, and dogs walk along the lone road. Passing pickups carry hitchhikers.



Construction workers carry on the completion of the telescope, playing Mexican music. Challenges include welding steel and pouring cement at altitude, according to British LMT director David Hughes. “You have to build the cement plant at the site. You have to be able to make cement at 4,600 m, with the low temperatures, with the humidity issues, with the mix of bone-dry days, snow, and ice.” Referring to the major Mexican company, Hughes notes that “CEMEX, they had to develop a new formula to make cement at that altitude, that would set.”

Drilling the rock to pour cement took time, adds project scientist Miguel Chávez: “It required a detailed analysis of the soil, because it’s an extinct volcano. Many of the drills broke when they were used.” During construction in the tough environment, a truck and a tower crane also broke.

### **An Intricate Giant**

On the LMT, the immense primary mirror has a metallic gray surface consisting of 180 segments, arranged in five concentric rings. To create each panel, workers electroform high-precision subpanels out of nickel, with a rhodium coating. The components rest on a complex system of stainless steel framing and aluminum plating. Even the secondary reflector is impressive, at 2.6 m in diameter and 30 micron accuracy, and the device also has an uncommon tertiary mirror. The entire antenna – at around 2,000 tons – rotates very smoothly on a rail track. Atop the revolving base, the mirror itself tilts up and down, to provide a full view of the sky.



The telescope has an active surface to make micron-scale adjustments in shape, compensating for gravity and temperature, and it uses holography to establish an ultraprecise surface. “Physically large, but a bad surface, you’ve wasted your money,” notes Hughes. By comparing high-frequency wavefronts coming from a satellite against the same waves after hitting the primary mirror, astrophysicists can map the shape of the mirror.

The LMT now undertakes early observations. The device studies the formation of structure in the universe, uncovering troves of new galaxies. Seeing cold, dark, young objects, the telescope most importantly informs us about the early stages of the evolution of the universe. The millimeter wavelength also lets information penetrate cosmic dust, further revealing how the universe constructs itself. Peering into the depths spanning the cosmos, the LMT can see the hidden starts of planets and stars.

The instrument combines its great size, sensitivity, and speed with an excellent location. Among scientific benefits, the device will provide a thorough map of the cosmic microwave background, which radiates at the millimeter wavelength. Very high mapping speeds enable surveys of massive volumes of space, revealing structure.

“That’s where the LMT comes in,” says Hughes. “You can detect not hundreds, but tens of thousands, hundreds of thousands, millions of galaxies,” allowing three-dimensional



statistics. “And that’s what makes the LMT an exciting experiment.”

### **Seeing the Light**

The bent Cassegrain telescope employs a range of custom instrumentation, including a camera and a spectrometer, to measure the location and intensity of incoming light. Scientific instruments play as important a role as the dish itself. Chávez believes that even the initial configuration can make discoveries. “If you have a 32 m antenna with a sensitive continuum camera, as AzTEC, or the spectrometer like the Redshift Search Receiver, you’re actually able to see what no one else has been able to see.”

SEQUOIA, a high-resolution, cryogenically frozen component, will provide the third instrument. It can pick out the molecular content of objects within the Solar System and elsewhere in the Milky Way. SPEED, another tool under development, improves the camera capabilities to record at four different frequencies simultaneously. An arsenal of receivers and cameras will later come online.

The LMT has another trick up its sleeve. Not only does it function as the most distinguished single-dish millimeter telescope, it can also team up with other millimeter observatories around the world to form a unique interferometric array. Together with telescopes and smaller interferometers in Hawaii, the mainland United States, Chile, Europe, East Asia, Greenland, and the South Pole, the Earth-sized Event Horizon Telescope (EHT) stretches over many



thousands of kilometers. Hughes points out the huge advantage: “You’re talking about 200,000 times the resolution of the LMT.” The monster will look at the supermassive black hole at the heart of each target galaxy, including our own.

After testing the Very Long Baseline Interferometry (VLBI) setup, the interferometer begins scientific observations. Then, in the autumn it will focus at higher frequency and increased resolution, looking for the first time at the digestive process of our black hole, watching it swallow a giant molecular cloud.

### **Across the Universe**

The Large Millimeter Telescope primarily investigates structure in the universe. However, it also contributes to a wide range of topics critical to the global astronomical community.

Planetesimals, small leftover chunks from the early period of planetary formation, surround many stars including our sun. Like any cold, dim bodies, the LMT sees planetesimals clearly. The device will survey our Solar System, discovering and analyzing planetesimals and comets. It could even shed light on the surrounding Oort cloud, strongly theorized though never yet observed. Hughes expects new views of asteroids, such as “the regolithic structure, the surface composition, the grain materials.” Millions of asteroids started out life as the original planetesimals from the formative stages of our sun.

When planets form in other systems, they do so in a spinning disc of planetesimals surrounding a young host star. This exoplanetary disc represents the remnants of the same source



from which the star itself came. Certain accumulations of dust collect yet more dust into planets, wiping out paths through the cloud. Blobs reveal the presence of new planets, Hughes says. “We’re detecting the earlier stage, the formation of those first planets, as they start to sweep up the material of dust and gas and start to form those Jupiter-sized planets.”

At a bigger scale, the LMT will observe active galactic nuclei, to understand how the supermassive black holes at the centers of galaxies feed on their hosts. Observing their evolutions and environments reveals how these black holes help convert material into stars. Here, even basic gravity could have surprises in store. Current predictions describe how such a black hole would behave, says Hughes. Now, “you can image it, so you can test those models.”

Large clouds of interstellar dust form the nests where stars get born. The cold dust, at mere tens of degrees Kelvin, emits millimeter radiation, ideal for the LMT. Clouds also scatter visible light, because the dust particles measure a micron or less, as do optical wavelengths. While observing star formation through the interstellar dust, the Large Millimeter Telescope can determine how and where the dust resides.

## **Curious**

David Hughes, a telegenic Brit, directs the Large Millimeter Telescope. When he arrived, “there was nothing there. I came to Mexico in 1999, for this project. And at that point they were starting to level the site, and put in the foundations.” Hughes converses fluently in English and Spanish. The main science





case driving the LMT involves distant, high-redshift galaxies. “And that’s the contribution I’ve made personally, the detection of the sub-millimeter galaxy population.”

Between Mexicans looking for a telescope, and Americans looking for a location, Hughes understands the joint LMT as an ideal arrangement. “This is where I’d say it was the best decision. The LMT is a unique facility. There’s no one planning a bigger single-dish telescope. And it doesn’t cost you a billion Euros,” in contrast with other new instruments.

In describing the “world-class facility,” Hughes highlights a surprising feature of how light travels between stars and observers. “The really cool thing is, you get a benefit in detecting distant galaxies, due to something called the ‘negative K correction.’ If I have a light bulb, intuitively you know that this light bulb gets fainter as I walk away.” However, “in the millimeter, that’s not the case. There comes a point where the universe is half its size. From that time and further back, objects have roughly the same brightness in the millimeter. It’s a combination of the shape of the spectrum and the geometry of the universe.” Hughes draws a whiteboard sketch, warning that the effect “is pretty outrageous.”

Why innovate? “We have always looked up and tried to understand why we’re here. What is the universe around us? It’s part of being human, asking these questions. And astronomy, and building big telescopes that let you understand the nature of the universe, have enormous value. Imagine that we don’t understand the sun, the moon, the planets, the stars,



our galaxy.” Hughes acknowledges the value of technological spin-offs. “But at least for me, I think what’s most important is the more human part of it.”



## **Flying High**

High-Altitude Water Cherenkov Gamma-Ray Observatory,  
Atzitzintla, Volcán Sierra Negra, Puebla, Mexico

February, Year One

*Atop the same mountain as the Large Millimeter Telescope, even within visible range, hundreds of vats of ultrapure water serve as a special new type of observatory. By detecting cascades of incoming high-energy particles, the High-Altitude Water Cherenkov (HAWC) Observatory too probes the deep universe, answering mysterious questions. Currently, the project delves into the uncertainty...*

In Puebla, Mexico, a large global team comes together to build an unconventional new tool to investigate the deep universe. As construction comes to its completion, scientific observations soar to new heights. This unprecedented array works at high altitude, and high energy.

The “telescope” is actually a set of cylindrical vats, “seeing” extremely rapid electromagnetic radiation which gets generated indirectly through a complex series of transformations. With 300 total cylinders in the observatory, combining all the signals together yields an image of the universe in a unique frequency range, far beyond what the human eye can see. The observatory will collect enough data



to create a new map of the sky. This will complement observations by telescopes of many other wavelengths and energy levels.

Following in the footsteps of an earlier, smaller extreme radiation detector, HAWC takes the technique to a new level. Sharing the same basic concept, it differs in size, and therefore in what it can see. Why here? Why now? Partly for the great location, near the highest point in Mexico. This site beat out competition from Tibet and Bolivia. And now is a good time, with Mexico becoming more actively engaged in scientific and especially astrophysical projects, and probing a blind spot where we still face cosmic ignorance.

### **High Altitude**

On a flat ledge atop Volcán Sierra Negra, technicians fill the last of the collection of 300 cylindrical vats containing millions of gallons of ultrapure water. Together, the vats serve as the High-Altitude Water Cherenkov (HAWC) Gamma-Ray Observatory, a vast particle detector covering an area larger than 5 acres. Scientists use it to catch signs of some of the highest-energy astroparticles to reach the Earth.

The vats sit at an altitude of 4,100 meters (13,500 feet) on a rocky site within view of the nearby Large Millimeter Telescope. The area remained undeveloped until the construction of the LMT, which began in 1997, brought with it the first access road, along with electricity and data lines.

Temperatures at the top of the mountain are usually just cool enough for snow year-round, even though the atmosphere at



the bottom of the mountain is warm enough to host palm trees and agaves. “The local atmosphere is part of the detector,” says Alberto Carramiñana, general director of INAOE, the National Institute of Astrophysics, Optics and Electronics.

Astrophysicists at HAWC are working to understand extreme particles that come from space. High-energy gamma rays come from extreme environments such as supernova explosions, active galactic nuclei, and gamma-ray bursts. They’re also associated with high-energy cosmic rays, the origins of which are still unknown.

When incoming gamma rays and cosmic rays from space interact with Earth’s atmosphere, they produce a cascade of particles that shower the Earth. When these high-energy secondary particles reach the vats, they shoot through the water inside faster than particles of light can, producing an optical shock wave called “Cherenkov radiation.” The boom looks like a glowing blue, violet, or ultraviolet cone.

### **Into the Cylinder**

The vats at HAWC are made of corrugated steel, and each one holds a sealed, opaque bladder containing 188,000 L (50,000 gallons) of liquid, according to Manuel Odilón de Rosas Sandoval (Tank Assembly Coordinator, HAWC). Each tank is 4 meters (13 feet) high, 7.3 meters (24 feet) in diameter, and includes four light-reading photomultiplier tubes to detect the Cherenkov radiation.

Crawling into a bladder inflated with air feels like spelunking, with little sprites of light dancing in the darkness. “When the



vats are finished, it would appear pitch black inside,” says the tank assembly coordinator. Within each vat sits its bladder. “Each bag alone costs around \$7,000 and weighs 100 kg (220 lbs).” The silos sit in neat rows, contrasting against the wildly ranging mountain backdrop. During construction, workers carry loads of hardware around on the remote site.

“The operation of HAWC involves a remarkable combination of processes,” says Carramiñana. After struggling to explain the complex apparatus, he concedes: “The question ‘How does HAWC work?’ has no simple answer.”

High-frequency radiation triggers the tubes, adding data. Electronic connections aggregate and synchronize the incoming information. Combining events in the twelve hundred overall sensors, astrophysicists can piece together the precise origins of the mysterious deep energy. With tens of thousands of events hitting the vats every second, around a terabyte of data arrives per day. The device will record half a trillion events per year. The faster the sensor network, the better it can pinpoint sources.

### **Painting a Picture**

From its perch on the summit, HAWC sees the extreme astrophysical spectrum, in which particles have more energy in their motion than in their mass. The device is open to particles from much of the sky at any time, painting with large swathes of the sky as the Earth rotates.

“HAWC is unique among detectors sensible to teraelectronvolt photons in being able to observe a sizable fraction, about 15%,”



of the sky at any given time, and scan through two thirds of it every single sidereal day,” says Carramiñana.

Astrophysicists have begun to investigate the sky at extremely high energy levels. HAWC sets a new standard here, complementing several recent, existing, and upcoming initiatives. Results from HAWC, a great mixer, will complement the Fermi Gamma-ray Space Telescope, which observes from space at lower energy levels, as well as dozens of other tools across the electromagnetic spectrum.

The Pierre Auger Cosmic Ray Observatory in western Argentina, in operation since 2004, uses similar surface detector tanks to catch cosmic rays, but searches for rare ultrahigh-energy particles – up to millions of gigaelectronvolts. HAWC, by contrast, observes widely and deeply between the energy range of 100 gigaelectronvolts and 100,000 gigaelectronvolts. With so much more data available, HAWC will effectively map the high-energy sky.

Another type of instrument, the Imaging Atmospheric Cherenkov Telescope, sees less than one percent of the area that HAWC sees, at greater depth, making the two techniques good matches. Meanwhile, a Chinese project has been proposed to rival HAWC, although it has not actually started. A HAWC predecessor in New Mexico, Milagro, had far less sensitivity.

Also, neutrino and gravitational wave detectors will benefit from learning about gamma rays, which these waves theoretically accompany. And follow-up investigations can



take place in traditional astronomical observatories, including optical, radio, and X-ray.

“HAWC is a highly synergistic instrument, able to pursue science projects in collaboration with other observatories,” says Carramiñana. Together with its many partners, HAWC serves “the exploration of the sky observed with the highest energy photons.”

### **New Heights**

The observatory, which was proposed back in 2006 and began construction in 2012, is scheduled to operate for 10 years. “I look forward to the operational lifetime of HAWC,” Carramiñana says, highlighting the uncertainty of its mission. “We are not sure what we will find.”

On the basis of early runs during construction, Carramiñana expresses enthusiasm for upcoming discoveries. “The ten months of data of HAWC-111 have given us a glimpse, but HAWC with 300 tanks will surpass that very quickly and will show us new things.”

With all the mystery built into the deep, dark universe, beyond what we can see, our knowledge and ignorance sit in the balance. After our explorations in the visible wavelengths and other conventional astronomy, we are now set to learn about a hitherto hidden side of the universe.

Luc Binette, an astrophysicist at the large Universidad Nacional Autónoma de México, went to HAWC to film





footage for a media project. “It’s a remarkable place, beautifully representing our state of knowledge.”

More than 100 researchers from 30 partner organizations in Mexico and the United States collaborate on HAWC, with two additional associated scientists in Poland and Costa Rica. Prominent American partners include NASA’s Goddard Space Flight Center, the University of Maryland, and Los Alamos National Laboratory. Funding comes from the Department of Energy, the National Science Foundation, and Mexico’s National Council of Science and Technology.

In high-energy astrophysics, intense radiation comes from deeply mysterious sources. Researchers seek the underlying explanation. Powerful astroparticles pose among the biggest, oldest, subtlest questions in the field. What will HAWC see?

An unprecedentedly detailed and expansive view of the cosmos painted in hues of extreme energy – and possibly the discovery of altogether new types of celestial body.



## **To the Southwest**

Southwest, USA

March – July, Year Two

*After returning from Puebla to Mexico City, Eagle flew back to the USA. From San Diego, California, we travel through Las Vegas, Nevada to Flagstaff, Arizona by rideshare. Then, after checking out the Discovery Channel Telescope, Eagle gets a second bike, and begins the sweet ride down to Tucson.*

After flying back from Mexico, I went to San Diego, California. While in San Diego, I wound up spending considerably more time than expected, a few months total, writing up some of my research material and taking a step back to ponder. There, I made plans for the Southwest again – and they failed to materialize as idealized again. Still, I finally found my way out of the beautiful Land of the Lotus-Eaters, and traveled by carshare through Las Vegas, Nevada, and into northern Arizona.

In Vegas, I had a great time partying things up, and seeing the surreal sites. While staying there, I also got a glimpse of several alternative views of Sin City. After a while, I left the dizzying lights, continuing to fun outdoorsy Flagstaff.



In northern Arizona, I went to the Discovery Channel Telescope, had a few adventures, got a new bike, and almost got to the Grand Canyon. Then, back on two wheels, I zoomed along to the big desert cities down below.

### **Return to San Diego**

Getting back into San Diego, I explored. San Diego is like several cities in one. The downtown area, where the big train station is, has a few nice restaurants and shops. The city has a few other fun neighborhoods, but beyond comfortable walking distance. Then it's surrounded by other municipalities in metropolitan San Diego, *really* inconvenient to get to without a car.

A lot of military personnel live in San Diego, and both military and civilian airplanes fill the skies with loud, loud noise. A lot of hippies and travelers seem to get to this southwestern corner of the country, then never leave. As a result there are some very fun parties on the beach. The city also has many students, and medical researchers, and tourists, all with a lush metropolitan backdrop. It's one of my favorite cities.

One fun party I went to was a Rainbow Gathering on the beach. Rainbow events bring together youthful free-spirited people across the country. The community is lovingly chaotic, and somewhat private, so finding these events can take a bit of magic.

There, on the beach, before the party got started, a few people and I stumbled upon a baby seal. It posed for the camera, and was curious about people – perhaps a little too curious. I



thought it may have been missing its troupe. Sea mammals have evolved curiosity – it seems like a deep-rooted and valuable character trait throughout the animal kingdom. It especially helps youthful animals learn their way around the place.

In neotenous humanity, where curiosity is much more highly developed, the curiosity trait now helps us learn our way around modern society, a far more complex place than what baby seals face. And for adventurers and astronomers, who travel around extremely complex worlds – the planet and space, respectively – curiosity comes in extra handy.

Life is like a plant. Modern life is like a refined drug.

After finding the seal, we went over to the bonfire. Lots of Molly (ecstasy) was going around, along with pretty much every other drug on Earth. The party featured a drum circle with wild dancing, and a light show. With people acting merrily and foolishly, clowning around and climbing up the huge rocky cliff next to the sea, the fun went on all night long.

In the dawn light, some government agents drove onto the beach. Telling people over the megaphone that anyone still there in ten minutes would face a state penalty, the fuzz had drawn assault weaponry. One of the revelers, an old hippie who led in organizing the festivities, yelled back at them: “Fuck you! Shoot me first! Make me a martyr!”



While in San Diego, I heard some awesome music, especially electronica. I also got a lot of thinking done, taking the time to catch up on many thoughts that had gone unanalyzed during my previous year's travels. My first six months had taken me down the US coast, my second six months through Mexico. Finally, taking some time to unwind helped me to contextualize my experiences.

Travel takes a lot of attention, and often leaves many open threads. It takes a number of iterations with pauses to process, in order to keep on visiting new places and learning from fresh experiences. Even now, years later while editing this for publication, I continue to process and learn from my travels.

Likewise, what may seem like a small dome covering our home, the sky actually has so many trillions upon trillions of things out there that we can keep on digging deeper, probing farther, casting wider, analyzing harder, and coming up with ever newer, more invigorating, insightful, powerful observations.

The sky is the future and the backdrop, the material out of which we and our passion and dreams and hobbies and lives are made. It is us. And it's even there when it's sunny or cloudy out, and you can't directly see the magnificent firmament. Sometimes the greatest discovery happens inside your head and heart.

Curiosity drives us. Curiosity delivers us from the relatively sad and stagnant state of our ignorant past. Curiosity lifts us up to new worldviews, showing us truths or at least beauty about



ourselves, our home. By contemplating our travels, through space or around the planet, we augment our capabilities, for further adventures of love and discovery. True in astronomy. True in life. That's *Astrotripping*, baby.

I wound up spending a relatively long time in San Diego, several months. There, I wrote up "Birth of a Giant Telescope." I kind of wanted to stay in San Diego even longer – a common experience, as I often find myself very sad to leave a place, even when I've decided I'm ready to move on. How do you know when it's enough? It's so bittersweet to leave somewhere you enjoy, even in order to quest after greener pastures. Finally, I forced myself, if I didn't want to spend a whole year or more there. I still had a stronger desire to see the Southwest.

Time to go to Vegas!

### **Vegas, Baby!**

Still without a bike, I thought I'd try another mode of transportation. In ridesharing, drivers pick up passengers, who chip in for gas. It's sort of like Couchsurfing for transportation. I got in a car with a guy from India driving, and two Israeli girls and the infant daughter of one of them as other passengers. We drove to Vegas. It was a good setup for conversation.

The place in Vegas where I met my host had a huge fire-breathing dragon outside, and brightly flashing lights, and vendors offering fried fair foods. It was just a parking garage. Ho hum Vegas.



In Las Vegas, I stayed in a gated community. It was by far the most conservative part of the country I'd seen yet, after traveling down the left coast. Friendly people, one with an NRA hat, all self-declared "messianic Jews" of Christianity going to the Holy Land, talked with me about their views on religious and scientific matters. We ate and drank by the pool.

My host was a more left-wing European longhair, himself somewhat out of place in the community. A few other travelers also stayed there at the same time. A gay couple from Denmark, three young girls from various parts of the former Soviet Union, and more. Together we went about the town, which has its famous surreal variety of shows and lights and sounds and international tourists, in the middle of the vast empty desert. Vegas is so artificial and beautiful. It's a non-stop global party, in the middle of an otherwise deserted sprawl. And the views are nice.

The Las Vegas lifestyle is not the healthiest. It basically consists of all the appetite-pleasin' you can handle, and then more, and then even more. It's OK if you're there to experience the overload for a bit. After a few days, or hours, or years, depending on your temperament, all the flashing lights and buzzing sounds blur into an indistinguishable blob. Some people apparently get stuck in it, like quicksand.

At one point, we went to an all-you-can eat restaurant. The food was actually decent, and it's a chance to mix and match all your favorites, whether American or southwestern or the common American interpretations of international cuisines.



However, seeing some of the already obese people gorging themselves on even more food, obviously unnecessary, reveals the sadder side of excess. Likewise, “problem gamblers” pulling the levers zombie-like for hours on end, to the exclusion of even important life functions, reveals the ugly side of a city that has its own brightly lit beauty. We have human appetites as a means of survival and flourishing. When our appetites instead become destructive treadmills, it’s unfortunate. At least our appetites can make for some uplifting fun.

We went a few times to a club that operates as a strip club at night, and a pool party with a fleshy attitude during the day. During the day, they blasted loud music, including a catchy theme song. Stretch SUV limos delivered us to and from the place, which featured girls in bikinis and lots of drinks, including bottles of wine that went for fifteen hundred. People are creative in finding ways to spend their fun money.

If things are bigger in the US, then things are even *biggerier* in Vegas. An infamous restaurant offers double- and triple-bypass burgers, with free meals for patrons over three hundred and fifty pounds. Stretcher service is available to deliver the gourmand from the grounds. A regular coffee at Starbucks costs something like three bucks. (I know, it’s like that anyways...) Pretty much everything is more expensive, and they even have innovative services like oxygen bars.

I had a really good time in Las Vegas, and was ready to move on.





A whole lot of possibilities avail themselves to builders in this modern day and age. Whether you are building a city or an observatory, with today's tools you can free yourself from the restraints of previous eras, and basically reify your ideas into reality. The sky's the limit. No, the sky's not even a limit, when you can breathe fire into the sky twenty four hours a day, or watch the sky with robotic cameras that see millions of times better than a human eye. Now, you can do a good chunk of what you can imagine, even above and beyond the sky.

Las Vegas means freedom. The freedom to do what you want to do, be who you want to be. In Vegas it feels perfectly comfortable to have any kind of conversation with any kind of person you run into, and you'll likely encounter a very different perspective. In Vegas, there are practically no rules, your wish is the city's desire. And desire runs high.

Still, somehow, the rules of reality still hold, even in this marvelous city. As fantastic as a newly discovered phenomenon such as a gamma-ray burst is, it still follows the fundamental laws of astrophysics. And as amazing as a newly created city such as Las Vegas is, it still follows the basic customs of humanity.

Leaving Las Vegas, I went to the bus station. However, the scene was pretty awful. Overzealous security guards, ineffectual ticket vendors, a disastrously disorganized clientele, and very limited service. Outside of the touristy strip, the city of Las Vegas has plenty of poverty, and down-and-out



story-holders, unfortunately. I wound up doing another rideshare, this time to Flagstaff, Arizona.

Let's go! ☺

### **Route 66**

Flagstaff, Arizona, a college town in the north of the state, holds a famous position in astronomy. It also defies naïve expectations of the southwestern state. This mountainous area has a ski hill, receiving considerable winter snow. There isn't a desert full of cacti. Instead, there's a mountaintop pine forest, where I visited the Discovery Channel Telescope for "The Big Picture."

When I arrived in Flagstaff, I thought I'd be getting desert, cactus, sagebrush, tumbleweed – stuff that you actually find further south. A recurring theme of my travels is going in with naïve superficial stereotypical expectations, then finding the actual, subtle, complex, texture reality.

I think this is the human way. We form our ideal notions. These may start on the basis of real, experienced observations, yet they soon depart into a world of their own. In this world of ideas, our abstractions live independently, growing in their own way regardless of reality. Then, when the two worlds collide – fantasy and reality – we have to make the choice of how to go forward.

When naïve ideals triumph over new observations, we see blind ideology. Ignorant of the subtle details of reality, we can easily continue to plow forth in useless directions. It takes



open eyes and an open mind to discover a truer nature of reality. This applies to visiting new places, as well as observing new celestial objects. Sometimes a wonderful new find is just waiting for us to pay attention clearly.

On the other hand, going in with a rough approximation still helps us to formulate a more exact later impression. Starting with something, however imprecise, at least helps us figure out where to look next. And knowing where to look next is a big key to adventure – in the stars or around the planet. There are three simple steps to success, but no one knows what they are. OK, so there is no secret recipe, instead it's like an art or science – start with what you know, use your logical and emotional creativity, and hone or refine your approach. With experience comes improvement. People who make advances often have stumbled through enough challenges to develop a more nuanced, realistic mentality.

I ran into the same issue in Mexico, where I went in with visions that probably mostly came from kitschy Mexican restaurants up north in Gringolandia. The actual country is huge, diverse, and very different than its popular perception in other countries. Likewise, northern Arizona has very, very little in common with the common impression of the southwestern state. Instead of the hot desert, I found the mountainous pine forest with a ski hill, an artsy college community who dig pizza and Thai food, and a super-enthusiastic outdoor adventure population.



In Flagstaff, I met Caleb and Jody. Couchsurfing with them, I learned about some of the local culture. Caleb had an interest in astronomy as well as photography, and wound up going out to the Discovery Channel Telescope with me for “The Big Picture,” and taking pictures. Jody had lived in Africa, and shared a lot of her experiences.

I often find it extremely humbling to meet fellow travelers, who have done things and gone places so drastically different than I know. It’s a great way to learn – about life and traveling and various cultures. And people I’ve met along the way agree with me: talking or reading about travels is like taking an adventure of your own – it transports your imagination.

When we went out to the DCT, it was a big group drive. Along with Caleb and me went the public relations person at the telescope, and an engineer who provided deeper technical insights. Also, a reporter and a photographer with the local paper went along. We piled into a couple of observatory vehicles and drove off.

It took about an hour to go each way, and during the drive we chatted about the telescope and more general topics. Often I go out to remote locations where I’m the only writer on the case. At times, though, there are others. At one of the sites I went to, a biomedical lab back in San Francisco, it practically felt like a big press conference, with an AP cameraman shooting video, and media people moving about.

After touring the telescope, we drove back to town, and I continued my adventures. While still in Flagstaff, I went for a



fun run in the sun, which turned into a heavy downpour of rain. At one point I stopped at a hot dog place and had a delicious breakfast burrito, even though it wasn't breakfast time. The place, on Route 66, is the inspiration behind the Eagles song "Take it Easy," which I just heard again while writing this chapter up a long time later. Life is a highway, the long and winding road.

Next, I planned to rideshare down to Phoenix, and get another bike. However...

### **New Bike!**

Finally, after a long wait – well, I considered the time a form of riding without a bicycle, so really no wait at all – I got a new bicycle in Flagstaff!!! It made me extremely happy.

I had planned on getting a new bike in Phoenix, a far bigger city, but I found a very bicycle-friendly community in Flagstaff, with plentiful options. I'm very glad that I got the bike in Flagstaff, as Phoenix actually turned out not to have much of a bicycling culture, despite one very enthusiastic rider who greeted me downtown on his pimped-up bike that looked like a tourer, with its big flashy lights, although it was only for local riding. By the way, sometimes it can be hard to visually distinguish a global bicycle tourer from a local homeless person. Anyways, new bike!!!

The bike I got was from a place called *Bici Mundo* (Bike World). Operating in the large front yard of a house, dozens of bikes sit on display there. The shed-turned-into-a-workshop



features a poster with a famous picture of Einstein riding on a bike, with his famous tongue sticking out.

The bike mechanic, who also plays polyrhythmic drums in a group that I heard in the charming town center, helped me assemble a new bike. Starting from an old mountain bike frame, vintage unknown, we turned it into a new superstar set of wheels. Now I call it a Rorschach bike, because everyone who looks at it sees what they want. People keep asking if it's a different make. It's ugly but it works. Those painful yet helpful five words can get a lot done.

I personally hold onto the philosophy that a bicycle provider, be it a friend or vendor or mechanic, is like an angel of some sort. A seraph? Is the bicycle provider even an earthly human? I do not know. They have a way of converting a small number of ordinary parts, to all appearances made out of regular materials like steel and rubber, into a kind of beast, a machine, a something magical that transcends mere ordinary mechanical parts, and is like a part of oneself. It truly becomes an appendage, a new limb, an extension of the mind. Pure, raw, life. The bicycle joins the life of the rider.

Wow!

If you dislike humor that gets carried away with itself, you can skip the next paragraph (the bike works).

The mechanic put together the bike. He got a little bit annoyed at my persistence in questioning every aspect of the magical process. I insisted – not merely on the highest quality



components, which I could not afford anyways – but on the best fit, or value, or some other set of constraints not clearly defined. We started with a steel frame – I could not handle aluminum again, not after some of the travesties that I had previously encountered in my riding during which the weaker, although lighter, metal had failed structurally, and not succumbed to repairs, leaving me up a tree. We put on a basket at the front, into which I could deposit and out of which I could withdraw my backpack, almost at will. And – get this! – we actually... added *three* water bottle carriers! Not just the more common one or two. And bar-ends for the handlebars! And... oh yeah!!!!!!! Arguably the best of all... I had long despaired of not ever finding a place sufficient to hold onto my precious cargo of belongings, most especially the large sleeping bag and camping tent into which I nightly deposited my person in order to catch a good night's sleep of a few zzzzzzz's. And here – the mechanic spoke almost wistfully, with almost a tear of regret, at least in this author's humble perception – “Sorry, all I have left is this” – and he pointed to a probably cheaply made saddlebag aka pannier, by which I mean to disparage the saddlebag aka pannier, and in no way to disparage its maker nor its vendor nor his workshop of wonders – “I haven't been able to sell it. It originally retailed for” – and here, I must digress again, to mention that I don't know or remember the exact price he named, only that it was an outlandish sum, for so poor a bicycle traveler as myself – “but because I can't get rid of it, you can have it for only \$20.” Upon hearing these his fabulous words, my heart nearly leapt out of my chest, and into his waiting arms. I tried putting my



tent into the pannier. It fit. Looking nigh-on-despairingly at the little remaining space in the said saddlebag, I wished earnestly for my sleeping bag to fit, too. I didn't dare. "Oh look," said the magical being, this worker of great mechanical deeds. "We could just snuggle this in tightly." And here he conducted a maneuver, which I shall not endeavor to describe in mere words, those conveyors of experience-representational sounds with which as you now know I am hardly handy, dear worthy reader. Nevertheless, the end result – and I nearly weep with tears of joy as I write these very words, my heart weary with the efforts of a long, caffeinated struggle to express this powerful impression of life into only a handful of assuredly insufficient phrases... at long last, dear honored reader... the sleeping bag fit snugly into the saddlebag right up next to its friendly camping tent.

Wow!

Having a new bike felt fantastic!

Flagstaff, which has a significant bike culture, hosts many bike stores, lots of bike lanes, and plenty of enthusiastic riders. At one of the bike shops that I went into, they even had a bike café! At a counter in the back corner, they made espresso drinks. I had a Mexican mocha, which the mechanic made delicious with spices. Other bicycle-friendly towns have their own unconventional tie-ins, like the Bike Church in Santa Cruz, California. The bicycle is no mere toy. In fact, I now think of it less as a "bicycle," and more as a "happiness machine."





Ah.

### **Gateway to the Grand Canyon**

To people outside of the astronomy community, Flagstaff is probably most famous as gateway to the Grand Canyon. The Grand Canyon is far enough away from town, however, that it would've been convenient to go by motor vehicle. While in the area, I made a few attempts to get out there. I wound up not making it out to the GC. Gah.

At one point, I went to a youth hostel where they arranged rides out to the Grand Canyon, although I didn't go on one. Lots of fun young folks hung out in the lobby. I met a Kiwi, a New Zealand guy, in town for a research conference. I also met a young lady from New Zealand. The two soon started figuring out all the friends they had in common. Small world. Small country, anyways. We chatted a while. The guy was going to the Grand Canyon later in the week, although our plans didn't mesh.

Some more people came by the hostel. One young lady stumbled by ataxically, looking drunk. We chatted a bit. I think she was sober. She started flirting with me. We wound up stumbling through town together. We went to an Irish pub, then this scenic garden place. She told me all about her spirituality. Lots more of that to come in Sedona, where she even knew a shaman.

Flagstaff is a beautiful town. It's like the northerly cousin of Tucson. Both are quaint small cities, with colleges, mountain backdrops, bike culture, and cool people. And both are funny



travel hubs in the middle of nowhere. Despite being many miles from the nearest big city, Flagstaff attracts crowds from lots of countries. It's got the Grand Canyon, of course. It's a big stop on Route 66, the Mother Road, the original interstate highway. It's also got like five or ten other highways running through town, and a big railway. Place makes the place – location often defines a city or town, not only location with respect to its geographic terrain, but also relative to other population centers. Likewise, Earth is only as fun as it is because of its location, where life forms like us can survive.

While doing a bit of shopping in Flagstaff, I met a shopkeeper with an accent. *Australian?* I thought to myself. We chatted a bit. Turned out to be from Paris, Mississippi. Oops. Ah well. She told me about a good food place in her hometown that I planned to go to, but didn't make it. Sometimes things don't pan out as we had dreamed. It's important to acknowledge those failure, as much as to celebrate the successes. Whether through changes in priorities, insufficient efforts, or for whatever other reasons, sometimes we don't achieve our goals. We can often learn lessons for the next time, anyways.

Travel is a mindset. It's an outlook. Same goes for home. It's a concept. You can travel, and/or be at home, anywhere. You can travel in your own backyard, if you have one, and you can be at home way up in some mountain in the middle of nowhere. These ideas relate to how you see the world and your place in it, rather than to geography. And travelers attract each other, everywhere. Like how like attracts like. People who feel "at home" also attract each other. How comfortable do you



feel with yourself? Often we go to great lengths only to discover ourselves. I think that *Astrotripping* is a book about travel and astronomy as ways to find oneself.

Two of my main motivations when I set out on this *Astrotripping* adventure were to learn about the external world around me, and the internal world within me. Flipsides of curiosity. It turns out that they have a lot in common. And in the course of my bicycle travels to space science research sites, I feel like I did learn a lot about how our world works, and what I value in life. By the way, we all share some basic drives, goals that we want to achieve, often revolving around food and sex but also involving other aspects of culture. We evolved to have these drives, as they make us move better, see more, travel farther, at a basic physical level. Same as how the stars have gravitational drives to travel around in circuits, or how scientists have curiosity driving them to investigate the stars.

I stopped in at a pub, and caught the end of Germany embarrassing Brazil at the World Cup.

Some people go a long way out of their way to get to the Grand Canyon. I heard of an East Asian traveler, who arrived without a word of English, in the dead of the night, and paid a large sum in order to be taken out to the show, snap a few pictures, and then be taken back. Apparently it was worthwhile.



People go to great efforts to reach some big goal, like seeing the Grand Canyon, or winning the World Cup. And don't always make it.

Also, people look really hard to find the next huge discovery in astronomy. Researchers want to be the first one to find a new type of object, the next exoplanet or supernova or quasar, or extraterrestrial intelligence, or some other discovery new to humanity. Yet, often these discoveries come about by chance rather than through a carefully thought-out effort that works exactly according to plan. And, conversely, often the little things that crop up by surprise along a carefully planned effort prove to be the most rewarding.

We don't always know what we want. Again, I think that it's important to go out on these big quests, in space or on Earth. It's a great starting point, to go off searching for some exotic new worlds. Then, when we get there, maybe we'll come across an outrageously huge and important new thing, by plan or by chance. Or maybe we'll see a simple, almost universal truth. Either way, we find out, and learn – a lot more so when we change our surroundings. By getting out of a comfort zone, by losing our usual contexts and the resources upon which we depend, it forces us into new postures, positions, and new ways of being. And these new ways of being enable new possibilities – new discoveries, interactions, ideas, lifestyles. Imagine flying for the first time – your view, your dreams, your life would change.



Back on Earth, in Flagstaff, Arizona, I tried again to go to the Grand Canyon, however that didn't happen. I figured some way would crop up. It would only be a matter of time. Meanwhile, I went about my life. I had a lot of writing to do. I had more places to go to in the Southwest. Anyways, there are bigger canyons. And I can always go back. And there are a million more excuses!

I wound up not seeing the Grand Canyon. And it's OK. Things don't always pan out, but try anyways.

Carry on! ☺



## **The Big Picture**

Discovery Channel Telescope, Flagstaff, Arizona, United States of America

July, Year Two

*In the forests of northern Arizona, the Discovery Channel and Lowell Observatory combine forces to open a large private telescope. It will conduct big observations on small objects, and it forms the basis of television programs. The new Discovery Channel Telescope now commences observations for science and communications. Its massive camera transforms how astronomers image celestial objects.*

Northern Arizona gets a lot of rain and greenery – especially in monsoon season. Near the town of Happy Jack, the new Discovery Channel Telescope rises above the ponderosa pine forest. Within, an innovative brand of camera combines science and communications, and creates tomorrow’s standard for astronomical imaging.

As the telescope undergoes commissioning, it gathers early data. Astronomers use the revolutionary camera to shoot tiny galaxies and Kuiper belt objects. The Large Monolithic Imager, an immense CCD camera, is its first and currently only operational instrument.



As spectrometers come onboard, the megacamera will continue to serve as the main instrument on the cool new telescope. Its results will inform astronomers and the general public about our cosmos. The sensor technology advances the state of scientific research and educational programming, and will soon serve on many more telescopes around the world.

### **Discovery Telescope**

Near the gateway to the Grand Canyon, the area surrounding the Discovery Channel Telescope (DCT) has a serene majesty. The device itself, first conceived in 2003, was built between 2006 and 2012. At its first light gala, astronaut Neil Armstrong made his final public appearance. The DCT, measuring 4.3 meters and costing \$53 million, ranks as a major astronomical facility. The telescope is run privately by a partnership that includes the Discovery Channel TV network and the renowned Lowell Observatory, as well as several universities.

Together, the group “wanted to build the biggest telescope that could do the most diverse science for the budget,” according to Kevin Schindler (Communications Manager, Lowell Observatory).

Since getting underway, construction has gone somewhat smoothly. Although the secondary mirror cracked during construction, it did not set back the schedule significantly, and the \$200,000 replacement cost was not prohibitive.

Bill DeGroff (Project Manager, Discovery Channel Telescope), a former Air Force officer and aerospace engineer, points out the optical encoder, which guides the telescope.



“The resolution is two thousandths of an arc second,” he says. The primary mirror reaches a very acute precision of 0.6 arcseconds. And a thin 100 nanometer aluminum coating provides extremely bright reflectivity. “To put that in context, that 100 nanometers is the length that a human hair grows in 25 seconds.”

The adaptable DCT most commonly uses a Ritchey-Chrétien configuration. At its heart, the telescope holds an instrument cube, which conveniently switches among the different detectors. Light reflects off the large primary mirror, to the focus. Astronomers can use a camera here. Typically, however, a secondary mirror bounces the light back through the primary, into the aluminum instrument cube. The cube then lets the light through into the large camera. Fast-folding mirrors also let astronomers flip the light over to a spectrometer, or to some combination of instruments.

The building, which looks like a tall modern shed, reaches around eight stories, of four thousand square feet each. The primary mirror weighs 3,000 kg (6,700 lbs), while the overall mount assembly totals a whopping 180,000 lbs. With its monstrous metal structures and profusion of colorful wires, the telescope feels like it could come alive.

### **Double Trouble**

The Discovery Channel Telescope’s large field of view provides for versatile observations. The resulting information serves two causes together: science and communications. The wide and deep optics do surveys of dim objects. Meanwhile,





the beautiful imagery helps convey the wonderful immensity of space.

Astronomical targets include Solar System objects, stars, and galaxies. The extremely fine photography yields scientific insight into hidden depths. Looking at a newly discovered asteroid, Schindler notes, “the telescope was actually larger than the target.”

The telescope design allows it to perform a flexible range of research. While not the biggest dish, nor the fastest scanner, the atmospheric seeing-limited scope can conduct investigations across the whole gamut of visible-wavelength research. And its results feed television and internet programs. A 60-minute 2012 television documentary, “Scanning the Skies: The Discovery Channel Telescope,” describes the telescope’s construction.

This is not primarily a scientific telescope, nor is it primarily an entertainment attraction. Instead, it is a hybrid. It is the most important research telescope at a major observatory, and it is also a mainstream media platform. The first, and so far only, operational instrument is the massive new camera, which will transform the way we see the stars.

### **Megacamera**

While the Discovery Channel Telescope uses a variety of innovative technology, the highlight is its sensor, the Large Monolithic Imager (LMI), a new breed of camera.



Astronomers mostly use CCDs, small chips that convert light into electronic signals. To make larger images, conventionally researchers tile a set of CCDs into a grid. However, this creates gaps, which introduce technical challenges while severely limiting sensitivity.

The monolithic design, which puts the entire sensor on a single, larger chip, comes at a cost. After a lengthy and expensive research effort, though, it can pick out contrasts in brightness an order of magnitude better than the competition, dramatically improving observations. What took months or years to record, if even possible, now takes mere weeks.

As plans congealed for the Discovery Channel Telescope, it dawned on the designers that the TV network would want more image quality than any existing astronomical sensors could provide. To create the appropriate “pretty pictures” would require a megacamera.

With design in hand, the LMI inventors went to British technology firm e2v. An engineering grade sample of the megacamera wound up working perfectly, so the observatory now has two of the devices to play with. The chip looks like a much bigger version of existing CCDs. Complex arrays of hardware and software control the camera. 36 million pixels, each one exquisitely sensitive, let the LMI photograph celestial objects like no other device. With its anti-reflective coating, a dark face conceals the subtle sensor.

A camera must maintain an accurate and consistent level of brightness across its pixels. On a mosaic of smaller chips, each



chip has a different brightness, and the process of “flat-fielding,” or calibrating across chips, devastates efficiency. With the LMI, a simple and effective calibration yields excellent sensitivity. Astronomers measure the very even dark sky right after sunset, and reset the sensors with respect to twilight.

Of the half degree of light coming into the telescope from the sky, the LMI covers a diameter of 12.3 arcminute field of view. With the remaining light, auxiliary detectors point the telescope and correct the surface, explains Tom Bida (Instrument Scientist, Lowell Observatory). “Imagine you have the primary mirror looking up at the sky, and it’s got 120 actuators on the back of it. The telescope tilts over, and it wants to fold like a potato chip.” The actuators counteract that tendency, using the auxiliary light.

Sitting snugly inside the heart of the Discovery Channel Telescope, the Large Monolithic Imager opens new windows on the sky, revolutionizing how we see.

### **Large Format**

The new camera changes the game for astrophotography. The professional field’s current predominant format is a rectangle of around an inch by two. The Large Monolithic Imager is a four inch square. Six thousand pixels of sixteen square nanometers fill each side. And some scientists foresee an even bigger future.

Phil Massey (Astronomer, Lowell Observatory), the principal investigator of the megacamera, came up with the design for



the million dollar device. Until now, manufacturers did not make cameras this big. The DCT plan therefore included a mosaic of smaller cameras.

The observatory director tasked Massey with developing a massive new instrument. After struggling with funding rejections, he says half-jokingly that “the timing was getting late enough that it was possible that if we didn’t get funding in the third year, we’d have this new telescope and have an eyepiece.”

Massey now uses the megacamera to look at Wolf-Rayet stars, very massive stars that blow away colorful cosmic material spectacularly. He moved to Lowell from the National Optical Astronomy Observatory at Kitt Peak, further south in Arizona. And his wife, also a Lowell astronomer, suspects that current star formation theory is wrong – although still with scant evidence.

“It’s hard, going down to a level of illumination that’s many, many times fainter than the night sky,” says Massey. A better camera, among other benefits, can collect data from dim dwarf galaxies, and find out if in fact stars get born in sparse areas, as a heterodox hypothesis suggests.

The innovation heralds a new standard, Massey proclaims. “The cost of one of these is comparable now to making a mosaic of CCDs that occupy the same space, so already no one is going to do that anymore.” Even existing observatories can make big gains by upgrading. Moreover, as the large format



goes into wider production, costs will drop, and astronomers can then tile them to make *really* big cameras.

A grid of the big chips, totaling over a foot per side, harkens back to photographic plates, which have the size of vinyl phonographs. The old analog films, using chemical emulsions, only responded to a tiny portion of incoming light – 1% instead of a CCD’s 90% – and easily got overexposed, among many limitations. The large format CCDs, by contrast, have efficient electronic imaging, taking us into a new age with broad *and* deep surveys.

### **Showtime**

The large format camera results in new scientific capacities, observing from the nearby Kuiper belt out to distant galaxies. The media-friendly instrument has already snapped some beautiful imagery, for example sharp photos of the barred spiral galaxy M109. The megacamera has also shot the Whirlpool and Sombrero galaxies.

The flexible LMI focuses on the formation of planets and the development of dwarf galaxies. Early analyses include hundreds of transneptunian objects, which orbit outside of the major planets, and closer comets that may threaten Earth.

Alongside the big camera, an infrared spectrograph will join the instrument cube on the DCT. With a dichroic (two-color) beam splitter, simultaneous snaps by both the optical camera and infrared spectroscope will let astronomers compare the spatial and spectral distributions of incoming light. And a large assortment of complementary filters will fit any purpose.



Looking far away from the dense cores of galaxies, away at the hazy edges, stars surprisingly form here. The LMI has the sensitivity to tell us what actually happens in these obscure corners. In high definition, we can watch stars and galaxies grow, and get a better sense of how the universe evolves.

The Discovery Channel Telescope, with its revolutionary Large Monolithic Imager, bolsters astronomical capabilities while making hidden corners of the cosmos more visible. These innovations inject vigor into astronomy in the Southwest, while spreading new light to astronomy enthusiasts around the planet. A new telescope with a new era of camera shows us the big picture.



## **Center of the Universe**

Arizona, USA

July – August, Year Two

*After Flagstaff, with a new bicycle ready to roll, Eagle rides down to Tucson. The route takes us through Phoenix, as well as a whole lot of ecological beauty. Getting back in the saddle feels beautiful. We have a lively yet tranquil time in the friendly city of Tucson. And then from Tucson, the opportunity to go onward to many of the most spectacular telescopes on the planet.*

From Flagstaff, Arizona, I rode down through Sedona and Phoenix, into Tucson. Tucson is in many ways the center of the astronomical universe. Furthermore, it is a very fun city. With its college in the heart of town, it attracts a youthfully energetic crowd. Combining all the astro people together with a bicycle friendly culture in the Southwest, Tucson was just about perfect!

The ride down the mountain from Flagstaff to Tucson was itself wonderful. Along the way, I encountered many cool people while experiencing the splendors of Sedona, Phoenix, and a handful of other desert towns. In the summertime, this was a hot ride.



After getting to Tucson, I bounced around the city a lot, exploring the town between visits to top observatories. I felt the living energy of a main hub of the global astronomy network. Finally, with new insight and inspiration, I set off from Tucson, deeper into the Southwest, crossing out of Arizona.

### **Wonder Ride**

Setting off for the big cities of Arizona, my first leg would go from the forest peak of Flagstaff down to the flat desert below. The ride from Flagstaff to Sedona was one of my favorites in my whole life.

It was my first long ride in ages. It was with a new bike. It was *puro descenso*, purely downhill. And it went through incredibly beautiful scenery. Any one of these alone would have made for a spectacular ride, and they all built upon each other holistically, like the rivers all flowing together into a great sea of wonder and joy.

The whole ride took on a kind of magical life, as I flew down the mountain road. The mountains running down here, which start all the way up in Colorado, were carved out over the eons by streams of running water. The resulting rock formations look like some kind of alien planet. With the glorious sunset, beautiful hues surround the rider, making for an enrapturing experience.

Wow!





As I swooped through the many layers of life, the different levels of mountain ecosystems, while inhaling the fresh air, a forest filled my nostrils with a heavenly smell of wood smoke. It sent my mind reeling.

Going by the occasional rustic village, I figured some people were having a campfire. The smell also reminded me of delicious food. As I kept going, for mile after mile, and the smell continued, I wondered what it was. When I finally got into Sedona, I was asked about the forest fires. Ah, ha! Well, the smell practically made the whole forest fire worthwhile.

Getting into the busier parts of the road leading into town, I got to a portion of the road full of switchbacks, short steep sections that repeatedly turn back upon themselves. Here, rather than the smooth easy cruising down the longer shallower slopes, it turned into a middle-of-nowhere traffic jam. I stood astride my bike, waiting in line with a column of vehicles.

Riding down on my brakes, I could gradually pull through the switchbacks. As the traffic picked up again, the road straightening out into a longer, faster ride, I could cruise without pushing, at around the same rate as the cars rolling in front of and behind me. It felt great to ride so effectively. Wouldn't it be awesome if all bicycle riding were downhill through beautiful terrain?

Well, I guess you've got to put in the uphill to get the downhill. Unless you buy your bicycle in a charming small town on top of a mountain. Quick piece of advice: buy all of



your bicycles on top of mountains. That way, you can just cruise downhill for seemingly endless miles, without doing any of the hard climbs.

Seriously, though, climbing uphill is great exercise and can be really fun. Plus, you then appreciate the downhill thrills even more. This is like the basic physiological metaphor for life. You strive up a challenging hill, sweating and having some fun. Then you get a really great view from the top for a little while, before rushing back down. And then you find yourself in a spiritual mecca where the rocks are alive and people listen to vortexes.

### **Spiritual Sedona**

Sedona is a special place. It is the site of several New Age vortexes. People there will tell you all kinds of things about the local magic. Some of the vortexes heal, other give strength, and some can be dangerous. At least, according to my experiences.

It's such a beautiful town, everywhere you go in town you get surreal views of the rocks. The same kind of rocks that garnish the ride down the mountain, adorn the town of Sedona. Many spiritual tourists flock to the place, coming to experience the flowing powers for themselves. There is also a beautiful church built into the side of one of the rocky cliffs.

With so many tourists coming to such a small town, the place is expensive. A lot of residents are interested in ecological activities, perhaps because they live in such precious surroundings. Wherever I've come across a lot of



environmental activism, it has been concentrated in scenic areas.

While in Sedona, I couchsurfed with Sky – our names made for a good match. Sky is a cool character, he has traveled to a lot of countries, and he makes delicious food and beverages including a custom water and a coca tea – the latter derived from the cocaine plant – and he drives a custom electric Porsche. You meet a lot of unique fellow travelers on the road of life.

In general, I find that travel attracts a lot of like-minded people. While previously living in one place, I had often felt a little unusual compared to the more settled part of the population. I had my own dreams, ideas, desires, which often differed from the statistical norm. In traveling, I have met so many other people who share this drive. We seem to attract each other, to create our own, new social groupings, regardless of however spread out around the globe. The club of open-minded people. In what kind of community to do you feel you fit?

Sedona has its own uncommon community, a place where New Age beliefs find support. While riding out of town, I went by one of the vortexes. It was an unusually shaped rock jutting out of its surroundings, spiraling like a Seussian dreamscape. Many people living and visiting here ascribe supernatural powers to the rocks. Right as I was riding by, my bicycle started to have mechanical problems. Then a wheel stopped rolling. I was stuck.



Getting off the bike, I inspected the damage. The rim rubbed up against another part of the bike. A similar issue had come up as we were setting up the bike back in Flagstaff. Amid the local rocks, I found that if I held the rear brakes in a place with enough space away from the wheel, then it would roll. So I propped the parts in position with a piece of the red rock. It held long enough to get to a nearby bike shop.

It turned out that my rear wheel was the wrong size for the bike! A mechanic inserted a small piece of metal to replace my jerry-rigged red rock. A lot of these makeshift fixes seem to hold things together well enough to carry on, which is often all that is necessary.

Anyways, the timing worked out fortuitously. I rode on to Camp Verde, AZ, where I stayed with a man who had done some bike touring. A blacksmith, he had gone riding to Alaska to teach blacksmithing workshops. He joked about building a hollow replica anvil, and dragging it behind his bike, so that as he zoomed by slower riders they'd wonder, "What the...?!"

Gordon, the blacksmith, made me a steel eagle in his workshop. The fork ornament adorned my bike. His garage has a full blacksmithing shop, which is amazing to behold. With furnaces burning, tools galore, and the blacksmith himself pounding away, cold metal comes to life.

After that, I kept on riding, down further, all the way down to Phoenix.

Rock & Roll!



## **The Phoenix Rises**

At first I was excited when I got into Phoenix. Then mystified. Then bored. Then I had a good time.

Phoenix is a big, flat city. From the time I hit the city limits, until I got to downtown – which still leaves the other half on the way out – it was like three hours of non-stop riding. That could be a solid day trip out in the countryside. Yet, here, you get to go through the seemingly endless expanses of low-built residential neighborhoods. There's nothing around Phoenix other than empty desert, so the city has just kept on growing outward. The city goes on, and on, and on, and on, and on. Sometimes limitations and constraints can help guide growth.

When I first arrived in Phoenix, I had hoped to find more of a thriving scene. The place was mostly empty, even downtown. Only a handful of people were out in the huge area. I felt like I was walking around in a ghost metropolis. To be fair, it was summer, and summer in Phoenix gets hot. But basically the coolest thing I found on my own was the electric light rail, which looked like it ran smoothly. It was pretty cool. Oh yeah, also a lot of the bigger buildings sprayed water on their outside guests, to help cool down. I'd never seen that before.

Sorry, this is like the most interesting I can come up with to say about Phoenix.

Then I couchsurfed with a Navajo chef! Actually, I couchsurfed with his roommate, because the host himself was almost never around while I was there, so we only met briefly. The roommate showed me some of his own artwork. This



neighborhood at least had more of a cultural vibe than the rest of the highly commercial city. Incidentally, I wound up later on, in Texas, running into a former Phoenician who had known the Navajo chef and that art crowd. People live in small-world networks.

I had originally planned to spend a few weeks in Phoenix. I mean, a huge city in the middle of the desert – how cool is that?! But without much for me to do there and then, it seemed better to continue towards Tucson. Sometimes you discover on the road that your initial plans no longer make sense, and it's important to adapt. On the way out, I rode through one of the many metropolitan municipalities, Tempe, which has a college and some attractiveness. Mostly, though, I found the Phoenix area too sprawly for my tastes, preferring the accessibility of Arizona's lovely smaller cities.

Next up: Tucson.

Let's go! ☺

### **Astronomy Town, USA**

I carried on, to Tucson. Tucson is everything that Phoenix isn't: A small, navigable, liberal town.

Arriving in town, I effortlessly found beautiful neighborhoods, gorgeous backdrops, friendly cyclists, and way more than a handful of astronomy items of interest.

The city of Tucson actually seems in some important ways organized around astronomy. This place hosts many of the



most important astro facilities on the planet. The University of Arizona, which sits conveniently in the heart of town, has several large buildings competing for astro people. The nearby mountains host dozens of telescopes at numerous major observatories. These include the Vatican Observatory (“The Mind of God”), the Large Binocular Telescope Observatory (“Big Binoculars”), and the National Optical Astronomy Observatory (“Digital Astronomy”).

From the city, I went on a couple of excursions to visit these observatories, in addition to the touring and interviewing I did around town. Kitt Peak, the national optical astronomy hub, hosts so many telescopes that it’s hard to keep track of them, and it feels like an astronomer’s paradise. Mount Graham, by contrast, hosts just a few large modern instruments, yet also does astounding observations. We drove up the former with a couple of guides to show me around, while the latter was a grueling bike ride up to over 10,000 feet.

Tucson also hosts the Steward Observatory Mirror Lab. This facility, located underneath the University of Arizona football stadium, casts and polishes mirrors for many of the most impressive telescopes on the planet. I had a chance to go through the laboratory, seeing their innovative technology which looks kind of like Zambonying a hockey rink.

I met lots of great people in Tucson, it’s a friendly town worth visiting, if not living. Personally I rank it up there with San Diego and several others among my faves.



Among the people I met there were Jay and Megan, and their young baby Ann. Jay, an engineer, had previous bike touring experience. Megan, a high school physics teacher, allowed me to speak with her students about space science and adventure travel.

In Tucson, I surfed around, also staying with another small family, a U of A student, a young cyclist, a retired couple, a group of young guys, and a left-wing female activist lawyer. With the latter, we went to an immigration rights event. Afterwards, some of the other attendees came back to the house, to dance and play music. I learned some Cuban salsa moves, and tried my lips at the didgeridoo. There are many cultures to exchange experiences with. That's a benefit of traveling, but also a key strength of the US. This country combines so many different viewpoints, arguably as does nowhere else on Earth.

Tucson, along with its surrounding area, is one of the most wonderful places I've been, both geographically and culturally. The state of Arizona reverses a common pattern. Often, small and spread-out conservative towns surround a large and dense liberal city. However, in Arizona there are small liberal college towns, like Tucson and Flagstaff, around a large conservative city, Phoenix.

Southern Arizona, along with Southern California, resonated with me. The two regions share much in terms of culture and geography. The dry warmth, the mountainous beauty, the intricate urban depth, the friendly cosmopolitan people, the





wide open space. For astronomy and for artistry and for lifestyle more generally, these are two brilliant hot spots.

Lucky to be here!

### **Bikes and Trinkets**

While in Tucson, I went out for exercise a few times. Running felt amazing, with the lovely sunshine and palm trees and mesquite trees and cacti and interesting insects. I found some parts of the city reminiscent of prehistoric dinosaur times, with tiny little lizards darting across my path. I also went on a bike ride that spontaneously turned into trail riding, when I encountered an area where some humorous riders had set up courses including things like repurposed hardware to make a playful amusement park: Fantasy Island.

I also went for a run with a guy I had met in a local café, Gavin, and a friend of his, making three. We drove up to Mount Lemmon, on the outskirts of town. Tucson is surrounded by mountains, making the city easy to navigate. Just look around and see which way you're facing! On the drive up, a state agent pulled us over. I assumed it was because Gavin was riding in the back of the pickup truck. So I sat waiting for it to be over with. But all eyes were on me.

The officer looked in at me through the passenger window. What did he want? He wanted to know why I had leaned out the window, while we were driving. I had leaned out the window to ask Gavin to pass me the blacksmithed eagle from Camp Verde, which had come off my bike when we turned the bike upside down to load it onto the truck. I had not yet affixed



the eagle to the bike, and didn't want it falling out of the pickup.

The agent went back to his vehicle, and called dispatch. After we had an unusually lengthy wait in the pickup truck, he returned, handing me the metal eagle.

“You can handle the trinket,” the officer said.

We drove on. Due to the delay caused by the law, we got up the mountain later than foreseen. Our “hike” turned out to be a run. I hadn't come prepared with water and phone GPS and other important supplies. Partway up, I felt like it was a bit risky, although it felt fuckin' great.

On the way back down, Gavin's friend stopped, tripping over himself. He had made the fall-resulting effort in order to avert a giant, hairy tarantula.

We picked up the tarantula and took some photos. We talked about travels, life, LSD.

An idea I had, inspired by these times, was for a new kind of event: *ultratipping*. Participants drop acid, which has an active duration of around twelve hours, and run an ultramarathon, which lasts around the same amount of time – coincidence?!

Back in Tucson, while I was at the lawyer lady's place, we did some house upkeep, such as cleaning and improving. Part of this involved spray-painting, so I gave my bike a bit of a yellow coat, to make it more aquiline.



At a bike co-op in town, which reminded me of the Bike Church in Santa Cruz, California, I got my eagle affixed more permanently to the bike. (Later, in New Mexico, I wound up getting it attached yet more firmly. Bike setups are ever-evolving, like life.) The co-op has a collection out front of sculptures and furniture made out of old bicycle parts. And people can come in and earn credits by doing work on bikes. And the place very progressively supports a variety of sexual and cultural groups. It felt like a welcoming community.

Meanwhile, some of the lightning storms in Tucson were simply amazing. Lightning would flash down thunderously, amid pouring rain, repeatedly for hours, lighting up the sky. Tucson is a spot with exceptionally suitable conditions producing frequent lightning, which scientists come here to study. I rushed through the storm into shelter. After the storm, it would be time to move on. Bittersweetly.



## **The Mind of God**

Vatican Advanced Technology Telescope, Mount Graham,  
Arizona, United States of America

August – September, Year Two

*The Vatican built its big telescope in southern Arizona, in the heart of the astronomy world. Using the first of the new Mirror Lab mirrors, the device mostly studies phenomena around our solar neighborhood. Nearly half a millennium after Galileo, the Vatican has changed its views on cosmology, although philosophically it still sits obliquely with mainstream astronomy.*

The Catholic Church has had a conflicting, complex relationship with astronomy. In snowy southern Arizona, atop Mount Graham, near Safford, not too far from Tucson, a new story takes place. Here, amidst the densest cluster of advanced astronomy in the world, clear dry air contributes to good seeing conditions. And it is here that the Vatican built its newest, major telescope.

Here, unburdened by the usual cycle of funding applications, astronomer-priests pursue a diverse mission that ranges from asteroids and meteorites through stars and galaxies to cosmology. The ultracompact telescope can do surveys very



well. It scans the skies for small, subtle objects, meanwhile taking in larger-scale structure.

The Vatican has had a hand in both creating and repressing astronomy – according to some. Now, it runs an important telescope facility in the Southwest. Why does the Vatican operate a big, fast telescope on the mount atop the desert? Its observational program plays a role that connects it with hundreds of years of history.

### **The Pope and the Astronomer**

Over its lengthy history, the Catholic Church has interacted closely with astronomers, going back to Galileo Galilei and before. The Vatican notoriously tried at the Inquisition, arrested, and censored Galileo. However, the Vatican has also had a collaborative connection with astronomy, contributing important insights since the early days. The Vatican became especially interested in astronomy due to inaccuracies in its calendar, which became apparent while scheduling Easter. This resulted in the development of the Gregorian calendar in 1582, which we still use today. How has the Church's position vis-à-vis astronomy evolved over time?

Early astronomy got its start in classical antiquity. Ancient civilizations around the world, including Mesoamericans and Mediterraneans and Asians, developed precursors to modern scientific astronomy. Ptolemy built a famous cosmology, as many students learn, with the Earth at the center of the universe. This old notion got handed down through the civilizations, winding up embedded in Catholic doctrine. The



centrality of Earth became such an essential feature that Church authorities considered heliocentric models heretical.

When Galileo looked through a telescope, and observed the complex system of planets and moons orbiting around the sun, he stumbled into a tumultuous history of conflict, which shook Christendom to its core, while giving rise to modern astronomy and science. Ever since, the Catholic Church and astronomy have had a rocky relationship, although not without common interests.

Curious minds both inside and outside the Church have investigated the nature of our world, discovering new distant frontiers. In fact, many of the founders of astronomy, including Galileo, functioned alongside the Church, even catering to it while under intense scrutiny. Now, the Vatican caters to astronomy, in a sense, operating a major international observatory and contributing to scientific publications.

Paul Gabor (Vice Director, Vatican Observatory Research Group), a Jesuit astronomer who describes himself as “basically an instrumentalist, but also interested in extrasolar planets,” believes that many people have a mistaken impression of the role of the large institution. “The Vatican is primarily a bureaucracy,” he says. It comes in to decide on controversy, not to make everyday decisions.

Between Galileo and the Vatican, a controversy arose, yet Gabor describes events differently than many astronomy enthusiasts may recognize. In a wide-ranging conversation stretching from ancient Egypt to extraterrestrial intelligence,



from philosophy to quantum mechanics, biology to geology, the past and future of society, and touching on many aspects of astronomy and religion, he supports the Vatican in its historical and current astrophysical activities.

Gabor blames much of the perceived issue between the Vatican and astronomy on philosophy, noting that historically Europe taught an Aristotelian worldview, which clashed with new observations. He asks of the erstwhile dilemma: “Should we ban Aristotle, and embrace Galileo? And the answer is no.” Aristotle had a “unified picture of the universe.” Politics also played a role, as well as Galileo’s personal relationship with Pope Urban VIII. Now, the topic comes to America.

### **When in Arizona**

The Catholic Church, in addition to its presence in Vatican City and around Rome, has its research group in Tucson, Arizona, which is basically the center of the astronomical universe. Meanwhile, at the charming nearby town of Safford, the Mount Graham International Observatory has its headquarters, and up at over 10,000 feet elevation, the Vatican Advanced Technology Telescope (VATT) scans the skies.

The telescope sits in the Pinaleño mountains, a remote location atop the desert in the Southwest – worlds away from the Vatican in Rome. The site is sacred to several native tribes. To get up to the mountaintop requires a squirrel permit. An endangered subspecies provoked an environmental challenge to construction. The observatory has the squirrel permit ready at base camp, across the street from a federal prison camp. Up



the mountain, the plump red squirrels hop about the pine forest happily, beautifully.

Here in the Wild West feels like the exact opposite of the Vatican. This is outlaw country, not far from where Billy the Kid earned his infamy. The frontier. The wild ruggedness of barren expanses. That classic American small-town feel. Guns in Walmart, pickup trucks everywhere, Mexican influence, country music and cowboy clothing, and candy shops with old-fashioned sodas.

Gabor often criticizes Americans: as having a literalistic view of laws, as forming false notions of religion, as having anti-Catholic bias. Meanwhile, at the VATT, individual researchers select their own investigation topics. Institutional inertia contributes to the process behind the scenes, which Gabor notes dates back hundreds of years. “Once you have something established, you need a major global catastrophe to disestablish it.”

The Vatican Observatory has bidirectional service with the Vatican. “Our mission is twofold. To explain the Church to the world of science, and to explain science to the Church. We do much better at the former.” Gabor denies the very controversy of the Galileo affair, attributing it to mistaken interpretations of religion. Regarding the banning of books, including Galileo’s, he argues: “When a book was on the List of Prohibited Books, it meant that it was to be read only by those who had the correct preparation. In that sense, the Bible itself





was a blacklisted book.” He alludes to the informal way in which laws operate in Italy, home of Rome.

“The real controversy, the one that actually produced the impression that there was a controversy around Galileo – there wasn’t – a contemporary of Galileo’s, a good Catholic, he taught there were many worlds. That was René Descartes.”

According to Gabor, a modern movement in the 19<sup>th</sup> century that taught the notion of progress in history introduced serious philosophical problems. With this philosophy of science, he says: “So you move from darkness to the light,” a notion which he calls “complete nonsense.” Rather, Gabor sees cycles that will eventually return, and believes that in the upcoming decades we may witness a return to more traditional educational modes. Does the perceived opposition of the Catholic Church to astronomy come from revisionist history? “History is to a large extent a result of this philosophical view.”

### **The Pope Scope**

The VATT sets precedents with its design and construction. The telescope, a 1.8 m Gregorian (unrelated to the Gregorian calendar), differs from a more common Cassegrain layout in using a concave rather than convex secondary mirror. The device sits next to the Large Binocular Telescope, billed as the world’s most powerful optical device, with which it shares some uncanny similarities, starting with the mirrors.

The primary mirror on the “Pope Scope” – as local astronomers like to call it – was built before the famous



Steward Observatory Mirror Lab had its current facility. It serves as a prototype for a new category of design, which now brings light to the world's greatest telescopes. The mirror makers gave it to the Vatican Observatory on the condition that they put together the money to build an observatory. The Vatican Advanced Technology Telescope got built, with a number of futuristic demonstration technologies. The casting and polishing of the primary mirror now shapes the Giant Magellan Telescope and the Large Synoptic Survey Telescope, two of the most impressive devices under construction.

The VATT primary mirror has an unusually short focus of  $f/1$ . This focus places the image at a distance equivalent to the diameter of the mirror. The overall system, including the secondary mirror, has a focus of  $f/9$ . The very small setup rotates rapidly, ideally suiting surveys.

A complement of three instruments, including camera and spectrometers, convert the incoming visible light into sets of data. Astronomers on the Vatican staff, as well as researchers at partner institutions, visit the site to conduct observing runs. Despite winter snow, the site has relatively good seeing year round, providing many nights of observations. With its glistening dome, the observatory looks modern and clean.

The ultrafast camera has a readout time of only 2 ms. In conjunction with radio telescopes, VATT studies micropulsars. These brown dwarfs – halfway between a planet and a star – emit powerful radiation in bursts that reach Earth. With its



very quick eye, the VATT can study stellar variability, the changes of stars over time.

VATT can also pick out double asteroids, twins of spinning rocks flying through the Solar System, which seem to make up the majority of asteroids. It can even look in detail at tiny objects that come between the Earth and Moon. Using a spectrometer, the Vatican looks at stars that it believes will evolve to look like the sun does today.

Astrophysically, the VATT produces new images and spectrographic data about our corner of the cosmos, says Gabor. “The solar neighborhood as we learn about it is not quite typical. It seems that the sun is in a bubble.” The density of the interstellar medium here appears below average. The telescope studies clusters of stars nearby, to find the clues that can explain our region.

Some young stars have their colors reddened by distorting dust clouds, appearing more like older stars. A very lengthy multiyear project analyzes enough data to distinguish stars near Earth from older, farther ones. The goal of the project is to understand the “solar neighborhood” of the galaxy. How normal or abnormal is our area? What is our background? The lessons could apply elsewhere in our galaxy, and in galaxies beyond as well.

### **What’s the Difference?**

How does the Vatican research affect society? Catholics? Astronomers? It turns out that the Vatican doesn’t see any major differences between its worldview and the modern



scientific worldview after the observational astronomy revolution.

Astronomy shapes our worldview, by giving us essentially our most literal view of the world. For centuries, the Catholic worldview prevailed in the West. With a political power structure that dominated European society, few could question many aspects of a world defined by the Church. Ever since Galileo opened the skies, and our eyes, we have a new source of information. Now, even the Vatican, whose supporters at first adamantly refused to look through an eyepiece, turns to observational evidence.

More broadly, many Catholics now conceive of astronomy, and the scientific enterprise, as fully consistent with their religion. To some, the material, mechanical system that astronomers study reveals the grandeur of divine creation. Symbolic of the revolution in science and technology and society, the Vatican Observatory issued a Tweet to wish Galileo a happy 450<sup>th</sup> birthday.

When the topic of Catholic enforcement of a geocentric model, against astronomy, comes up, Gabor asks, “Who was punished?” It appears that the Vatican does not now accept that it once played a heavy hand against the nascent scientific discovery of space. Gabor sees complications where many astronomy enthusiasts see straightforward political quashing of open-minded inquiry. He claims that historians’ inability to come up with more examples than Galileo and Giordano



Bruno – who Gabor claims wasn't really an astronomer – reveals the weakness of the case against Catholicism.

In turn, not only does the Vatican alter the course of astronomy, astronomy also alters the course of the Vatican. For many astronomers, going back to Galileo, the observation and analysis of the universe constitutes an attempt to understand the mind of God. In this sense, some Catholic astronomers consider the Bible one book of God, and nature the other book.

According to Gabor, merely the fact that the material world contains phenomena such as electromagnetic radiation, which permit astronomy, strengthens his Catholic faith. However, he does not ascribe his faith to the results of astronomy, rather saying that his faith precedes his research activities. Does Gabor think that astronomy can inform us about God? “If it does tell us something about God, it is this: God wants to be known. That on its own is a very powerful statement.”

With the Vatican now operating one of the premier astronomy tools, the discussion has moved fairly firmly into the realm of scientific debate. Questions remain as to how Vatican astronomers view the connection between science and religion. One way or another, we are in a new era of investigation into nature.

Outside of the Church, what does the VATT mean? The Vatican still takes the astronomy revolution seriously, and pursues its own route of investigation. This entails differences sometimes, and commonalities sometimes, in dealings



between the Church and the secular astronomy community. Moreover, to a large extent what we see results from inertia as much as politics or curiosity.

Hundreds of years have passed since the Catholic Church crushed, then acknowledged, astronomical revelations. Now the Vatican runs surveys of many meteorites, stars, and metagalactic structures. New discoveries have implications for astronomers, Catholics, and the general public. And things will continue to evolve from here.

### **The Next Five Hundred Years**

Why does the Vatican run the VATT? Does this signal a new era in the relationship between the Vatican and the astronomy community? Where will Church-astronomy relations go in the next five hundred years? It's hard to say for sure, with the unpredictable changes happening in society. Yet, at least we now see a common basis of rigorous investigation going into discovery of the universe all around us.

It can sometimes appear that the Vatican wishes to return to days of yore. Ever since revolutionary observations conflicted with cosmological doctrine, humans have had a different relationship with the Church. By engaging with modern astronomy, the religion puts some of its chips on the table. Will VATT shift scientific results? Public opinion? Church policy?

These developments could lead to future innovations in the Vatican astronomy program. Already, the VATT has advanced the state of telescope optics. By contributing to astronomy in



this southwestern stronghold, the new technology and science and philosophy integrate with ongoing advances throughout the domain.

Many ambiguities remain, including the political and religious sides of the matter. But, the bottom line is that as of now, and going forward, the Vatican has expressed its interest in observational astronomy, in the universe, in our physical world, through actions. Specifically, through the operation of the Vatican Advanced Technology Telescope in southern Arizona.

The Vatican observes space, contributing to technological innovations and scientific discoveries. It participates in dialogues with astronomers, and communicates with Church authorities. In short, the Vatican now does what it once opposed. Maybe we all stand to benefit from such an upheaval. Or maybe there never was any upheaval. And maybe it signifies a different course for the future. For the Vatican and for astronomy. Anyways, for now our calendar works.



## **Big Binoculars**

Large Binocular Telescope Observatory, Mount Graham, Arizona, United States of America

August – September, Year Two

*The world's most powerful optical device has many parallels with the Vatican telescope. With an immense focusing ability in its twin eyes, it sees what nothing else can, perhaps opening our view to alien worlds. Can we find intelligent life elsewhere in the universe?*

The Large Binocular Telescope Observatory (LBTO) now has the world's best vision. With its twin eyes on the skies, it produces the equivalent of one massive single image. It sits just next to the Vatican Advanced Technology Telescope in the Arizona mountains. And its office sits just a few floors up from the Vatican office in Tucson. The similarities go deeper. Yet, in some ways, the astronomy couldn't be any more different.

Atop Mount Graham, in the Pinaleño forest, an international consortium runs the telescope. NASA now uses the Large Binocular Telescope to look at exoplanetary dust for the first time. Astronomers also use the telescope to look at distant quasars, which signal the presence of mysterious early galaxy





clusters. And the LBT may even reveal other intelligent life in the universe.

The twin-mirror telescope will unveil remarkable new sights. It also pioneers many of the technology advances that will take us into the next generation of large-scale observations. Overall, the double-mirrored device sets the stage for another set of dramatic changes in modern astronomy. And it may even shed new light on our humanity.

### **Telescope Ecosystem**

Riding up the Pinaleno mountains by bicycle, to elevations as high as 10,700 feet (3,300 m), feels like awesome magic. The ride is difficult, although beautiful. Much of the way has a paved road climbing through increasingly wet layers of life. Near the top, the road turns into dirt. Then, a hard-to-find telescope access road climbs much more steeply.

At the peak, shiny metal buildings sit among a handful of vehicles, tranquilly. The police run a station here, the “star” unit patrolling the area and available by radio. The pine forest mountaintop rises proudly above the desert. Here, the LBTO sits just next to the Vatican Advanced Technology Telescope, in a quiet retreat.

The site has great astronomical seeing. On a beautiful fall evening, staff from the LBTO congregate on a balcony outside the telescope, looking out over a breathtaking panoramic sunset of purple and pink. The moon shines brightly. The air feels cool, just chilly enough to make the time outside extra scarce.



Employees drive up to the observatory, which has dormitory-style rooms. However, unlike some other large telescopes, the kitchen has no catering, so staff must prepare their own meals. Next to the kitchen and sleeping quarters, the telescope features a cool control room, which feels like the set of a science fiction film. At one point I jokingly ask if they'll let me know whether they found ET while I run to the bathroom. Oh, I'll find out if that happens.

In the darkened area, typically in use at night, a row of computer stations sit side by side. These systems run the telescopes, with a suite of custom software on Linux desktops. Tilings of multiple monitors provide constantly varying status reports, while the staff work on calibrating and recording with the massive telescope. Occasionally, when an issue comes up calling for further information, the telescope operators call on a roster of outside contacts, including both computer and telescope experts.

The observing conditions here play a huge role in what transpires. On a bad night – too cloudy, too windy, or otherwise unable to observe – the room feels tense. Will there be any observing time at all? Will it be mostly a waste? At the least test runs can be done, to check on software and hardware.

On a good night, after the initial configurations of the device, it will do several lengthy, carefully planned runs. Each run collects substantial data on a chosen target, which astronomers will later analyze off-site.



Around the observatory itself, the forest has a life of its own. An ecosystem, a society. Signs indicate a Christian bible camp a bit beyond the observatory. Rangers drive the curvy roads. A handful of people live in the mountain forest. A beautiful smoky smell emanates from the woods.

On the way up, I encounter a car full of German astronomers coming down. They inquire about the smoky smell. Did I see a fire? Nope. Maybe it's higher up. I explain my confusion about finding the way to the observatory, and they point me to the telescope access road.

The telescope itself looks like a gigantic Transformers robot. With its two huge eyes looking out, it could potentially turn into some kind of destructive or constructive monster. Luckily, it didn't transform while I was there.

Meanwhile back at LBTO HQ in Tucson, before going up to the observatory, Christian Veillet (Director) welcomes me into his spacious office. After many years doing astronomy in his native France, he moved to Hawaii for many more years – another astronomy mecca – then recently joined the LBTO here. We talk about the telescope itself, as well as what the research means for humanity.

The LBTO office shares with VATT the same building on the campus of the University of Arizona. It also sits just down the hall from the Large Synoptic Survey Telescope, having a common lounge with coffee and snacks. The LBTO and VATT furthermore share primary mirrors from the Steward Observatory Mirror Lab – a Gregorian design with convex



secondary – and, of course, the telescope site up on Mount Graham.

From these common grounds, the observations look in completely different directions.

### **Double Vision**

Starting out in the imagination of telescope designers in the early nineteen eighties, the LBT progressed through several stages of development until its current incarnation on Mount Graham. The innovative mirrors, from the same source as the VATT and other important research telescopes, define much of the scientific mission.

First light on the first mirror came in 2005, while the binocular sight became available in 2008. Over the following years, instruments such as cameras and spectrometers came online. Generally, the designers create first one instrument for one mirror, then make the second of the pair to bring binocular vision.

With such large mirrors, adaptive optics become increasingly important to see better than Earth's atmosphere would otherwise allow. Adaptive optics rapidly deform in response to the shifting atmosphere, allowing the telescope to see through the distortion.

So, the LBTO uses some of the most technically advanced correction. It does its adaptive optics in the secondary mirrors, each of which has 672 actuators. By contrast, most telescopes with adaptive optics – which tend to be large and new and



expensive telescopes – do the corrections elsewhere in the optical path. The adaptive secondaries provide much faster response, and much better correction.

The twin adaptive secondary mirrors are Gregorian, like on VATT, yet unlike most research telescopes. A Gregorian telescope uses two concave mirrors, unlike the popular Cassegrain style. Also, the LBT and VATT both have very short focal ratios, making them compact telescopes that rotate fast.

The two LBT primary mirrors have diameters of 8.4 m each. This gives the combined collecting size of a single 11.8 m mirror, or the interferometric baseline of 22.8 m. The latter statements mean that because of the spatial arrangement of the two mirrors, they can see the common light *amount* covering a single 11.8 m mirror, while seeing the common light *extent* covering a single 22.8 m mirror.

Both sides of the twin device sit very close together, much more so than on most multiple-mirror telescopes. Together, the two are capable of serving as a single mirror. Alternatively, they can be used in a different configuration in which they take double observations with the individual mirrors, separately. The latter can help by allowing simultaneous observations of a single target with two different instruments, for example using both a camera and a spectrometer together.

The combination of large mirrors operating in harmony makes the LBT the first of the extremely large telescopes. This new generation of devices, such as the European Extremely Large



Telescope (E-ELT), Thirty Meter Telescope (TMT), and Giant Magellan Telescope (GMT), will gradually replace the current crop of “world’s biggest.”

The GMT in particular is in many ways a sequel. It expands from LBT’s two closely spaced interferometric mirrors to seven. It takes a different tack for the next generation of extremely large telescopes, differing from alternative approaches such as the E-ELT and TMT in having a small number of very carefully crafted large mirrors, rather than a large number of smaller, simpler optical components.

In a way, the LBTO paves the way for all of those larger upcoming telescopes. While not seeing quite as faint or as far, the big binoculars can do essentially the same *type* of research. It can combine its two mirrors to see more of the cosmos, and it can see more precisely by going into interferometric mode. These large, Earth-based, single-mount telescopes conduct comparable observations.

NASA has recently reported on research with its new interferometer onboard the Large Binocular Telescope in the prestigious *Astrophysical Journal*. It has discovered the visibility of exoplanets through the zodiacal dust of other stars, meaning that upcoming observations could detect alien worlds. This advance inaugurates the LBT in its double optics as arguably the greatest active single-mount telescope.

To date, the LBTO has already provided unprecedented views of galaxy clusters and gamma-ray bursts – very large, distant objects. Now, astronomers use it to scan stars for orbiting



planets – exoplanets – and to see their properties in better detail. By combining its two primary mirrors in different ways, the LBT gets a unique glimpse at the universe. This advantage, in terms of the technical capability to see the stars, lets us see impressive new details, which elude all other telescopes. And the results that it observes will surprise and amaze.

As the LBT interferometer comes online, it yields through its 23 m joint diameter by far the best images of dust in the habitable zones of other stars. This provides unique insight into planetary formation, and signals the beginning of the quest for exo-Earths, realistic locations for intelligent life.

### **Signs of Life**

“I think we are likely to find life,” says Veillet.

The LBTO will tell us about exotic worlds, strange distant planets living in the swirling dust that surrounds other stars. And in doing so, it will tell us about ourselves, and our place in the world. Are we unique? Or do we have cosmic cousins?

“It’s civilization that stands in the balance,” says Veillet.

“Time and space extend to billions of years, and there are hundreds of billions of stars in our galaxy.” And we only have a tiny piece of space and time. “We have this little slot on Earth, which is not that long. In one billion years we are not going to be here anymore.” Will we find anyone else close enough in space and time?



“We realize that many stars have planets, so we have to think about a lot of planetary environments. Now we know that there are many, and that’s a good thing. We may find out that there are plenty like ours. Or we may have to say, ‘OK, so we didn’t find any others, perhaps we are more unique than we think.’”

We may live in something of a Goldilocks world: not too big, not too small, not too hot, not too cold. The ambition to find habitable – and even inhabited – planets, depends on finding other worlds that are just right. And right now, we have ideas, yet we don’t know. Uncertainty.

“The more we look, that’s going to bring a change to the way we consider ourselves,” says Veillet. Are we in a place that is just right for people? Or are there other people out there too? We have ideas, but we lack knowledge. We have – possibility.

Veillet depicts religion as providing one view of our place in the world. “You look at religion, and we are pretty unique. We are created. There are intuitions. You read Genesis, it’s all chaos, then you’ve got the Earth. I really like that. It’s one act of creation. We were man and woman, and at some point we’re separated. It’s very nice, because life actually started asexual, and gender came very late. So you have these intuitions, which I like to read as, ‘wow, it’s a poetic vision.’”

From the first bang came our world, and we from the space dust. “But then we have this idea that we are the center of the world. We didn’t intuitively make our Copernican revolution. Copernicus came with this idea that the sun was the center of the universe, but nobody was open to that idea.”





We can expand our view beyond Earth. How unique is our star, the Solar System, in our galaxy, the Milky Way? “Our next step, if we can have more information, I think it can have an impact on our own perception of what we are in the world.”

Finding plentiful Earth-like planets increases the likelihood of finding Earth-like life. So, searching out the cosmos for habitable planets informs us about the formation of physical and biological systems. “The probability of us, the equivalent of us, you know what? It’s really high. The more we look, the more things like Earth we find. Then if we look at them, we can explore them more.”

What will we discover? “It’s a way to find out, if we are not alone, life is all around.” If we do find life, it defeats the intuition of those who think we are unique. If not, then it changes the odds in favor of our special status. Either way, the effort will yield useful information. “If we don’t find life, or if we do, the search will improve our understanding of life.”

A lot of statistical results will inform us about the processes necessary for creating biological life forms. “How easy or difficult is it to go from complex chemistry to life?” Other questions also arise. And more data means greater understanding.

One especially cool new trick that is just becoming possible takes the quest for life even farther. What if we could detect not just a plausibly habitable planet, but even more direct information? “One of the very interesting things that we are looking at now is how we can see artificial light.”



We don't fully know what to expect, but with new powerful telescopes like the LBTO, we can make out the chemical composition through spectrometric instruments. When an exoplanet transits (passes in front of) its star, we see the nighttime side. When a star eclipses an exoplanet, we see only starlight. We can see different combinations of starlight and planetlight. By measuring the difference, we can see the planetlight alone, and analyze it for chemical indications of artificial origins. "If we know that there is a planet, then let's go there with a telescope, and look at the light."

The LBTO advances our larger efforts at finding extraterrestrial life forms. "We bring our little contribution. Science goes forward. We are trying the best we can with the technology we have to contribute to that. Astronomy these days, more and more of it is collaboration."

### **Life Changes**

Even if life exists on other planets, it could exist only in unaware forms, like life at an earlier stage on Earth. "The vegetable world is a very archaic form," says Veillet. "They are there and happy. We are here for a very short time. I have no idea, no clue, how long we can stay. It's a big question mark, for civilization."

The question comes down to timing. Intelligent life on Earth is pretty short. So it's less about life itself than about whether life can get elaborate enough. How elaborate a life form could we find? Consciousness, and specifically conscience, is a much more difficult step than life itself.



Complicating the process is that to date we have just one example of any kind of planetary biology, which is what we know here on Earth. Comparing with the vast majority of animals with less complex inner lives, humanity stands out, and furthermore most of the rest of the ecosphere has even less in the way of control. What percentage of habitable planets harbor a highly intelligent living being?

Humanity could self-destruct in the near future, further limiting our time as intelligent life to a cosmically tiny eyeblink. This introduces the question of how history develops. Are we on a track of progress that will continue uninterrupted? Or will some event transform our course? Or are we going through cycles, or randomness?

Veillet alludes to various potential threats, including water rising from global warming. “Earth goes through cycles, and saving Mother Earth is saving ourselves,” he says. Moreover, our species used to move a lot more, living a nomadic existence. Since the agricultural settlement pattern, we have become attached to what we have, specifically to sedentary living arrangements.

“People used to have ten babies, and two would survive,” says Veillet. “Life was risky, mothers would often die giving birth.”

Going back to global warming: “New York’s going to be underwater, because it’s an island. This just meant it’s time to think about moving.” When the water rose on an island, people could get on a boat and move from island to island. Now we can still adapt. Change is part of life.



This goes all the way back to our evolution from more primitive forms of life into a relatively intelligent species. Through hardships and adaptations, we moved and changed, developing into ourselves of today. Now, through culture and technology, we continue to change.

### **Change of Mind**

What implications does the LBT quest for extraterrestrial intelligence have now? Can the search for intelligent life on other planets have bearing on religion? God? Humanity?

If we found intelligent life elsewhere in the universe, what would happen? Would people change their religious beliefs? Their metaphysical, ethical beliefs?

Not according to Veillet. “I don’t think it’s going to change much.”

People will still look for succor in their favorite sources of belief, regardless of the presence or absence of smart aliens. The truth or validity of religion may not intersect with material observations at all.

Some people already read the Bible without literally believing the story of Genesis, for example. Observations do rule out highly literal interpretations of the Bible, but not more figurative interpretations. “If you believe that God created the Earth five thousand years ago, too bad, that’s not true,” says Veillet. However, you can still move back the point in time of God’s involvement.



After astronomers found that the Earth revolves around the sun, rather than the other way around, some Christians claim that God created the Solar System instead of creating the Earth and sky. As observational knowledge expands ever further, the creation event can be claimed ever further back, even back to God starting the Big Bang. “We don’t know why the Big Bang happened, and we are far from knowing. Why? Because this is beyond science. If you say that ‘my theory is that something I call God made the Big Bang happen,’ you won’t find any evidence against that.”

And scientists have their own bugaboos, as do religionists, says Veillet. “When scientists challenge God, because it is just a name for something, I tease them, saying, ‘Well, what is dark energy, but naming something you don’t know about in order to explain?’” The vast majority of the universe is sometimes ascribed to dark energy and matter that have never been observed.

Aside from saying how the universe started, religious and scientific perspectives can provide people with direction in living, says Veillet. “We all have a little bit of the divine in us, which makes us all similar in that way.”

This view moves God from the universal to the personal. “We all have the power we know we have. If I want to call it God, I can put God inside. These principles of churches, religions, God, praying to God to help – it’s a very empowering thing. I claim that all of these were created by people.”



Morality, the choice of behaviors, can thus come from an internal source with rational explanations, which we can also discuss in religious language. “I can explain moral consequences, so we know by experience that this happens when you do that. It’s all about consequences. We choose to do at a given time according to consequences, and we change our follow-up through our own experiences.”

Under this view, God essentially becomes our conscience. “Inside we often know an action’s not good. We have something deep, I can call that God, why not?” This contrasts with the view of God as creator of the cosmos. Instead of an explanation of what *is*, it explains what *to*. “I have no problem relating to religious people then. Take your theories of God, it’s part of you. We’re all the same. Our brain working, chemistry, and whatnot, you can call it God, conscience.” In this understanding, we all as humans have the same basic wiring. There exist a lot of variations, but with a common core. Whether God or matter, we can seek insight into what what we should do, where we are heading.

So, what does this quest for meaning in life in the stars entail? Will the LBT’s new vision reveal exoplanets? Signs of intelligent life? Awesome new discoveries? What will future observations, of the cosmos and possibly of life, do to our philosophy?

Well, if we find biological life elsewhere, then one big question is whether it harbors consciousness, conscience, or anything else that would guide our own lives. This same kind



of mind, the will to do good deeds, or divine spark of God, could tell us more about our own lives.

The Large Binocular Telescope is the most powerful optical telescope in the world today. It revolutionizes how we build and operate complex astronomy machinery. It also sets the scene for the upcoming generation of even bigger telescopes. And it evolves from the large single to the extremely large composite telescopes. And it finds quasars. And exoplanets. And maybe intelligent life.

“Can we find life evolved in a way where this is this conscience?” asks Veillet.

We’ll see.



## **Digital Astronomy**

Large Synoptic Survey Telescope, Tucson, Arizona, United States of America

August – September, Year Two

*The Large Synoptic Survey Telescope, now being built by the National Optical Astronomy Observatory, will revolutionize how astronomy is done. It abstracts away the observations, turning astronomy into a primarily digital pursuit. We meet the designers in Tucson, and go up to Kitt Peak.*

You can't see the most amazing part of the telescope. And you can see a lot of amazing parts.

Atop Kitt Peak, home of the National Optical Astronomy Observatory, sits the world's greatest collection of telescopes. Here, and at headquarters in nearby Tucson, a brilliant team crafts the next stage in global astronomy.

With its immense camera and complex mirror, its supercomputer, and its astronomical ambition, the Large Synoptic Survey Telescope (LSST) overturns Earth-based observations. Its goal is to create an immense digital video of the southern sky, and make it publicly available for everyone who wants to fly through the universe.





The telescope will conduct a decade-long digital survey, so big that it will change the way researchers do astrophysics, and reorient amateur astronomy, and even alter the course of technology and society. In southern Arizona, the big sky survey heralds the era of the virtual observatory. By making video of the universe accessible to everyone, it revolutionizes astronomy.

### **The New Sky**

The Large Synoptic Survey Telescope bills its output as the “New Sky,” claiming that the project will observe more in its first month than all previous telescopes ever have, together. With the largest digital camera and the largest data collection, the effort converts observational astronomy into an informational activity. The “astronomy capital of the world” is a suitable place for such a transition.

Astrophysicist Tony Tyson originally had the idea, in the late 1990s. He dreamt of a telescope to detect mysterious dark matter. Simultaneously, astronomers interested in near-Earth objects wanted a fast survey device to track incoming projectiles. Hence, the concept was born with the name Dark Matter Telescope. The telescope, now a billion dollar project, sports an interesting 8.4 m mirror, built at the world-leading Steward Observatory Mirror Lab in Tucson, under the football stadium at the University of Arizona.

“LSST, in a nutshell, is a deep survey of the southern sky, covering about 20,000 square degrees. We’ll do it in six spectral filters that cover the optical spectrum,” says Chuck



Claver (Systems Scientist, LSST). Claver, a talkative fellow, has a ruddy face, long hair, and a beard.

In the major decadal review, “New Worlds, New Horizons,” American astronomers considered the LSST to be the single most important telescope project on Earth. In addition to the US Government, financial support comes from some possibly surprising sources. Software billionaires Charles Simonyi, Bill Gates, and Eric Schmidt donated tens of millions of dollars.

The National Optical Astronomy Observatory (NOAO) organizes the development of the telescope. While in the design phase, most work happens in Tucson. The LSST used a small telescope at nearby Kitt Peak, called Calypso, during development. The final survey telescope will eventually get installed, along with Calypso, at a dark sky site in Chile. Later, the device will have its operational headquarters here in Tucson.

With federal funding officially available, construction now gets underway on Cerro Pachón, Chile. And with information processing accounting for around half of the overall operational costs, the project will also include facilities at the National Center for Supercomputing Applications. The LSST design looks futuristic, a sleek and modern facility. It sports vanguard parts for optics, and for data. And, through its partners including Google, the flows of data will go out around the world.



## **Supercomputer**

The scale of data-processing – gathering, storing, distributing, analyzing – is huge, and unprecedented. This is largely an IT telescope. Focusing on a massive volume of the sky, it will form the most impressive data manipulation project of any type. And with the largest digital camera on the planet constantly studying the sky, its gigantic database will stretch the limits of technology.

To discuss the data volume in question requires those prefixes that were fun to learn as a kid, but which didn't seem to have any practical value. Every night, 30 terabytes of raw data will arrive. Over a year, this totals a petabyte. After processing, the size will add up to half an exabyte. That's around a quadrillion, or a billion billion bytes.

The full database will provide an extremely large library of information on 20 billion celestial objects. Astronomers will constantly analyze incoming data, looking for transients, objects that change over time. Statistically relevant observations will become plentiful. Simply to convert the raw data from the hardware into useful imagery is a huge hurdle. 100 teraflops of computational power will kick into high gear.

With around a gigabyte per galaxy, the database stores a trove of information. The impressive telescope will record approximately four billion galaxies – around one for each living human. Imagine that: you could have your own galaxy to explore!



The survey will see ten billion individual stars, as well as tens of millions of bright supernovae, nearby asteroids, and distant quasars. We will discover the contents of the Solar System, and learn the shape of the Milky Way. This is a uniquely large volume of space to put “under the scope.”

And the LSST will share its data publicly. Claver likens the process to open source software. Alerts from the entire database will become available almost instantaneously, so anyone could find a space anomaly! Also, annual reports will include the entire catalog. To start, only formal partners will receive the full raw data, in addition to the public processed data. However, a primary goal involves making the overall results available to everyone, notably in the form of an interactive video of the universe.

### **Informational Astronomy**

Astronomically, the huge volume of data from LSST enables a great variety of research. It covers everything from near-Earth asteroids to distant stars and galaxies, and the cosmology of the entire universe. It changes the investigative enterprise from one of running observations to one of analyzing data.

Figuring out the optimal spatiotemporal sampling of the sky poses a major challenge. “That is the fundamental currency of the LSST,” says Victor Krabbendam (Project Manager, LSST).

By looking at billions of galaxies, the survey can give us amazing insight into what the universe holds and how it behaves. For example, many astrophysicists now believe in



elusive dark matter and energy. Investigating the dark side of the universe will restrict what these can be, if they even exist. Instead, we may uncover new astrophysics.

The telescope will look at the mysterious increasing expansion of the universe, searching in many different directions and with many different techniques. This should reveal whether the expansion happened uniformly in all directions, or differently in each direction, providing clues to the behavior of space, and our origins and destiny.

The LSST is also predicted to be the first telescope capable of detecting most of the asteroids that threaten Earth – up to 90% of them. Current telescopes can only see them down to around 1 km diameter, while this scope should see as small as 140 m. The machine should also find some of the most fun objects in the universe. Random surprises, like neutron stars or gamma-ray bursts, pop up a lot more often when you look at more space. We could even discover altogether new types of object.

This revelatory survey will overturn how we see the universe. The massive data tool marks a new age in digital astronomy. Enthusiasts as well as professionals will pore over the information flow, instead of peering into telescopes. Over five thousand astrophysicists will produce research on the basis of the data set. And everyone with an inclination can zoom through a mind-expanding movie of the universe. The Large Synoptic Survey Telescope is realizing this dream: an interactive software version of the universe.



### **You Call That a Camera?**

Welcome to the world's largest digital camera. With a resolution measured in *gigapixels* – 3.2 billion pixels, to be exact, equivalent to a thousand conjoined smart phones – the camera induces gasps. The mosaic of 189 individual 16 megapixel detectors captures an image with a diameter of 64 cm. Even the physical dimensions of the device are stunning, at 3 m by 1.6 m, and weighing 2,800 kg. We are talking about a camera the size of a rhinoceros.

In another optical innovation, the f/1 telescope combines primary and tertiary mirrors, mediated by reflections from a secondary mirror. For the extremely large field of view, the compact triplicate mirror design eases surveys. Because of how much light the large secondary blocks, the 8.4 m primary only has an effective size of 6.7 m, still plenty for the survey. Already, the combination M1M3, and the separate M2, have been built in Tucson.

The composite mirror comes from the famous Steward Observatory Mirror Lab. Here, molten glass gets spun into its complex form, with a honeycomb backing to allow for lightness and cooling. The pure borosilicate glass spins at around 5 rpm, then cools from around 2,100 °F over a few months to solidify. The LSST mirror glistens as it gets polished, looking something like a hockey rink getting Zambonied. In the unique construction process, the entire mirror was first shaped for the M1 primary, then the M3 tertiary portion was ground out of the middle. Sharing the same substrate, both mirrors will focus together on a field.



According to Dennis Zaritsky (Deputy Director, Steward Observatory), the mirror shares its genealogy with other top telescopes, including the Large Binocular Telescope and the Giant Magellan Telescope. “All of our mirrors are built to give you images as good as what the atmosphere will get you,” he says. “That’s true with LSST too. LSST will not have adaptive optics, it will be seeing limited, and our mirror is prescribed to introduce very little additional noise to that image.” Yet, the three-mirror design enables a uniquely wide field of view, and thus the massive survey. “The telescope design, to get the big field of view, that is very different than any other telescope.”

For a big survey of many dim objects, mirror size matters a lot. And the LSST sees a lot. With a field of view of 10 square degrees, it takes in large chunks of sky in a thousand nightly pairs of 15-second exposures. The twin exposures eliminate false positives from when cosmic rays set off camera pixels. Accumulating tens of thousands of square degrees each week, then rescanning, the telescope covers over half of the southern sky.

Moreover, the device observes deeply, and diversely. With an average view out to magnitude 24, the telescope can focus all the way out to 28 – a hundred million times fainter than the human eye can see. This takes it back to redshift three, a time when the universe was around 15% of its present age. “It’s deeper, it’s wider, and it’s faster,” says Krabbendam.



## **Home Movie**

Recording over a decade of the evolution of our region of the universe, the LSST will make the biggest home movie of all. The major advantage that the new technology introduces includes observations of the changes over time of a huge space. “The systematic exploration of the time domain, across such a large part of the sky, has never been done before,” says Claver.

The mapping of the LSST is kind of like when humans first completely documented the globe, but for our entire neighborhood of space. More detailed maps remain possible, yet with this we get the big picture. The resulting image will change our knowledge of the sky, says Zaritsky. “Every field of astronomy will be advanced.” Moreover, we watch the world as it changes over time. “I think the real revolution in this is the transient universe.”

The results will dramatically alter astrophysics – to start. Going three orders of magnitude better than existing surveys, the new level of information will serve the public a look into our place in the world. The public education portion of the mission is intrinsic to the project, on equal footing with professional and amateur astronomy research. Krabbendam wants the telescopes to reach out “to the classroom, to interested people at home, lifelong learners.”

Improvements to space models like Google’s Sky and Microsoft’s WorldWide Telescope will share the astronomy with everyone. Discovery in astronomy, and science generally,





comes from curiosity together with new technology, says Krabbendam. “We’ve never had somebody look at the sky in that way, and recognize that, ‘Hey, there’s something different here.’” The survey hardware and software herald the era of the virtual observatory.

To get a feel for what the telescope will see, first imagine taking a photo of the moon. Then, expand the view to a grid of seven moons by seven moons. And imagine that you can see really, really faint, far objects, thousands of times better than high-definition. Then, watch the sky like this as it evolves over ten years.

Now, with federal funding in place, construction starts. Krabbendam observes: “As we go into operations, we will have more partners contribute.” A pilot project, the Deep Lens Survey, shows a glimpse of the brilliance that LSST will display. According to a sample, the cosmos looks like a bag of multifarious marshmallows, each one dense with secrets. Although only representative of a tiny fraction of the data that LSST will produce, the image reveals the intricate puzzle that is our universe. Tomorrow, with information technology, we delve far more deeply.



## **Wild West**

Arizona to New Mexico, USA

September, Year Two

*After a great time in Tucson, Arizona, we're ready to move on into New Mexico. The area we go through, the Wild West, was home to many famous figures, or infamous ones anyways. The route takes us through the open desert and small towns, and up to the next telescope destination.*

Here we go! On a wild trip from Arizona through New Mexico. Ripping by bike through the vast empty desert, and Silver City, all the way to the National Radio Astronomy Observatory in Socorro. These areas encompass the background of many notorious characters, including Billy the Kid. Outlaws no longer loom quite as large in this day and age, although riding by bike sure feels like being a cowboy on a metal steed, zooming by the old railroad and making camp under the hot desert sun.

The small towns around here have hard arid ambiance, and it was a real treat to ride through. When the West was settled, these communities spontaneously grew in their sparse surroundings. Life was rough, and the distinction between good guys and bad guys unclear. Nowadays, the locals are ornery yet friendly. And the mesquite smoke smells so good.



After crossing into New Mexico, I went to the town of Socorro, home of the national radio astronomy facilities. This remote location also has a reputation as one of the top sources of alien encounters. With the advent of radio signals a few decades ago, and the eerily empty setting, we can now look into the roots of these spacey apparitions. And the radio telescopes here may actually have insight in the search for extraterrestrial intelligence around other stars.

### **New State, New Mexico**

After coming down from Mount Graham, it was time to keep on riding through Arizona and into New Mexico. Coming down, after a trip up to a telescope or of any other kind, always provides a refreshingly joyful, free feeling. Revelatory. Light. Altered. Transcendent. It's a different state of mind.

After Tucson, Arizona, I'd wanted to head south a bit, to see some of the smaller towns near the border, and maybe even cross back into Mexico. However, with the clock running, I made a beeline due east, from Tucson to Silver City, New Mexico. Time for a new state!

New Mexico is like Arizona's poorer cousin. Sorry, New Mexico. Everything seems sparser, although there is one big huge advantage in New Mexico's favor: chiles.

In the late summer, when I arrived, the air – everywhere – is full of the unmistakable aroma of roasting green chiles. It smells like a combination of the vegetable scent itself, and the smoky aroma of burning fire, with an overall impression of timeless deliciousness.



Riding out of Tucson, I felt ready for adventure. I had spent a considerable amount of time in this city. It was one of my favorite places to visit, personally, as well as having perhaps the densest concentration of astronomy activity on the planet. Despite my readiness to go, it was still bittersweet to leave, as so often happens. I find departures to be among the hardest parts of travel – almost never wanting to move away from one place, yet still looking forward to the next.

In a way, the same inertia with motivation holds for astronomy or any scientific research. Or, more generally, for our beliefs, and for any part of life. We find new truths, discover new techniques, move on, and feel a new quality of understanding that supplants the old. Yet, it's still hard to leave behind the old beliefs.

Then, after some time, we can build upon the newly existing base to find yet another technique, revealing yet another level of truth. With scientific discovery, the process seems a lot faster and deeper than with personal adventure, due to the bigger scale of the efforts involved. However, in whatever endeavor we pursue, we continue to grow. However hard we push, we go. To a statistically meaningful degree, within the error bars, anyways...

When I got into New Mexico, I had a few route options. I knew vaguely that I wanted to go to Socorro, and possibly also to the more eastern side of the state, for the observatories. To start with, I kept it simple, riding due east out of Arizona. Instead of dipping down closer to the Mexican border, which I



would've liked to do, I prioritized just getting to the telescopes in a timely fashion.

The road from Arizona into New Mexico was very empty. I rode the scenic highway. With a thicker tube in my tire, I finally felt more confident in my defense against flats. After zooming over a hill, I pulled into a pit stop at the intersection of several different highways. The intersection had a handful of buildings and a picturesque view. While refilling my water and eating, I chatted a bit with some of the handful of locals. People here drive rough pickup trucks, live hard, and love each other a lot. A small, close-knit community, in the middle of nowhere.

Then, carrying on, I camped out by the roadside. The next day, I rode on, farther through the empty desert, getting closer to town. The first sizable place in the state would be Silver City.

Approaching the outskirts of town, it started to rain, out of the blue. I pulled over, and wrapped some extra plastic bags around my backpack, in a possibly vain attempt to try to keep the damaging rainwater off the sensitive contents. Then, I strode on valiantly through the downpour, even though the rain came down harder.

A car pulled over next to me, and a woman rolled down the driver-side window. "Do you want a ride?"

## **Silver City**

After riding through seemingly endless long beautiful empty stretches of road, including some of those fascinating highway



intersections, I had arrived in the vicinity of Silver City. Soaking wet in the Land of Enchantment, I greatly appreciated that woman offering me a ride.

Sure! Getting out of the rain would be great. So she picked me up, and drove me over to her adoptive father's nearby place, where she was headed. There, we sat inside, and dried up with some herbal tea. They told me about some of the local customs, in which they participated, including the Native American sweat lodge, and the ceremonial use of peyote.

The sweat lodge is a purification ceremony in which a small enclosure is filled with steam, from hot rocks, to the point of being almost unbearable. Then, a group of community members sit in the steamy room, cleansing their bodies, minds, and spirits.

Peyote is a psychedelic cactus that takes its consumers to distant worlds. A blend of aboriginal and European traditions has resulted in the large peyote religion.

People living here in relative seclusion could still travel beyond many brave horizons.

The woman's adoptive father was in remission from cancer, and it was inspirational to speak with him about life and death. People who have experienced great changes, which often take time to transpire, have valuable insight into our future, because we share so many fundamental commonalities. The differences in perspective from people with greater life experience contrasts against our existing knowledge. Therefore we can



learn a lot by speaking with people from different generations, people with different backgrounds. Life is a beautiful gift.

The old man and I smiled at each other as we parted ways. Then, the daughter drove me over to the “BikeHaus.” This place, a large residential building in town, hosted a group of youngsters, as well as loads of bicycles. I stayed here a bit, and the rain cleared up. We cooked together, talked, and toured the town.

Silver City has a colorful history with outlaws and prospectors. Before that, it was home to Apaches then Spaniards. Since then, though, it has evolved into an artsy regional hub, which still does have its fair share of characters for such a small place.

Anyways, with some of the BikeHausers, we drove around and collected firewood, and went through some of the drive-thru everythings – pharmacies, stores – a great part of America.

While I was in town, we also went to cafés, art galleries, spiritual shops, and more. And we talked about life, about what it means to feel connected with people or places, and how we change and adapt throughout the challenges of our lives. We often face problems that seem to fill our lives, at least emotionally, and managing them while pursuing our deepest values can break or build people. Getting away from the hustle-bustle gives you clearer perspective.

The sparse simplicity of the state of New Mexico actually brings out a lot of good things. Place strongly affects both self



and community. Here and elsewhere, whether living together in traditional or unconventional ways, we get to create cooperative arrangements that help groups of people thrive in tough environments, like the barren desert. Solitude and company each have a role in guiding our growth. The young BikeHausers came from diverse backgrounds, some as far away as Alaska and some from troubled homes. Here they found each other and gave each other succor, support.

Apparently, many New Mexicans see their state as around twenty years out of date. That seems about right. Also, a funny saying encapsulating local wisdom from Silver City: "Why is New Mexico so dry? Because Texas sucks and Arizona blows."

New Mexico sits at a lot of crossroads. Tying together strands of Old Mexico, with Native American tribes including Apaches and Navajos and many earlier populations, and also integrating more recent European populations, a new identity has grown. The people are proud of their state, despite its low population and its poverty and its other setbacks. And, truly, the land does enchant, evoking dreamy states.

Time to go deeper...

### **O, Socorro!**

From Silver City, I rode up towards Socorro, for "Earth to Alien Galaxies." On the way, I passed through a fun area where nuclear scientists once swarmed for the Trinity tests, and where UFO sightings run rampant.





The whole area is enchantingly expansive, rural. A few small towns have New Mexican restaurants, which often serve green chile cheeseburgers, sopapillas (fried dough with honey), and smothered burritos. The surreal combination of sparsely populated simple communities with sophisticated radio and atomic science makes this place stand out. Socorro is at a special epicenter, having produced a disproportionately large amount of history and culture.

The town name comes from the Spanish word for “Help,” which is what a group of missionaries needed, and got, after the *jornada de la muerte*, walking the trail of death. It’s also what I needed and got, after riding my own trail of death.

After a grueling ride, on my first night in Socorro I camped out in a park where apparently I shouldn’t have. I was awoken by the same region’s finest who have previously reported a highly notorious UFO sighting, a close encounter of the third kind, which federal intelligence and military agencies later investigated and cleared. After getting popped by the UFO police, I spent a while eating burritos and writing.

Actually, all the UFO stuff kind of makes sense. In the wake of World War II, and its huge development of radio gear and aircraft, people had a hard time adapting to this new invisible world. Waves of electromagnetic radiation that you can’t see or hear, or otherwise sense, can nonetheless guide machines to perform superhuman feats. If airplanes and bombs and all that magic can happen, then why not aliens who fly through space and land on other planets?



Hasn't life already flown the spatial coop?

Socorro itself is a small town on the *Rio Grande*. However, due to its proximity to the huge national radio telescopes, it does host a sizable number of professional and amateur radio enthusiasts. And it does have a few nice places to visit.

With my first local attempt at camping not working out, I went for a different site. And I found a few lovely spots to camp along the *rio*, the river. As far north as Socorro sits, it actually connects with the rest of the Rio Grande. The same river flows all the way down to the Texas-Mexico border, which it in fact defines, although there are long dry gaps along the way. I enjoyed sleeping out by the river, under the stars, dreaming of arriving at the *frontera* (border) again in the future. In the mornings I would munch on peanuts, picturing myself as a freewheeling country boy. Which in a way I was.

You can learn something from everything. The more places I've traveled, the more people I've met, and the more astronomy I've learned, the more I've realized that the patterns of nature spread everywhere, and we can always interact in novel directions. We can learn about universal laws of physics from observing trivially small objects like bits of dust, or intricately gigantic objects like galactic clusters. And we can learn something valuable from everybody. And we can even learn from relatively average towns like Socorro. A lot of people lead meaningful lives here, and contribute to our knowledge with deep implications throughout our world.

And what about the wonders beyond our world?



## **Contact**

From Socorro, I rode out to the actual site of the National Radio Astronomy Observatory. It was a dark and stormy time. I was cold and wet, although glad to ride anyways. I got offered at least one ride along the way, but declined due to reasons of having a good time.

This area of the Southwest has some very gorgeous scenery, like old rodeo arenas, charming small-town architecture, and the people to match. I met dealers of old-fashioned gear, and took in the breathtaking sights and smells. This land is not the most hospitable, but it does have a strong draw due to its character, and travelers have sought out the area for ages.

After pushing hard on the pedals, I arrived close to the observatory, and camped out under its highway sign, happy to have found it. At the observatory the next day, I got to climb up on a gigantic antenna – just like Jodie Foster in *Contact*. This is where they filmed that Carl Sagan-based classic, along with many other media appearances over the years. The dozens of huge dishes stand out against the otherwise expansively unbuild backdrop, with plants and animals setting the scene. The site feels pretty surreal, hence all the movies and videos and photos and everything shot here.

Around the observatory, I toured the grounds and interviewed staff. It's a fun place, if you ever get the chance to visit. An eclectic mix of people go to these telescopes, which are open to the public.



Afterwards, I rode back to Socorro. I was planning to write much of the first draft of *Astrotripping* after seeing these radio telescopes. Therefore, I hoped that my bike setup would hold just a bit longer, despite its rough condition. It had been getting into ever ricketier shape, under the stresses of all those miles.

I felt great, cruising back downhill from the observatory, coming down, confident of a sweet smooth landing. Suddenly I got a flat. Oh no!

The miraculous slime deployed. I have become a great admirer of a bicycle product, a slime which is generally fluorescent green in color. This slime, which I think of as magical, bursts out when a tube gets a puncture. It quickly covers the hole, and its fibers solidify into an almost perfectly functional tube repair. An automatic patch kit. I tried becoming a product SPOKESperson. I know, it's for the tubes not the spokes, but it still counts as a bicycle pun. Anyways, that project didn't pan out.

To my chagrin, the hole was too big. It was huge. The tire itself had ruptured, torn to shreds, an old tire that had been waiting to go. Now the tube stuck out. The poor tube protruded from the shredded hole in the tire, rubbing up against the bike frame. Every spin sent a disturbing friction sound to my ears. I deliberated whether or when to stop riding. Just a little bit further, just make it into town.

*Kaboom!* The tube exploded.



Since then, I take heed of any disturbing sound emanating from the bike, and treat it as an important signal to stop, and figure out what the problem is. THEN go on, if reasonable. I think the same guideline applies more broadly. If something is bothering you, it's probably an indication at least to look into the source of annoyance.

Anyways, I tried forcing the wheel together long enough to get back to Socorro, using everything from tying it up with rope, through binding it together with old scraps of stuff I found on the side of the highway. Yet, nothing held. I kept on trying, making gradual headway. Finally, a passing pickup truck stopped, offering a ride. I hitchhiked with an Apache in a pickup truck!

He dropped me off back in Socorro. When I got into town, I finished up my writing. It took a few hard weeks, just writing. Many more drafts would follow, each somewhat better than the last. I was somewhat wistful that the timing worked out with me there to finish that draft. Instead, I had hoped for a bigger and more exciting place, or a smaller and more charming place. Nonetheless, finishing the *Astrotripping* draft took precedence over spending time in a fun place. So I got the thing done.

Finishing! ☺

### **Flash Floods and Firefighters**

Then, ready to ride out of Socorro – although the weather was still stormy and nasty – I went to the only bike shop in town. The storefront window was adorned with very numerous cut-



out cartoon strips, depicting highly political left-wing humor, such as prominent conservative politicians photoshopped being led away in prison uniforms. Outside the shop, in the parking lot, a pickup truck idled, with awesome country music blasting (including the lovely song by The Judds, “Mama He’s Crazy”). I love the southern US/northern Mexico border region, for its food and music and hospitality and overall culture.

On the bike shop door, I noticed a handwritten sign. It was a lengthy explanation of the owner’s present circumstances: how his childhood friend had just passed away in a nearby town, and the funeral was now happening, and the store would reopen in a week or so, and for any urgent needs one could contact a friend of his at the given number.

So I walked away, a bit lacking in confidence about doing my repairs in this situation. A man in the idling truck’s driver-side seat told me that my only hope was Walmart.

I walked over to Walmart. I may have sometimes in the past criticized Walmart, or found my voice among that chorus critical of Walmart. And this Walmart was far more Walmarty than most. I went in, and found the bicycle section. Lo! they had a wide selection of parts.

There, I found three excellent SKUs. A tube – extra thick, with the magic slime preinstalled. A tire – right fit, and with a Kevlar protective layer. And a repair kit – cheap. I was especially happy about the tire, as I’d been looking for a Kevlar tire, which provides extra tensile strength against



punctures, and all the ones I'd seen had been two-and-a-half to three times more expensive. Now I love Walmart.

Furthermore, as a point of sociological interest, this Walmart seemed to serve as a kind of communal gathering place, the modern American equivalent of old European town squares. Now I find Walmart to be a reliable and important part of many American communities.

Back at a camp spot in Socorro, in a municipal park with some cover from the ongoing flash floods, I contemplated and wrote. One morning, while I was writing outside under the rain shelter, a firefighter came out from the station next to the park, bringing a cup of steaming hot coffee and some good cheer. He asked me if it was OK black, the way the firefighters took it. Yeah! We talked a bit more. Firefighters do many heroic acts of goodness, from putting out fires to rescuing cats and freeing stuck bikes and waving from trucks. May firefighters experience much bliss.

After finishing the book draft and fixing the bike, I was ready to go to the next destination. New Mexico still offered plenty of options, but I wound up keeping it simple. In general, I have found that a simple plan, with adjustments in the course of progress, yields better results than trying to do everything you want, or expecting everything to go exactly according to plan. Like a person, a plan should be firm yet flexible. With good planning, and bold action, we can move confidently forward. Into the future.

Finally, time to leave Socorro!



## **Earth to Alien Galaxies**

National Radio Astronomy Observatory, Socorro, New Mexico, United States of America

September, Year Two

*In heady New Mexico, a place where police see UFOs, and just a stone's throw from famous Roswell, the US operates the largest radio antennae in the world. Now, a major retrofit updates the Very Large Array with new electronics, dramatically augmenting its capabilities. And together with the globe-spanning Very Long Baseline Array, these radio telescopes look deep into space, finding...*

New Mexico is the under-the-radar state. Not the most populous state, and some people don't even know it's a state. (A lot of people wrongly believe that it's a country, like Mexico.) Site of alien sightings and the birth of the atomic bomb, this area features classic Americana, alongside poverty. Signs everywhere, many handmade, proclaim the contestants of ongoing sheriff elections.

Radio astronomy was born in the 1930s, and came of age in the 70s. Alien and UFO beliefs also took off in this same period, as participants in World War II developed advanced radar dishes for their air forces. For the first time, it became believable – to many, anyways – for extraterrestrial aliens to





come in flying from the sky. Now, as we look out, and as they may look back at us, invisible radio waves carry signals deep throughout the universe. We can pick these emissions up on radio telescopes. Using the same principle as the transmission of television and AM/FM broadcasts, we can get a glimpse where optical telescopes cannot penetrate.

The biggest radio facilities in the world operate around Socorro, New Mexico. These include the Very Large Array, a huge radio interferometer, and the Very Long Baseline Array, a globe-spanning distributed interferometer. The two instruments, cousins, served up intensely new scientific results a few decades ago. Now, the major radio astronomy facility gets an overhaul.

### **Glowing Skies**

Just ten miles to the north of where nuclear scientists came for the Trinity test site explosion of the first nuclear weapon, sits the New Mexico town of Socorro. The Spanish colonial town has around ten thousand people. Here, halfway between Albuquerque to the north, and Truth or Consequences to the south, and just a stone's throw from Roswell, the skies glow with highly varying sunsets every evening. Anything could happen.

In and around town, the planet's premier radio instruments observe those very same skies. Seeing not the glow of visible light, but rather the invisible vibrations of long radio waves, these massive arrays of antennae collect and analyze data from deep in the distant cosmos. What they pick up describes



ancient stars and galaxies, and may even provide some evidence for the local superstitions about aliens.

This is the kind of place where speculation runs rampant. The Roswell UFO report started here. Another notorious UFO sighting happened here in the sixties. A state police officer on a high-speed chase encountered a bright thunderous object. He cut off his high-speed chase to investigate, and found a mysterious device matching the iconic impression of a flying saucer, including big-headed aliens.

The scene here – featuring UFO sightings and radio telescopes – resonates with the public imagination. Hollywood movie-makers filmed the key scenes of the science fiction classic *Contact*, based on the Carl Sagan novel and starring Jodie Foster, here. While filming, the studio vied with astronomers for time on the telescopes. In the clash of cultures, both the sky sentinel and the silver screen came away with new sources of inspiration. The longer one spends here in this zone, eerily quiet, the more reasonable it seems for mystery to come from space.

The terrain has a stark beauty to it. Sudden thunderstorms can flood the area with strong waters, while the dry earth still lacks much in the way of plants. The people, the few who live here, also have a kind of starkness. Somewhat aloof, the large areas leave plenty of room for people to live in their own ways. Rather than a busy beehive of activity, this place is more like a lone cactus. Hardy and self-sufficient.



## **Rancho Radio**

The planet's great radio astronomy facilities look like an oversize antenna ranch, appropriately for the region. Residents here have an active interest in radio signals, and live the kind of casual lifestyle that fills yards with machinery. And anyways, radio astronomy is a kind of American astronomy, in its origins.

The National Radio Astronomy Observatory runs its major facilities outside of a small southwestern town. These facilities include two large telescope arrays, one local and one global. The radio observations reveal a side of the universe that is opaque to optical telescopes.

These two arrays serve complementary functions. One, the Very Large Array (VLA), is a group of radio telescopes located onsite. The other, the Very Long Baseline Array (VLBA), brings together radio telescopes located around the planet. Between the two of them, the US national radio squad operates the biggest setup that we have on Earth for observing at these wavelengths.

The Very Large Array forms pictures of the deep sky by combining a Y-formation array of radio dishes on the Plains of San Agustin. The Very Long Baseline Array, with its headquarters in Socorro itself, measures distant objects by managing a set of radio dishes spread all around the planet. Both telescopes operate according to the same general concept as optical telescopes, yet using different technology



appropriate for the longer, slower vibrations at radio wavelengths.

At the VLA station, around sixty miles out of town, the large antennae sit around the site, waiting, watching. Each dish on its own picks up a signal from remote radio sources, focusing the signal to its receiver. Celestial objects such as supernovae and galaxies, and even our own sun, emit electromagnetic radiation in this frequency range – from around fourteen megahertz to around fourteen hundred megahertz. We use the same bands for radio broadcasts and other communications, giving us the name for radio astronomy. These very faint signals reach each antenna, which collects the waves at the focus of its surface. A dish holds essentially a very sensitive transistor radio, picking up and processing the incoming signals.

Each antenna is huge, an imposing multistory building. Climbing up onto a dish, one goes past electronic controls and mechanical components. Then, standing atop the antenna, one feels the immensity of the supporting structure, and looks out across the vast expanses of otherwise empty New Mexico land. Groups of antelopes and birds also move about the site.

Radio waves are a form of electromagnetic emission, like the visible light that we see with our bare eyes or with traditional telescopes. Some space sources emit a mix of optical and radio waves, which travel differently across the cosmos because of their relative sizes. This means that radio waves provide



valuable complementary information, in addition to what we already know from traditional optical astronomy.

Combining the incoming signals from all of the antennae, radio astronomers convert the data into informative visualizations. The amounts of energy involved are tiny. According to Dave Finley (Public Information Officer, National Radio Astronomy Observatory), “all the energy collected by all the radio telescopes in the world, since Karl Jansky first did this in 1932, you have roughly the amount of energy that’s released when a snowflake hits the ground.”

The Very Large Array instruments are so sensitive that visitors must turn off cell phones, says Finley. “If you take that cell phone in your hand, and you put it out at Jupiter, we could detect it here with the VLA.”

Now, the Very Large Array gets a very large upgrade. Over the course of the last decade, research teams have redone basically every component except for the dish reflectors themselves, and the rail track on which they run, in order to rebuild the array into a whole new device.

### **Catching the Big Wave**

Radio astronomy has an interesting story. It goes back from its accidental discovery by Bell Labs engineer Karl Jansky in 1933, when signals from the nucleus of the galaxy interfered with his telephone tests. And that story extends all the way to the newly rebuilt Karl G. Jansky Very Large Array. Throughout, the technology has advanced so much that it now takes a major governmental project, with a supercomputer and



a team of international collaboration, to conduct leading-edge research.

The Very Large Array features a configuration of 27 antennae, each one 25 meters in diameter. This is the size of a pod of blue whales, on land. Through its signal combination system, the VLA senses with the equivalent clarity of a single 130 m dish, and the precision of an impressive 36 kilometer antenna.

In addition to the dishes themselves, the most important telescope parts include the receivers, which convert incoming radio waves into electrical signals, and the correlator, which combines the signals from all twenty-seven individual antennae.

The VLA was built in the seventies, and gradually improved throughout the following decades. However, over the last decade, the \$100 million Expanded Very Large Array (EVLA) project transformed the telescope into effectively a new telescope, explains Finley. “This one was designed and built with the electronics of the 21<sup>st</sup> century.”

Because of the huge gulf in electronics between the seventies and today, the upgrade brings an accompanying improvement in observation quality, says Finley. “We have essentially a brand new VLA. Anywhere from ten to several thousand times more capable, depending on what parameter you’re looking at.”

Astronomers search for spectral lines, signals of remote chemical contents. “The old correlator allowed you to break up



your observing bandwidth into 512 spectral channels, to look for lines. The new correlator allows you to break up your bandwidth into 4 million spectral channels.”

The new correlator sits behind closed doors, in a highly sensitive room where any minor static discharge could damage the expensive equipment. Taking signals which are now digitized right at the antennae’s receivers, rather than after transmission, the specially built supercomputer combines the data in hundreds of different ways simultaneously, requiring immense processing power. Overall, the machine rebuilds a comprehensive image from the patches of electromagnetic activity hitting the complex array.

The Very Long Baseline Array performs a similar function, but on a way larger scale. Its technique is called Very Long Baseline Interferometry. In fact, it is the largest astronomical instrument in the history of humanity.

The VLBA operations center in Socorro connects ten radio telescopes, each resembling a VLA antenna, spread around planet Earth. Some are located in the continental US, such as the antenna around the Sierra Nevada in California, or the one in New Hampshire. Others are distant, such as the ones the US Virgin Islands in the Caribbean, and Mauna Kea in Hawaii. The distances separating the antennae stretch to over 8,000 km (5,000 miles). Integrating the signals from around the world presents its own challenges, yet yields a uniquely big picture, complementing the VLA.



The two sets of telescopes get combo power. Astronomers can amplify the global array, improving its observations by five times or more, by combining the Very Long Baseline Array with the Very Large Array, as well as the Green Bank Telescope, a gigantic 100 m radio dish in West Virginia. The VLBA can also connect with other global arrays, including even antennae in space.

Through all of these radio dishes, astronomers put together a picture of the deeper, darker parts of the sky. We can see things that are far too faint to see any other way. And all of this radio astronomy sheds light on the universe, without even using visible waves!

### **Tuning In**

What do we see with these massive arrays? The combination of radio waves reveals impressive details of our material realm. Radiation traveling billions of years brings us news of the young, growing universe.

The Expanded Very Large Array observes distant galaxies as they form stars. The telescope can look at stars that resemble our sun, much earlier in the stellar lifecycle, helping astronomers understand how this type of star develops over time. Its temperature, chemistry, and other properties determine the radiation that comes out, arriving at our antennae. The array can also look at later parts of the evolution of a star, watching as it goes supernova.

The Very Long Baseline Array can place celestial objects like no other device. With precision reaching 10 microarcseconds –





millions of times finer than human vision – the array surpasses even the upcoming space mission Gaia in this respect. With its extremely exacting measurements, the VLBA now maps our own Milky Way in exquisite three-dimensional detail, making use of masers, naturally occurring stellar lasers.

Another project involves the measurement of our neighboring galaxy, Andromeda, including details of its nucleus and its position. This unique global instrument can also investigate other phenomena, for example peering into the sources of deeply mysterious gamma-ray emissions, explosions of ultrahigh energy. Sometimes, extremely active objects release this radiation across the universe, and looking for accompanying radio waves helps unravel their secrets.

The VLBA is the best available device to observe the pumping hearts of galaxies. And continuing upgrades improve its capabilities, as astronomers digitize and modernize the facilities alongside the VLA, bringing a bigger and better focus.

### **What's Out There?**

The immense radio astronomy facilities around Socorro, New Mexico, extend our vision deep into outer space. The upgraded VLA and EVLA now use a full suite of digital electronics with their existing massive radio receivers. These clever arrays that operate as single gigantic telescopes permit observations of extremely remote sources, such as supernovae in exotic galaxies, as well as nearby observations like the radio waves shooting out of our sun. From the land of UFO believers, all



the way out to alien worlds, what can we learn from our compound radio eyes?

Through the major American radio astronomy assets, we learn more about the formation and evolution of stars and galaxies. We learn about the evolving growth of the universe, a kind of cosmic life. We may find out how our own homeworld came to be. And maybe, just maybe, we will find out where those glowing eyes in glowing skies came from.

This southwestern radio center also conducts research for the Atacama Large Millimeter Array (ALMA), currently under development. ALMA, now coming into active service, will eventually supplant the Expanded Very Large Array as the world's leading localized radio receiver. Incorporating lessons from the vanguard of radio astronomy research in New Mexico, the futuristic array will probe even deeper than we can now see.

What will we find? Is it all mysterious? As we keep probing the skies with our new and improved radio telescopes, will we stumble upon new stellar sources? Distant galaxies? Our very origins? An advanced alien civilization?

Stay tuned!



## **Last Stop**

New Mexico to Texas, USA

September - November, Year Two

*After touring the National Radio Astronomy Observatory, we go through a number of interesting points in New Mexico. These include heading to Alamogordo and nearby Sunspot, where the National Solar Observatory operates a big telescope. We also go to the main cities of the state, before heading on into Texas.*

Traveling through New Mexico from Socorro, I went to Albuquerque, Santa Fe, Los Alamos, Taos, and more. The beautiful trip took me through much of the state. During this time I visited the solar facilities near Alamogordo, and had a chance to refresh bit in the relaxing state. In Albuquerque, I met up again with Avril, who flew in from Mexico City. Together, we rented a car and drove up a storm throughout New Mexico.

This period was probably the most relaxing of the trip. After all, lots of people have visited New Mexico for its therapeutic benefits. Still, the period had its share of adventures. It felt great wrapping up this phase of *Astrotripping*. After two years on the road, I had seen and done a lot, and was ready for a chance to change perspectives – again.



Leaving New Mexico was just what I'd hoped for. I'd had some festive times, met many lovely people, and learned more about America and astronomy and adventure and life. Finally, by the time I got down to the south of the state, I felt ready to move on, into Texas and a new phase of life.

Next!

## **ABQ**

Rode up by the train tracks. Got to Albuquerque.

Albuquerque was a blast. I couchsurfed, partied, and felt the allure of the Southwest. For some of the time there, I stayed with a Taiwanese host, who volunteered at the Albuquerque Hot Air Balloon Fiesta. This annual festival is the centerpiece of the town. Through his kind efforts, I had the opportunity to volunteer for a couple of days at the Fiesta, and get the inside scoop. Together, we helped launch a French team's hot air balloon, and then we chased after it post-flight. Watching the balloons launch into the air was breathtaking – seeing hundreds of brilliantly multicolored gigantic balloons floating up into the sky!

While in ABQ, I also camped, and spent some time with other hosts, including a cool young couple who were thinking of getting started on their own travels, and a few very hospitable families. If you're thinking of traveling, by the way, the best first step is just to go for it!



Albuquerque has beautiful geography by the Rio Grande, some pleasant neighborhoods whose architecture has character, and really friendly people. It's also a very spread-out city.

Then, Avril flew into town from Mexico City, so that we could spend some time together again. While we were in Albuquerque, Avril and I stayed at a couple of hotels, and explored the city. We went for a walk through an industrial neighborhood at night, which was a bit scary. This led us to joke about a future date in a dark alley. While in that sketchy area, we went to a liquor store that came straight out of a Hollywood movie, complete with bad guys. However, we escaped with our lives, and a bottle of Wild Turkey.

We stayed in hotels, and walked a lot, checking out everything from antique stores to breweries to the hardware store. In the hardware store, we pretended to be married and building a balcony for our house. It wasn't long before we started bickering like an old married couple. Anyways, it was beautiful and romantic, and reminiscent of the old *tlapelarias* (hardware stores) back in lovely Puebla.

Albuquerque has a lot to offer. It's not the biggest city, nor the wealthiest, yet it has charm, and good food. What more could you want? Much as we could have spent more time there, we were ready for some adventure, so we decided to go to Santa Fe and farther north.

Santa Fe was really *fresa* (yuppie, literally "strawberry"). Same story for Taos, and other parts of New Mexico. The highlight of the state for me was the chiles. In the summertime,



the smell of roasting green chiles fills the air, and every eatery offers the spicy vegetable plentifully. I love how the state has a question that everyone knows: “red or green?” It means what color chile do you want. You can also answer “Christmas.”

To get to Santa Fe, we took the charming little passenger train. We ate charming candy bars at the charming station, and hurried to get on the train. Then, we rented a car for the rest of our trip together.

We flirted on the train ride from Albuquerque to Santa Fe, pretending that we were strangers seated next to each other by chance. Finally, the train pulled into the city. We almost got off at the first Santa Fe stop, on the outskirts of town, but wound up getting off at the central station, very sleepily.

*¡Ándale!*

Let’s go!

### **Santa Fe Express**

Santa Fe is the smaller sibling of New Mexico cities. The town has a lot of art, right from the get-go. We walked into a brewery and restaurant right by the station, to inquire where we should go first. Inside, we found the ambiance pleasant, and stayed for some delicious brews and foods. The friendly locals helped orient us, and we went off to find a hotel.

One of the places where we wanted to stay, with a Western theme, wound up being unavailable the whole time we were there. The nearby hostel closed their office before we got in,



although a guest we ran into there wound up also crossing our path later on. She was walking across America, with a heavy backpack. A bicycle goes a lot faster, and provides a convenient way to hold and move belongings, too. If you're thinking of long-distance hiking, I would recommend you at least look into getting a bicycle beforehand. We encountered her again when we got to Los Alamos, and helped her find a place to sleep.

With many of the hotels in Santa Fe being full or extremely expensive, we wound up staying at a series of cheaper motels. It felt like a flashback to a simpler, seedier time. Anyways, it also gave us a chance to see more of the town, including vendors of turquoise and silver jewelry. The town has subtly elegant designs, as well as its more touristy, tacky side.

While in Santa Fe, we went to lots of shops and restaurants. We went to a design shop, a sweets shop, a book shop, cowboy shops, and more. At a cowboy shop, full of beautiful old leather boots, cowboy hats, and all the paraphernalia you could dream of, the dealer told us about a man named Will James. Born in St. Nazaire de Acton, Quebec, Canada, he rustled cattle, and wrote. In trouble with the law, he moved to the American West, where he achieved some success.

I took to speaking with a bad southwestern accent, and Avril enjoyed seeing what the "New" Mexicans were up to – although actually New Mexico got its name from the Aztecs hundreds of years before the country of Mexico. We camped out in the car, and gazed at the stars. Like good *norteños*, the



cowboy cousins on the southern side of the border, we opened our doors and blasted loud *banda* music, dancing away the night. A bottle of whisky and some leftover chocolates contributed to a memorable night.

One day we went to Taco Bell, and it was funny to eat quasi-Mexican food together. On a night with an amazing sunset, we went to Cowgirls, a touristy barbecue place. With delicious food, a wide selection of beer, and moving live music, we danced that night away too. Many memories streamed to mind, and tears streamed down my face. We looked into each others' eyes, and gazed.

From Santa Fe, we drove up through the neighboring towns. We went to Los Alamos, birthplace of the Atomic Age. We went to Taos, a quaint artsy community. We went gambling, at one of the many nearby casinos. We went to a little restaurant where the Mexican lady could talk fluently with Avril *en español*, and we went to a little Mexican shop that reminded us both of being in an actual Mexican shop, like the ones in Baja California.

Making a loop, we cruised through the gorgeous hills, blasting loud rock music, and making frequent roadside stops. At one place, a cute roadside restaurant, we had barbecue and ice cream floats and other classic American fare. Sometimes we had difficulties getting along or agreeing on what to do. Taking a little break helped immensely. Then, back on our merry way.





Wrapping up like a burrito, and ready to go back, we still had the rental car, so we drove back from Santa Fe to Albuquerque, and Avril continued on her way back to the border.

*¡Rocanrol!* ☺

Rock & Roll! ☺

### **Alamogordo**

After returning to Albuquerque, I decided to do a fairly straight shot over to Alamogordo. While there are tons of telescopes in New Mexico, which has among the best viewing conditions on planet Earth, I had limited time and plentiful material, and only wanted to visit the cream. So, I went to the National Solar Observatory in Sunspot, New Mexico (“Peak Astronomy”).

The ride was sublime, as usual. I love to ride, especially after a lot of days off. It feels delightful, full of the sensations of flying and freedom. Wind in my hair, lungs full of air, legs pumping, senses finely attuned, and a magnificent sunset to top it all off.

I cruised into Alamogordo, a gratifying although admittedly somewhat regular city. Anyways, I found a convenient place with wifi to confirm with the observatory. Then, I went camping in a park.

That night, I got woken up by an official in a uniform, telling me I couldn’t camp there. He wasn’t a cop, but threatened to



call the cops. As a municipal parks agent, he insisted that I could not sleep there.

So, in the night, I walked away towards greener pastures. Actually they were browner, and cactusier, and along the way I heard one of my tires go pop, on a thorn.

I also heard the slime deploy automatically. That stuff's fantastic!

The campsite looked inspiring, with cactus patches and the sunset and the mountains. Due to the difficult thorniness I didn't risk a ride up the mountain, so instead got a ride with Dr. Uitenbroek. We talked along the way and it was warm and informative, although the mountain was so stunning that it would've been sweet to ride up, and more than twice as sweet to ride back down.

The mountain with the solar observatory also contains Cloudcroft, a pretty town. The mountain used to serve for forestry purposes. Many remnants still dot the landscape, such as impressive engineering feats that transported the wood. People can achieve remarkable goals with enough motivation. Another legacy is the road that makes travel to and from the observatory more feasible. There aren't any grocery stores on the mountain, however, so astronomers and other residents drive down into Alamogordo to pick up items.

Atop the mountain, I toured the big telescope for "Peak Astronomy," and spent some time back at Dr. Uitenbroek's comfortable place speaking with him and his partner. Sunspot



is a neat little town, the close community really cares for each other, and it comes across as a good place to live. One of the few downsides is that the altitude is so high that it's a bit harder to breathe, even while just standing around or walking, let alone doing any strenuous exercise. However, one acclimatizes, and can lead a fulfilling life in a small, astronomically oriented neighborhood.

Back in Alamogordo, I met a few cool people. There were some European travelers in town for a conference. And in a book store with a coffee shop, I met some other friendly folks, and caught up with my communications, which can be hard to do on the road. I also browsed the bookshelves – apparently you can learn a lot from books!

### **Ghost Experiences**

There were a lot of other places I wanted to go. As usual. Here in the New Mexico desert, and also elsewhere in my travels, I yearn to experience so much more. I'd wanted to see many of the small towns around the country. Those that I did see, almost universally amazed and astounded me. I still wish I could see more, although I recognize the limitations on time and other constraints in what we can do. In life and in astronomy, it's important to focus on higher-value targets.

Among the other things that I had wanted to do, I still haven't gone to a ghost town. Back in the California desert, I came very close, going right near some areas of interest. Like the Grand Canyon, although on a smaller scale, I feel that many possible experiences could add enormous value, yet for one



reason or another don't transpire. We can call these "ghost experiences."

I've realized that you and I and other people can do many of the things we dream, although sometimes it takes longer or comes about differently or otherwise varies from the original plan. Still, it's important to adapt, and to take the best experiences we can realize, rather than living only with unfulfilled dreams. Live magically. Explore!

A few other activities were suggested by people, and would have been fun to do if possible, although again didn't always materialize. For example, Avril and several other people suggested checking out Roswell, which would've offered a fun "aliens experience." I didn't find it feasible to make the efforts to get there. Does that make it a "ghost alien experience"? Or an "alien ghost experience?" Hm...

Anyways, we always have more options, possibilities, prospects, than appear on the surface. Sometimes, digging into these promises reveals a very valuable opportunity. Sometimes, the wealth of options can seem daunting in its own right, threatening us with regrets. Yet, being aware of the possibilities is a key to living magically.

Astronomically, open eyes and open minds yield new insights, new discoveries, new knowledge. We grow in our awareness of possibility, and this enables us to grow in our own lives. Likewise, in our personal lives, open eyes and open minds yield the keys to unlock our chests of dreams.



When we take chances on a new route, or make extra efforts to get to a destination, unexpected surprises often await. These can be positive or negative, yet often offer precious rewards. A spur-of-the-moment route selection to a place solely on the basis of its name can yield a new outlook on life. An astronomer's whim can open our eyes to a new view of the universe. The shocking revelation often comes from humble beginnings.

We owe it to our dreams to take a shot at newer, bigger realizations.

### **Missile Launch at White Sands**

From Alamogordo, I rode on down further south. One place along the way, which a few New Mexicans had recommended to me, was White Sands. The place has sand dunes, really beautiful structures of – you guessed it – white sands. The place also hosts a US military base, which is where a lot of the development of missile launch systems has taken place, and which is where my story comes in.

As I rode past the White Sands military base – there are so many military bases in the USA! – I took in the natural beauty of the vast expanses of the Southwest. You don't generally see such large areas without much impact of human development in other parts of the country. I could ride my bike for miles while seeing mostly white sandy hills.

After checking out a bit of the dunny area, just a tiny fraction, really, I stopped and had a snack. Then, I found a place to camp out for the night.



In the morning, I awoke with loud sounds and bright lights piercing through into my tent. Who was it? What did they want? Was it for me?

Sure enough, there was a large military police vehicle outside my tent, facing me and loudspeaking to me. The MP insisted that I would have to move. Why? I asked. “A missile’s coming overhead.”

Oh.

Well, I packed up and put away my camping gear, and the MP insisted on giving me a ride out of the location. After dropping me off just outside of the flight path, it was possible to turn around and watch the missile go by, right over where I had just camped. It went by really fast, and I was glad to have been awoken.

From there, I kept on riding. I rode, and I rode, and I rode. All the way down New Mexico. Through Las Cruces, the third city in New Mexico. Through more sand, more desert, more time. Through anything and everything that came my way. By this time, I had become a real bicycle rider. No longer just a beginner, I came to the realization that I could do this. I could ride, surmount the challenges of the road, and figure out how to carry on.

There is something very general about the lessons of adventure. We all go through challenges in the course of our endeavors. Whether in everyday life, or while riding by bicycle across the desert or the country or the planet, or while



investigating the latest frontiers in the world of astrophysics, we have hurdles and obstacles and obstructions in our way. And it turns out that we have to deal with these, and that how we handle them can be far more important and defining and meaningful than the challenges themselves.

From back in the first days of my trip, when I struggled to figure out how to ride, to survive – right up to this point when I could fluidly navigate fifty million little considerations, from the sparse environment through the ongoing military operations through the unusual social and professional demands of writing and riding – I had transcended the initial newness of this brave undertaking, to grow into something bigger, someone different.

That still leaves a lot of learning left to do. I don't think that I or anyone every fully attains our ideals, exactly as imagined. I guess that's maybe part of life, even more fundamentally than part of our humanity. Yet, as we grow, we incorporate our previous selves into our new selves, we build upon our knowledge, to reach ever higher levels. Now we can reach new worlds. Now we can reach the moon. Maybe one day we can reach the stars.

I kept on riding.

Through Las Cruces.

Through New Mexico.

Into El Paso, Texas.



Into the future.

¡Jajajaj! 😊

Let's glow! 😊





## **Peak Astronomy**

National Solar Observatory, Kitt Peak, Arizona & Sacramento Peak, New Mexico, United States of America

November, Year Two

*Solar observations tell us about the most important star in the universe, for us. The USA's national solar facilities, on Kitt Peak in Arizona and Sacramento Peak in New Mexico, provide unique insight. Next, the sun watchers take their newest kit to Hawaii.*

On southwestern peaks, the United States of America leads research into the star at the center of our system. These astronomy meccas feels like a stargazer's dream. Solar astrophysics has developed along somewhat different lines than the study of other stars. However, the two types of investigations share sites with many long, clear nights on desert mountains.

Atop Kitt Peak in Arizona, at the USA's home for optical astronomy, sits one station for the National Solar Observatory. Here we find the McMath-Pierce Solar Telescope. One state over, in New Mexico, atop Sacramento Peak, we find another superstar, the Dunn Solar Telescope.



The southwestern solar telescopes, two of the most important astronomical facilities, were built in the sixties. Both have unique architectures, and have revealed the intricate structures of the sun. Meanwhile, a new era of solar technology develops towards the Pacific Ocean. What brilliant light will we see?

### **Stare at the Sun**

It is important to study the sun in order to understand the major external influence on Earth – and on all of our lives. To study the sun, astronomers collect some of the plentiful light hitting the Earth. Despite the abundance of sunlight, however, once astronomers have finished dividing it up into various categories, they are still “photon starved,” meaning that the insights they can glean are limited by the amount of light reaching the lenses.

Solar astronomers can observe in broad daylight, unlike observers of other stars, whose light is drowned out by the sun. With this vast collection of light, it’s then possible to analyze the star. The sun is deep, space is wide – we have plentiful information on just one sun, and little information on plentiful stars. We can delve into immense detail on the sun, and we can do statistics on the stars. The two optics topics are complementary.

Because we get so much more light from the sun compared to other stars, we have a totally different view of the life of a star. Data from solar light gives us maps revealing structure, as well as spectral graphs revealing composition. The sun goes through cycles, and it has complex dynamics. Alive.



The sun contains a massive amount of plasma, making it almost a million times heavier than the rocky Earth. As the sun spins through itself, with different layers flowing, it creates a magnetic field. Astronomers ask: how does the sun's magnetic field evolve?

With only a handful of solar observatories around the planet, astronomers also research space weather, which affects electronics and other important systems on Earth, and which will play a growing role as humanity spreads out into space. As the primary source of energy on Earth, it pays to understand the sun.

### **Kitt Peak**

Kitt Peak sits around sixty miles outside of Tucson, the astronomy capital of the world. Numerous mountains in the area host many of the planet's most important telescopes. The site looks like an astrophysical Disneyland. On this mountaintop, considered sacred by native tribes and a sanctuary by environmentalists, the NOAO hosts a large stable of instruments. The different devices serve distinct purposes, and have contributed some of the domain's most important insights.

Here amongst the domes, the McMath-Pierce Solar Telescope stands out, with its rectilinear forms. Built in the early sixties, it looks like a science fiction grain elevator. With the glorious Kitt Peak statuary of large telescopes for surroundings, it feels even more like science fiction.



The extremely tall telescope has a 1.6 m prime focus reflector, with a focal length of over 80 m. This gives it an amazing focal ratio of  $f/54$ , dozens of times greater than a typical nighttime telescope. The largest telescope of its type, McMath-Pierce overthrew solar astronomy on a global scale upon construction.

A flat heliostat tracks the sun, and brings the light down below. A concave M2 focuses the image. Then another flat mirror redirects the light to its ultimate target for recording. The image rotates in a full circle once per day, as the Earth spins around with respect to the sun. A special challenge in solar astronomy is managing the huge amount of heat, which introduces turbulence that distorts the image.

Bill Livingston, who has a reputation as a “rock star” in solar astronomy, walks amongst the instruments. He developed this telescope’s control system back at the beginning. Today, his research focuses on sunspot magnetic fields, and monitoring the sun’s spectrum. A circle of light, around a foot in diameter, forms on a flat surface. Livingston explains how the image of the sun comes through the optics and arrives here. He and other astronomers look at it to track variations in the sun.

### **Sacramento Peak**

The McMath-Pierce Solar Telescope, while a highlight of Kitt Peak, represents just one part of the USA’s solar astronomy efforts. Another part sits on a different mountaintop, not far away. At roughly the same latitude one state over, in southern New Mexico, we find the appropriately named town of



Sunspot. Here in the Lincoln National Forest stands Sacramento Peak, with its own facilities for solar observations.

The astronomy at Sacramento Peak has a more underspoken beauty compared with Kitt Peak. After curving up through scenic winding roads, through the small resort town of Cloudcroft, this quiet little astronomy community has a quaint charm. Remnants of the old forestry industry remain. Sunspot has housing for staff, natural beauty, and of course a huge telescope.

The Richard B. Dunn Solar Telescope, designed and built largely by the pioneer Dunn himself, started as a project of the US Air Force. After transfer to civilian astronomers, the military still conducts some research here. The device has a vacuum tower over 300 feet tall, to remove heat noise. Amazingly, the entire telescope rotates, in order to compensate for the rotation of the solar image.

Han Uitenbroek, who moved here from the Netherlands, studies how the sun transfers energy through electromagnetic radiation. He rides his bicycle avidly, and describes the pleasures of the mountain. This observatory receives a fair number of visitors. Around the time of my visit, a meeting takes place to plan an upcoming NSO telescope, the solar heir.

Uitenbroek describes how this site was originally developed for a coronagraph, which blocks out most of the incoming sunlight in order to study the corona or crown that fringes the periphery. "Because the corona is so faint, you need very clear sky conditions."



Unlike the huge collection of stars available for nighttime astronomy, solar astronomers have to be creative with their tools. “You always look at the same object, right? So the only way to make progress is to look at that object in a different way.” Uitenbroek and his colleagues constantly bring in new instruments, sometimes crafting new *ad hoc* devices.

### **Set the Controls for the Heart of the Sun**

The combination of NSO’s Arizona and New Mexico facilities yields interesting insights. The sun has multiple layers, which exchange heat as they rub up against each other. The sun also transfers heat through radiation – electromagnetic exchange. All the interaction at the threshold generates powerful magnetic fields. The shape of the magnetic fields, the polarization and wavelength and intensity of the sunlight, and the other characteristics of the sun affect life and everything on Earth.

Within the sun, at its heart, an extremely hot and dense core undergoes nuclear fusion, emitting huge amounts of energy. Every second, the spendthrift sun blows through a trillion pounds of hydrogen. However, it occurs over such a sizable volume that the process is equilibrative, not explosive.

Astronomers can’t see directly into the sun, because light can’t make it out. However, using a technique analogous to the detection of earthquakes, they can infer from sound waves reaching the surface, the inner nature of the sun. It takes tens of thousands of years for energy to make its way from the core to the surface of the sun. By this point, small numbers of high-



energy photons have converted into large numbers of low-energy photons, which we see.

Somewhat surprisingly, the same processes in light erupting out of the sun also share similarities with how solid objects form out of galactic dust. We can learn a lot about the cosmos by looking into the sun from the hot and clear Southwest.

The sun goes through phases, on an eleven-year cycle. At the high points, it produces greater numbers of sunspots, which are areas where the magnetic field gets so strong that the space is emptier, and thus cooler, and darker. At these times, the sun also shoots off bright flares and ejections. In one recent observation, Livingston and another astronomer observed on the McMath-Pierce telescope at Kitt Peak the strongest sunspot magnetic field of the decade.

Understanding in depth how the sun operates provides a unique perspective into the processes underlying stars more generally. Astronomers can then combine knowledge of the different domains – the sun plus the other stars – and put together a clearer, better picture of the universe as a whole.

## **Sunset**

Astrophysicists badly want to understand the mechanical processes that generate powerful magnetic fields in the sun, and what effects these magnetic fields cause. To do so requires a telescope with fine enough precision, collecting a large enough amount of light energy, with sophisticated sensors. Just such a unique beast is now under construction.



The NSO is now constructing an entirely new facility. The Daniel K. Inouye Solar Telescope (DKIST) redefines solar astronomy for this generation, as the McMath-Pierce and Dunn telescopes did for the previous generation. DKIST uses a totally different layout, and offers unprecedented functionality in a solar telescope. It also has a site with lots of hours of sunshine, and clear sky, in Hawaii. With the move, the NSO is looking for partners to take over the New Mexico site, says Uitenbroek, possibly turning it into an educational visitor center.

Many of the technical advantages of DKIST stem from its larger, 4 m primary mirror. Solar telescopes generally have significantly smaller apertures than nighttime telescopes. This largely has to do with the much higher energy level introducing noise in the optics. Whereas earlier solar telescopes like McMath-Pierce and Dunn used their very long light tunnels to reduce mirror size, and therefore deformations due to heat, DKIST instead has an open-air design with a heat filter, says Uitenbroek. “The new telescope is an f/2 telescope, but it has at its prime focus a heat stop, which rejects most of the light, it only allows a small part into the telescope.” DKIST will be the world’s largest solar telescope.

Today’s solar astronomy needs precision. A pixel representing as little as a few dozen kilometers on the surface of the sun will enable astrophysicists to piece together an understanding at a level of detail previously unavailable. Furthermore, the polarization of light – which means the orientation, or the way





it spins – is especially important in solar astro, and greater precision means better pictures.

The new telescope, in addition to its larger primary lens, has such modern features as a large-format infrared camera. Finally, DKIST adds adaptive optics updates to solar. Dunn was the first solar telescope to develop functional adaptive optics for the sun. AO is taking off in nighttime telescopes, and now solar is catching up. All of this makes DKIST a revolutionary device for the study of the sun.

The sun is now midlife. Solar astronomers still have lots left to learn. As we gain a clearer picture of the sun, we can better understand how the source of essentially all energy in our lives behaves. Also, we can infer the behavior of distant stars. We even learn about space weather, which has implications for current communications, and quite possibly for future transportation. Overall, the study of the sun with these magnificent solar telescopes on southwestern mountaintops is a key to unlocking our past, our present, and our future, as humanity.



## **Epilogue: Ad Astra Per Aspera**

Sedillo Park, Socorro, New Mexico, United States of America

September, Year Two

*An amazing astrophysics adventure paves the way for a new day. In learning about the universe, and in traveling around a part of the planet, lots of wonderful opportunities become apparent. Tomorrow we have a new dawn!*

Writing a book about astrophysics adventures is hard. Dancing about architecture. Writing rock & roll, the blues, country, *banda*, electronica. Writing life.

Riding a bike across countries is hard. Especially because they build the observatories so fuckin' high!

And writing astrophysics while riding cross-country is extremely hard. Dauntingly hard.

Yet, worthwhile. As astrophysics can seem quite abstract, and its purpose perhaps difficult to understand, so can *Astrotripping*, or any adventure. But let's not lose sight of the reasons for doing these observations and adventures. We learn, and grow. We find and create meaning. We discover ourselves and our environments. We gain practical benefits, and intangible advantages. We LIVE. We love. Overall,



astrophysics and adventures give us context, meaning, depth, richness, value. Who are we? This is one way that we answer. And that's not just a smart-ass answer.

We go on big adventures – by telescopes through space, or by bicycles around the planet, or by psychedelic substances through our minds – only to learn more about ourselves, our home.

The point of leaving is to find home, to find oneself. The self-reflecting world, the ouroboros of self-discovery, in the cosmic and personal sense.

Home.

Adventuring around a part of the Earth, I went out looking for a greater understanding: of myself, of countries and societies, of the Earth, and of space – of our world. I had only a vague plan, necessarily. However, as I went along, I learned, and improved. And in the course of facing difficulties, I had to adapt. A small growing burst of energy turned into a great adventure through geography and culture while becoming more attuned to the universe. The wonder and joy of travel – learning about people and places – is very much like the wonder and joy of astronomy – understanding the cosmos. After all, we are of the cosmos. We already are in space.

Life is an adventure. Traveling through space is moving to a new home.



Writing about space is writing about Earth is writing about humanity. We all share the same life.

What makes humanity so wonderful?

Well, let's start by looking at those goat skulls from chapter six. They store a pretty good representation of their little corner of the universe. But our goat skulls, metaphorically speaking, are a lot bigger. Informationally. Our goat skulls can store practically the whole observable universe.

That is what makes us so special. And that is what makes it possible for us to go *Astrotripping*.

We *can* get to the moon, the planets, the stars. At least with our imaginations, and with our technologies, and maybe with our future embodiments.

We *can* find ways to travel around the universe, through our tools, cosmically curious. Trippy, right?

Those goat skulls apparently have a lot of lessons for us.

We now enter a new era in which millions, billions, trillions, quadrillions of astro data affect our lives in unprecedentedly insightful ways. While before we had a few stories about the stars, then a handful of simple geometric models, now we know immensely more about many metagalactic clusters full of stars and life. We now see how life flows throughout the cosmos, in the beautiful designs of the stars, and our little home.



And life flows on. All around us, in so many directions. While we look for signs of specific alien intelligences, we can see the evolving thriving beast that sprawls throughout the cosmos. From Earth to distant dreamlands, the growing vibrantly pulsating heart of life beats across the light years.

In conclusion: Our little goat skulls can take us on voyages of cosmic curiosity, tripping the light fantastically as we make our way out to distant realms, exotic destinations, exploring and experiencing through the subtly morphing waves of our minds – our fancy bio-socio-telescopes – what is it like way over yonder on the other side of the universe, on the far side of space and time.

How cool is that?!

The difficulties that we face, and hopefully surmount, in our lives here on Earth, looking out into the sky with all kinds of amazing new tools, remind us of our past and help prepare us for our future. For our future as individuals, and for our future as a species, and even for our future as progenitor of what follows.

Astrophysics is a first step. It is the information-gathering part of the process. Afterwards comes the really hard part. The important part. Which is for us to go out there and live with what we now observe. To continue the adventures in space. From our origins in space, through our brief time here on Earth, and back out into the wild beyond.



Here on Earth, my little bicycle adventures have been buckets of fun, and I feel so fortunate to have had this voyage. Along the way, I've seen so many mind-elevating sights. The incredible experiences have come pouring down like a kaleidoscopic waterfall. Even just to survive has been an exhilarating challenge. And through these developments, I've had a great opportunity to grow as a person. I now feel like I have a clearer sense of self and home, of space and time, of culture and geography. And I'm a way better bike rider, and even a mediocre mechanic. What a transformative trip!

Have you found any new clarity? Is this journey anything like a psychedelic drug trip? Does the universe look different in the brilliant view of modern astronomers' most inventive new investigations and discoveries? How does the world look in the new light of a liquid mirror, a gamma ray array, a new religious telescope, an extraterrestrial radio network? Have you learned a new way of looking at the world? Have you at least had fun?

I sure hope you enjoy *Astrotripping*!

On the basis of what we learn about our origins, we can improve how we look out into the future. We came from the cosmos evolutionarily, and we live here now, and we're moving out through the universe as our planet spins around our sun and our wheels spin around the Earth – into the future. Will we find ourselves in new places, in new forms? Will we fly, freely, out into deep space, stars far distant from Earth



Will we transform into something different? New kinds of people?

I'm not sure whether riding a bicycle around the planet and writing a book about space will help with our expansion outwards. Even if it doesn't directly push us on some specific path to the stars, it should at least contribute by providing valuable insights, shining some light, showing a new way. Plus, it's a lot of fun. I highly recommend doing something outlandish like this, even if it's just for a lark. Hopefully also more meaningfully. You can realize amazing dreams – just take that first pedal. Metaphorically. You can also do a first step, word, line, thought, or whatever suits your fancy. Do it anyways!

Neurons travel through the nervous system, resulting in all of our thoughts, feelings, and decisions. Planets travel through the solar system and other parts of space. Cyclists travel through the road system. Anything, you name it, travels through some system.

*Astrotripping* is about more than just a joyride, and more than just astronomy research, and more than just funny hallucinogenic drug jokes. *Astrotripping* is about life. The life that flows throughout our wonderful world. Through us, through our veins. In our sweat, our blood, our tears. In our words, our ideas, our dreams. Our life flows from the Big Bang, and whatever may have created that. Our life flows through our minds, our spirits if we want to call it that, ourselves. Our life flows out into our futures, our fantasies, our



imagination, our hopes, our ideals, our loves, our passions, our desires, our values.

Our lives are part of the life of the universe, the world.

The world.

We are the world. We are a small, mini-micro-nano-scopically small part of this crazy beautiful wonderful gift of life and love and whatever trippy spacey stuff you can dream up.

And when we apply ourselves, holistically, to this cool adventure, we can acknowledge reality, embrace nature, and grow into the best people we can possibly be in the world.

Wow! ☺

Anyways, we're on the verge of many further exciting developments. Which ones materialize will evolve from many intricate factors, including prominently who we are now and what we do next. And learning about our world, and going on adventures – this avenue strikes me as a rewarding way forward. Hopefully you agree. We have a long way to go. Who knows what's next? Whatever it is, it will surely have lots more action in store. Wherever we go in the world, let's keep in touch!

We're alive.

Rock 'n' Roll!!! ☺

LOVE,





*Astrotripping: A Cosmic Joyride*

Eagle Gamma

Eagle

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