ASTRONOMY BEAT

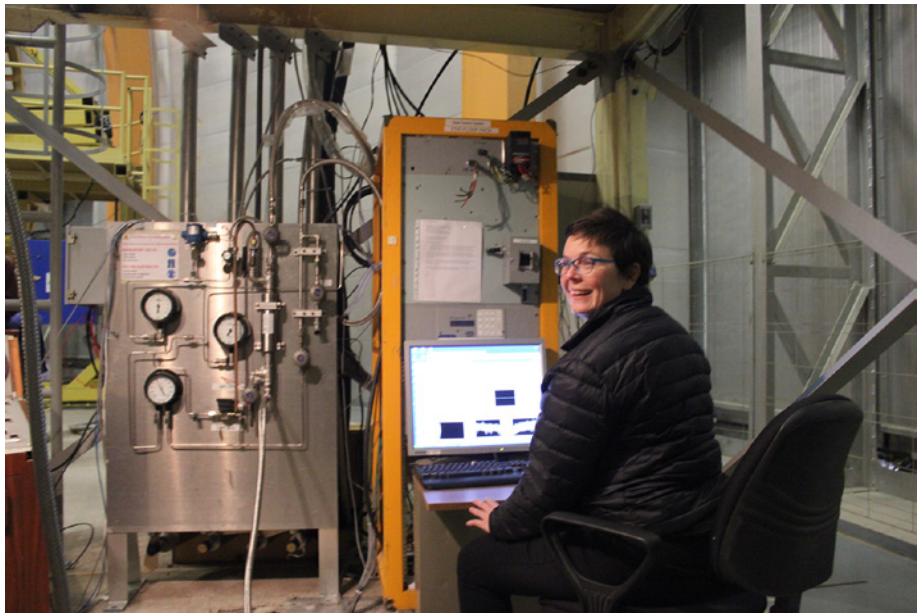
Exploring Chile, the Astronomy Capital of the World

Vivian White (*Astronomical Society of the Pacific*)

New Horizon's arrival at Pluto has some people asking why we're spending money exploring the Solar System when there is so much to do here on Earth. Exploration of the unknown seems to be one of the motivations that makes us human, and I feel both privileged and honored to be part of that story for my generation. While space-based telescopes are hugely useful for some pursuits, there is much we can do right here at home for less. One of the best places on our home planet to study the expanse of our Universe is on the otherworldly plains of the Atacama Desert in Chile.

I traveled to Santiago, Chile last month for the experience of a lifetime as one of nine educators in the inaugural Astronomy in Chile Educator Ambassadors Program (ACEAP). In less than 2 weeks, we visited dozens of telescopes perched in the high, dry mountains of Chile. We learned about the science, facilities, and communities surrounding these centers for astronomy knowledge. We were also welcomed with open arms into a culture permeated with astronomy and generous hospitality.

Northern Chile has become the go-to place for most of the world's largest telescopes for good reason. The huge Atacama Desert has everything astronomers could ask for in a location. Dozens of professional observatories stretch along the plateau nestled between the Pacific Ocean and the range of the Andes. It is one of the driest places on the planet, covering an area of over 40,000 square miles.



The author about to push a button on the controls of a 4-meter telescope *[Jim O'Leary]*

With 300+ clear nights a year, steady air coming off the ocean, and altitudes high enough to require additional oxygen for visitors, it's the ideal place for telescopes, from optical to radio. Combine that with a stable government, skilled workers, mountaintops galore, and the ground-based astronomy community is practically in heaven.

Cerro Tololo Inter-American Observatory

Our group of nine astronomy educators visited two Chilean locations where the US has placed telescopes in partnership with the Chilean government and worldwide collaborators. First we flew north to La Serena to visit the Cerro Tololo Inter-American Observatory (CTIO) at just over 7,000 feet. The campus includes two mountains: Cerro Tololo (meaning "hill in front of the abyss") and Cerro Panchón, where the Gemini telescope peers out with its giant eye.

CTIO is home to dozens of telescopes with fanciful names doing cutting-edge science. GONG (Global Oscillation Network Group) watches sunquakes, PROMPT (Panchromatic Robotic Optical Monitoring and Polarimetry Telescopes) is able to quickly catch gamma-ray bursts, and SMARTS (Small and Moderate Aperture Research Telescope System) is operated by Yale University to give telescope time to universities and other institutions. By far the largest of the telescopes in this group is the 8-meter Gemini South, the

Star Trails on CTIO *[Pete Detterline]*

The ACEAP Team clockwise starting from far left: Ryan Hannahoe, Peter Detterline, Jim O'Leary, Michael Prokosch, Sergio Cabezon, Brian Koberlein, Renae Kerrigan, Vivian White, Charles Blue, Sarah Komperud, and Shannon Schmoll *[Tim Spuck]*

Southern Hemisphere twin to Gemini North located on Mauna Kea in Hawai'i, whose mirror dwarfs its human operators.

While staying at CTIO, we were lucky to make an observing run with Chris Smith, who was studying light echos from ancient supernovae on the 4-meter Blanco telescope. Between observations, he told us about one of the most fascinating current projects on the mountain — the Dark Energy Survey. Working with a single camera made of 74 CCDs observing an area of about three square degrees (almost 50 times the size of a full Moon), this survey will record information about hundreds of thousands of galaxies to help us unravel the mysterious nature of dark energy in the universe.

Cerro Tololo has been a major astronomical center since the 1960s, but its influence is just beginning. Coming online in 2019, the Large Synoptic Survey Telescope (LSST) is poised to revolutionize

This panoramic view of the Chajnantor Plateau shows the site of the Atacama Large Millimeter/submillimeter Array (ALMA), taken from near the peak of Cerro Chico *[ESO/B. Tafreshi (twanight.org)]*

astronomy as we know it. Its mirror will be only a little larger than Gemini's 8 meters, but the LSST is like nothing ever built before.

Currently, when astronomers want to look at a part of the sky, they seek funding, apply for telescope time, and hopefully get to make their observations, deciphering the meaning hidden in the images for a year or so and then opening it up to the larger community, who may or may not care about that set of data. It is a model of scarcity because telescope time is at a premium, and we have more questions than answers. That model is about to change.

LSST is set to observe the entire southern sky every three nights — in astounding detail. And it will make these observations available for free to anyone who wants them right away! The team is touting it as Wide, Fast, and Deep but the reality is it will be Wild, Furious, and Demanding. The largest CCD camera ever built will have three billion pixels and will generate up to 20 terabytes of data a night. There aren't computers invented yet to handle the stream of data that it will produce.

According to the LSST website, "In its first month of operation, the LSST will see more of the Universe than all previous telescopes combined." We are looking at a whole new astronomy paradigm. It will find near-Earth objects (NEOs) all over the place, hopefully giving us enough time to avoid a disastrous impact. It will catch supernovae exploding, search the Solar System beyond Pluto, and learn about how our galaxy formed — just for starters. For new astronomers, this is a game changer. The skills needed for accessing this kind of big data are different than what I learned in school and open up a world of possibilities for connection with other disciplines, from security to marketing. I'm inspired by this project in a major way.

Atacama Large Millimeter/submillimeter Array (ALMA)

Next, we traveled farther north to San Pedro de Atacama, a small traditional oasis at least 600 years old, built mainly from red clay and surrounded by some of the most striking environments on Earth. It is currently supported by tourism, including adventurous climbers, sand skiers, cyclists, and astronomers, who value the location for its salt lakes full of flamingos and the terrain of geysers, volcanoes, and

The author flying high at 16,400 ft with the ALMA antennas *[Tim Spuck]*

sand dunes.

Just a few volcanoes down the chain lies the Chajnantor plain, ("place of departure") where the ALMA array of radio antennas observes the skies 24 hours a day in a dizzying dance. We learned how radio telescopes combine signals from several antennas to create an image equivalent to something you might see with a telescope almost a mile in diameter. To make these observations, the positions of the dishes must be known to within a hair's width. Each data point is fed into a massive computer called a correlator that combines the information from all antennas plus information about weather and atmospheric effects.

This feat of construction and imagination is an international collaboration between the US, Europe, and Japan, with each group building dishes that all worked together in the end. A collection of 12 Japanese antennas is placed close together to survey larger areas of the sky with lower resolution, while the others are constantly moved around to image a smaller area with astounding resolution. There are over 60 antennas that can be moved into arrays as large as 10 miles across. The wider their separation, the more detailed their measurements.

The ALMA detectors are looking for cold carbon molecules, like those around black holes and in the interstellar dust clouds. One of the most incredible images that ALMA scientists have created recently is a newly forming star that is building planets out of the surrounding dusty disk. The long wavelengths ALMA is observing means it can see through much of the dust envelope that obscures the star from our view in optical wavelengths. We are seeing this for the very first time, and it will inform us about how our own Solar System developed as well.

Chilean Skies Opened Our Minds

With all of the new and amazing things I encountered, the southern skies stole the show. Staying at such remote, clear, and dark sites afforded us clear views of the southern skies. It was my first time

Magellanic clouds with an iridium flare for good measure *[Pete Detterline]*

Observatorio Astronómico Andino — a beautiful tourist observatory 40 mins outside Santiago *[Vivian White]*

seeing the other half of the sky, and I was brought to tears by the beauty. The Milky Way drips down from the heavens in three dimensions. The Magellanic Clouds float alongside more star clusters than I've ever seen. My roommate and I woke one morning before dawn to be dazzled by the moonless sky. It was so dark and clear, we could see the zodiacal light — the dust in the plane of our Solar System lit up by the Sun yet to rise.

All of Chile seems to be enthralled with astronomy. There is a countrywide light ordinance in effect to keep the country a great place for astronomy. Tourist observatories operate for schools and international visitors, and as local gathering places. We stopped at two of these and I was impressed with their incorporation of cultural history, along with local food and wine. The observatories were warm, welcoming, and engaged all of our senses, making observing nights an active group activity.

Perhaps the most peaceful moment of the trip was astrophysicist Brian Koberlein playing his flute as the Sun set over the mountains of the high desert near La Serena. Perched on the edge of the world, the horizons extended almost to forever, both above and below. As the sky darkened, first the planets, then stars peeked into view and the wonders of a new night were shown to us. We could see the mountains behind, the sea in front, and the stars above. It was a beautiful country indeed.

We met as nine astronomy educators from across the US — planetarians, teachers, amateurs, and informal educators. Leaving our adventure together, we look forward to becoming future collaborators. International exchange programs are always learning experiences for their participants, and this was no exception. We grew tremendously as people and educators both through this program.

The country welcomed us warmly at every turn. We were invited to planetariums, observatories, and into the homes of the observatory staff. We learned astronomy, communication, international relations, and how to make pisco sour cocktails. Chile awaits astronomers of all varieties, from professional to amateur to educator. The skies, science, and hospitality won't disappoint.

This trip was funded in part by the National Science Foundation (NSF). CTIO and Gemini-South are supported by NSF and managed by the Association of Universities for Research in Astronomy (AURA), and the ALMA Telescope is a collaborative effort between the National Radio Astronomy Observatory (NRAO), the European Southern Observatory (ESO), and the National Astronomical Observatory of Japan (NAOJ), and is managed by Associated Universities, Inc. (AUI). ALMA is partially funded by the NSF.

About the Author

Vivian White is an astronomy educator at the Astronomical Society of the Pacific. She works closely with amateur astronomers across the country through NASA's Night Sky Network and creates outreach activities and demos for use by the network's 400+ clubs. She is also creating a suite of activities for museum educators to use with preschool children, grounded in research and inspired daily by her young son. Vivian holds a bachelor's degree in Physics and Astronomy from San Francisco State University and for the last decade has been working with educators from preschool to graduate studies.

Resources

- To read more about the author's journey, see the blog "My Head Is in the Stars": http://myheadisinthestars.wordpress.com.
- To learn more about the Astronomy in Chile Educator Ambassadors Program, visit: http://public.nrao.edu/look-deeper/aceap
- For more information about the Cerro Tololo Inter-American Observatory, visit: http://www.ctio.noao.edu/noao/
- The Large Synoptic Survey Telescope website is here: http://www.lsst.org/lsst/
- Learn more about ALMA here: http://www.almaobservatory.org ✦

Astronomy Beat

Number 136 • July 30, 2015

Publisher: Astronomical Society of the Pacific
Editors: Linda Shore
Designer: Leslie Proudfit

The Astronomical Society of the Pacific increases the understanding and appreciation of astronomy by engaging scientists, educators, enthusiasts, and the public to advance science and science literacy.

astrosociety.org

390 Ashton Avenue, San Francisco, CA 94112

Save The Date: October 10, 2015

Universe 2015, the 127th meeting of the ASP, will be held at Chabot Space and Science Center in Oakland, California and will feature astronomy activities for families, public astronomy lectures, an astrophotography contest, Chabot's interactive exhibits, the Annual ASP Awards Ceremony, and much more!

www.astrosociety.org/meeting