# SkyWAAtch


## An Interesting Pair

Mauri Rosenthal aimed at the Owl Nebula in March and discovered that it forms an attractive duo with galaxy M108. While appearing to be neighbors in our night sky, the Nebula is right next door at about 2000 light years; the galaxy is a mind blowing 45 million light years further out in space. The image was taken from Mauri's Yonkers yard with a Borg 55FL lens on a Starlight Xpress SX694-C camera mounted on an iOptron CubePro 8200 portable mount. The stack of 30 and 60 second exposures totals 9 minutes of integration time and was processed with PixInsight.

## In This Issue . . .

# Events for August

## WAA Lectures

**Leinhard Lecture Hall**
**Pace University, Pleasantville, NY**

There will be no lecture for the month of August. Lectures resume on September 8th with Member Presentations Night.

## Upcoming Lectures

**Leinhard Lecture Hall**
**Pace University, Pleasantville, NY**

Our traditional Members' Night starts this fall's meeting schedule on September 8th. There are sure to be eclipse stories, eclipse and deep sky images and perhaps member presentations about other astronomy trips, new equipment or inventions. If you'd like to make a presentation, let Pat Mahon know (waa-programs@westchesterastronomers.org).

## Starway to Heaven

**Saturday August 19th, Dusk.**
**Ward Pound Ridge Reservation,**
**Cross River, NY**

This is our scheduled Starway to Heaven observing date for August, weather permitting. Free and open to the public. The rain/cloud date is July 26th. **Important Note**: By attending our star parties you are subject to our rules and expectations as described here. Directions and Map.

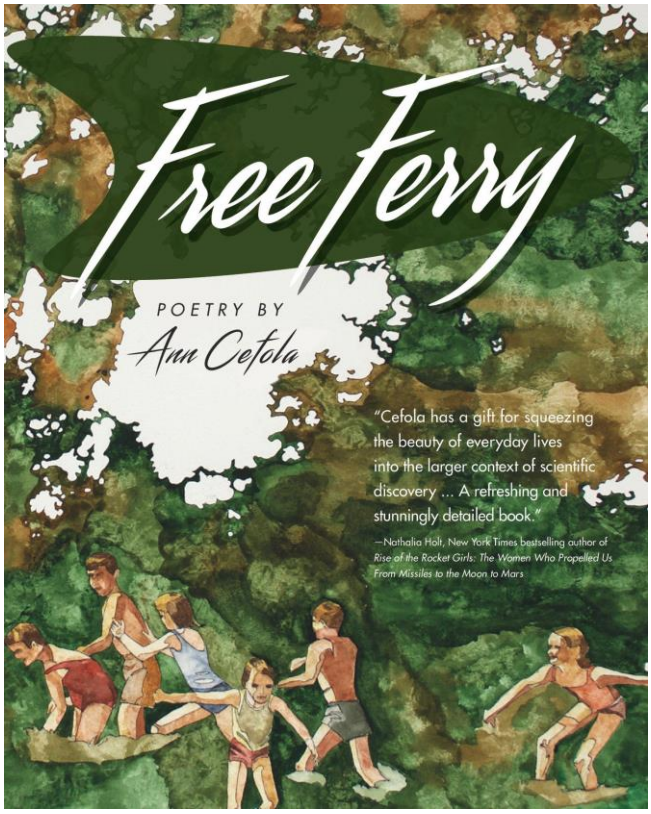
## New Members. . .

Peter Young - Bronx
Wilfrid Beauzile - St. Albans
Looking Up Photography - Cos Cob

## Renewing Members. . .

Barry Feinberg - Croton on Hudson
Charlie Gibson - Scarsdale
Sushil Khanna - Katonah
Arumugam Manoharan - Yonkers
Eric and Katherine Baumgartner - Redding

**Call: 1-877-456-5778 (toll free)** for announcements, weather cancellations, or questions. Also, don't forget to visit the WAA website.




**New Book From Ann Cefola**

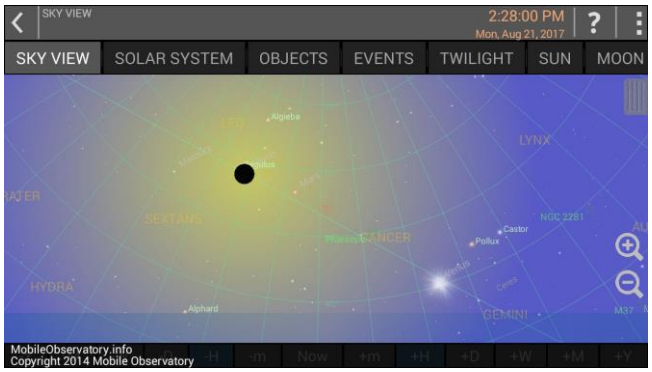
Ann Cefola's second book, *Free Ferry* (Upper Hand Press), made its debut earlier this summer at a launch party hosted by Fordham Westchester. The book-length poem features a dual narrative, and WAA President Larry Faltz read the scientific lyrics which concern the isolation of plutonium. Several WAAers were on hand for the event, including Michael Cefola, Darryl Ciucci, Elyse Faltz, Bill Newell, and Angela and Mike Virsinger. Ann thanks both Larry and WAA once again for its support!

Larry and Ann reading from her new book, *Free Ferry*, at Fordham Westchester.

# ALMANAC
## For August 2017 by Bob Kelly


Aug 7 Aug 15 Aug 21 Aug 29

As you may have heard, there is a great, all-American eclipse on Monday the 21st of this month. For those of you watching here at home, the Moon will cover 71 percent of the Sun, most at 2:44pm at 53 degrees above the horizon. The first nibble will began at 1:23pm and it's all over at 4:00pm. Watch at 2:30pm and you'll see the Moon at the exact moment of new moon! Venus is the next brightest object in the sky that afternoon, to the right of the Sun/Moon combo. Venus is lower in the sky than the Sun, which makes it harder to find, but you might have a chance to see it if the sky is very clear and blue as the Sun dims.




Venus and the partially eclipsed Sun in the sky of the afternoon of Monday, August 21st. Venus is a good 40 degrees above the horizon, but 20 degrees lower in the sky than the Sun, which makes it harder to find.

One additional note of caution; be especially careful if the sky has a layer of clouds that allow the Sun to be dimly visible. It may frustrate people with solar viewers and tempt people to stare unprotected at the dimmed Sun. Don't take the risk – our eyes don't have pain receptors, so we don't know if damage has been done until too late.

In the night sky, Jupiter is low in the southwest, up for 2½ hours after sunset to start the month and only 45 minutes by the end of the month. We still get enough time to gaze at Jupiter's belts and moons.

We have Saturn for a few hours more than Jupiter, starting nearly a third of the way up in the south when the sky goes dark. You can't get much more of a tilt to its rings this year.

Going out further, Neptune, then Uranus, rise in the evening sky. Pluto is really deep, just to the left of Sagittarius' teaspoon and much fainter.

Back closer to home, Venus is highest above our morning horizon on the 2nd, well after June's greatest elongation from the Sun. Sunrise moves up into the 6 o'clock hour this month, so take a peek before work. Find Venus in a bright sky and look there any clear morning for a friend on the morning commute.

Mercury starts out in the evening sky, but it's a struggle to find it so low in the west. Mercury just claimed the title of closest planet to Earth and keeps the title for the rest of the year.

Our favorite summer meteor shower—the Perseids—struggles to be seen in the glare of the chubby morning moon. The peak number of Perseids fall during the daytime of the 12th, but the Perseids keep falling near the peak rates for a few days.

Our Moon poses with other members of the solar system and twice with Saturn this month, including a very close conjunction with the Sun on the 21st. Saturn's turns are on the 2nd/3rd and 29th/30th, Neptune's on the 9th. On the 19th, there is a great photo op with Venus and the reemergence of Orion from his time behind the Sun.

The full moon on the 7th will give us practice for photographing the solar eclipse, since the moon (of course) is about the same size as the Sun. The farther side of the Earth sees part of the full moon pass through the Earth's shadow, but not for us.

This is vacation time for the people who run the Mars orbiters and rovers! With the spacecraft and mars-craft behind the Sun from Earth, the managers of these ships have loaded them with housekeeping programming and taken a vow of silence for several weeks. Attempts to send commands to these craft through the strong radio emissions from the Sun could have unintended results due if the code get corrupted.

The Beehive cluster in Cancer buzzes off to the right edge of the SOHO C3's view by the 8th of the month. Mars traverses the scene through the 20th – but at magnitude plus 1.8 it may not stand out much. Mercury sails wide to the south of the Sun from the 23rd through the 31st. And, if you don't get to see Regulus next to the Sun during the Total Solar Eclipse, look for it in the C3 view around mid-month.

The International Space Station passes over in the evening sky through the 14th.

## An Astronomy Trip to Chile: Part 4 – Gemini South & Observatorio del Pangue

Larry Faltz (photos by the author except as noted)

Gemini South telescope, 8.1 meters in diameter. Wide angle photograph by Bob Reynolds (Houston, TX)

Read the earlier articles in this series in the May, June and July 2017 SkyWAAtch newsletters.

The dome of the Gemini South telescope

We arrived on Cerro Pachón about 2:15 pm after having visited Cerro Tololo that morning. Unlike the observatories at La Silla and Cerro Tololo, the crest of Cerro Pachón doesn't have a gaggle of instruments in smaller domes accompanying the major telescopes: there are only 2 large domes, housing the 8.1-meter Gemini South and the 4.1-meter Southern Astrophysical Research (SOAR) Telescope. The Large Synoptic Survey Telescope (LSST) is currently in an early stage of construction on the mountain. Like Cerro Tololo, the three telescopes on Cerro Pachón are under the overall management of the Association of Universities for Research in Astronomy (AURA), but each is actually run by its own organization. SOAR, which we didn't visit, is funded by a partnership among the Ministério da Ciência, Tecnologia, e Inovação (MCTI) of Brazil, the U.S. National Optical Astronomy Observatory (NOAO), the University of North Carolina at Chapel Hill (UNC), and Michigan State

University (MSU). It was conceived at UNC in 1987 but construction only started in 2000. First light was in February 2005. A problem with the lateral mirror supports had to be corrected before full operation commenced in August 2006. SOAR's alt-azimuth mounted 4.1-meter f/1.68 mirror is only 4 inches thick. There are 120 actuators for active optics on the primary. A "rapid tilt-tip" rotatable tertiary mirror directs the optical path to one of 2 Nasmyth foci and 2 folded Cassegrain foci, operating at f/16.63. The tertiary can be repositioned within 60 seconds, facilitating the use of multiple detectors during one observing session. SOAR is highly automated: 80% of its observations are done remotely.

SOAR telescope, just ¼ mile from Gemini South

For reasons that were never quite explained, before we left for Chile we had to sign releases in order to visit Gemini South, indicating that we accept the risk of adverse effects of altitude and we would agree to be given oxygen if needed. We didn't have to sign anything for La Silla or Cerro Tololo, which are at similar elevations, or for the even higher ALMA Headquarters we were to visit a couple of days later. Gemini South is at 2,722 meters (8,930 feet). Sea-level folks will get a mild headache at that altitude if you stay long enough, like overnight, but no one in our group had any problems during the 2½ hours we were there.

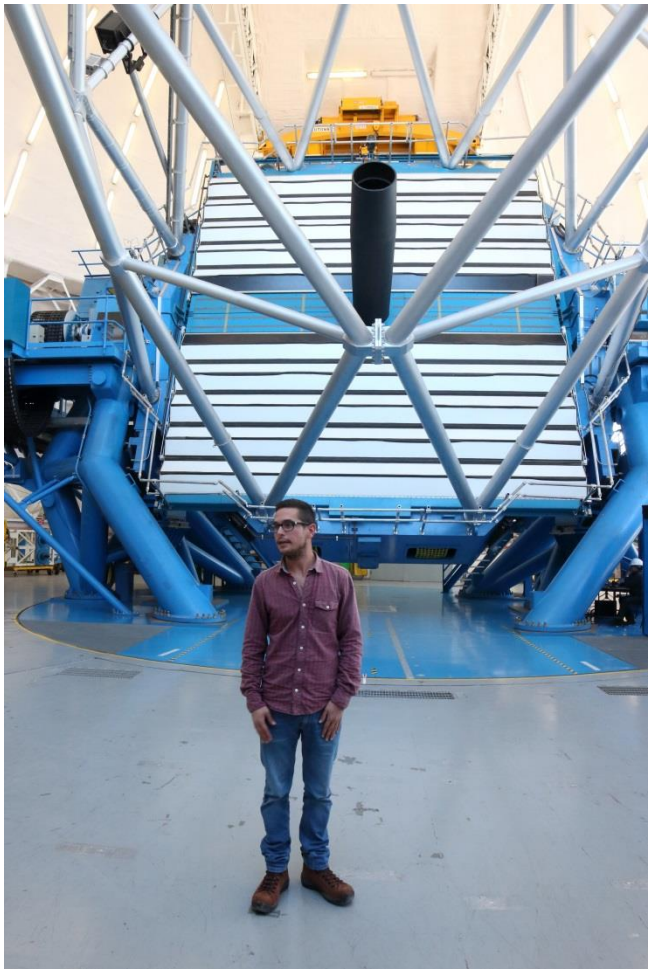
Outside of the Gemini dome we met our guide, Manuel Gomez. Manuel is an actual telescope operator at Gemini. He was an amazing source of information about the telescope's design, construction and operations and answered every question thrown at him from the mundane to the highly technical.

The dome has an attached one story building with offices, bathrooms, storage areas, conference rooms and workshops. The control room, also in this structure, was quite large and had several workstations each with many computer and video screens. A digital computer display of the time in Chile and in Hawaii (Gemini North is an identical telescope, although with different instruments, on the summit of Mauna Kea) avoided the gaffe we encountered at the Victor Blanco telescope on Cerro Tololo where the analog clocks were not synchronized (see last month's article).


Manuel explained that the control room is actually only used for telescope operations when the adaptive optics system is activated, which apparently is a minority of the observing nights. On other nights, the telescope is operated remotely from the Gemini headquarters in La Serena, with no one at the observatory at all. Control is through a high-speed microwave link. There are seismic sensors, weather instruments, cloud detectors, an all-sky camera and of course lots of monitoring devices on the telescope, the instruments, the dome and the utility systems. Since the possibility of communications failure is always present, independent control systems at the observatory, connected to a back-up power system, ensure that in the event of a communications disruption or main power failure all the systems are automatically shut down, the dome and ventilation louvers are closed and the instruments powered down. Someone will then be sent out from La Serena to troubleshoot the problem, taking well over an hour and a half to get to the scope. Remote control of this magnitude was apparently undertaken primarily as a cost-saving measure. Although there is a maintenance crew on site Monday through Friday during the day, from Friday night until Monday morning the site is not staffed unless there is a laser run. Manuel admitted to me, rather wistfully, that sometimes he misses nights at the telescope.

Manuel Gomez in the control room

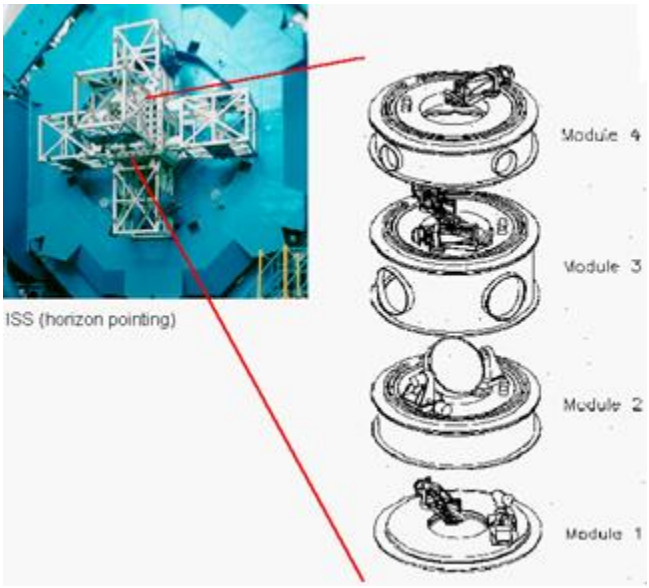
We then went up to the main telescope floor. The Gemini telescope is enormous, yet it doesn't give the impression of being massive. The Gemini mirror was cast from ultra-low-expansion glass by Corning but figured in France. It is an 8.1-meter meniscus just 20 cm (8") thick, weighing 22,200 kg (24.4 tons) and figured to f/1.8. The thin Zerodur secondary mirror, made by Schott and polished by Zeiss, is 1 meter in diameter and weights 54 kg. It is figured as a convex hyperboloid. The secondary support is a rapid tilt-tip mechanism capable of 200 corrections per second. The scientific instruments are located at the Cassegrain focus under the primary. The system is a Ritchey-Chretien and operates at f/16 with a focal length of 128,120 millimeters (a typical 8" SCT has a focal length of 2,032 mm). This gives a field of view of about 5 arc minutes. The mirror is coated with silver and not the usual aluminum in order to optimize its reflectivity in the infrared. The two Geminis are the only large telescopes in the world with silver-coated primary mirrors.



Manuel Gomez in front of Gemini South

The mount is alt-azimuth. Although the primary mirror support and fork (the blue parts in the photos) are fairly massive, the tube's truss structure is almost spindly. The top of the telescope is 71.2 feet above the floor, about 7 stories, when pointed at the zenith. The whole telescope weighs 418 tons. The dome rises 15 stories above the ground and has a moving mass of 858 tons. It can rotate 360 degrees in 2 minutes. There are thermal vents around the perimeter of the dome that can be opened to circulate air across the mirror surface. The mirror was covered with a retractable protective accordion-style baffle and so we didn't get to see it. Gemini North saw first light in 1999, and South followed a year later. Between the two of them they can observe the entire sky.

All of the detectors (imagers and spectrographs) are mounted on the rigid Instrument Support Structure (ISS) at the Cassegrain focus. A series of stacked ports with mirrors on the optical axis redirects the image to the instruments. The ISS rotates on the Cassegrain Rotator to compensate for field rotation inherent in the altazimuth mounting. Ever since the pioneering (but optically flawed) Russian 6-meter BTA-6 telescope saw first light in 1975, all large instruments have been designed with alt-azimuth mountings and field derotators.




The Instrument Support Structure and its instrument ports (Gemini)

The Gemini Multi-Conjugate Adaptive Optics System (GeMS) is used when observations are to be made with adaptive optics. AO can operate using an artificial guide star (via laser) or a natural guide star. A 50-watt laser beam is carried through optical fibers to the

top of the telescope, where five beams are projected into the upper atmosphere. The laser generator is located on the telescope pier (it's the large grey box on the left of the photo at the top of this article).

The Acquisition and Guidance Unit on the ISS contains the Acquisition Camera and three Peripheral Wavefront Sensors (guiders) that manage the adaptive optics compensations. The ISS contains 4 stacked modules, listed from the bottom up:

- Module 1: acquisition camera/high resolution wavefront sensor (up-looking).
- Module 2: science fold mirror, directs telescope beam to a side-looking science instrument or retracts to allow passage of beam to the up-looking instrument. Alternatively it can feed the AO-corrected beam to science instruments.
- Module 3: second peripheral wavefront sensor and facility AO pick-off mirror.
- Module 4: (closest to the sky) first peripheral wavefront sensor.
- Modules 2, 3 and 4 may rotate independently about the vertical axis.

There are actually a total of 8 wavefront sensors to analyze and provide corrections, 5 for the laser guide stars and 3 for natural guide stars.

Instruments on the Instrument Support Structure

There are four science instruments on the ISS. FLAMINGOS-2 is a near-infrared wide field imager and multi-object spectrometer operating at 0.95-2.4 microns. The Gemini South Adaptive Optics Imager (GSAOI) is a wide-field imaging system with a 4080 x 4080 pixel detector, operating in the same near-infrared range. The Gemini Multi-Object Spectrograph (GMOS) is an imaging camera and spectrograph working primarily in the visible range. It is the most used instrument on the telescope. The Gemini Planet Imager (GPI), an adaptive-optics imaging polarimeter/integral-field spectrometer, works in the infrared. The ISS is capable of switching instruments in 15 seconds.

The telescope is programmed in "queue mode" to make multiple observations with one or more of the instruments each night. Scripting for an observing session takes into account the sky conditions, transparency and seeing (atmospheric stability). Certain observation programs can be executed even if conditions are not optimal, while others can't. Telescope control software is programmed to automatically readjust the observing sequence as sky conditions are measured in real time. In addition, operators can reorder the sequence so that new phenomena needing immediate observation (like supernovas) can be studied.

Elyse at the Gemini South telescope

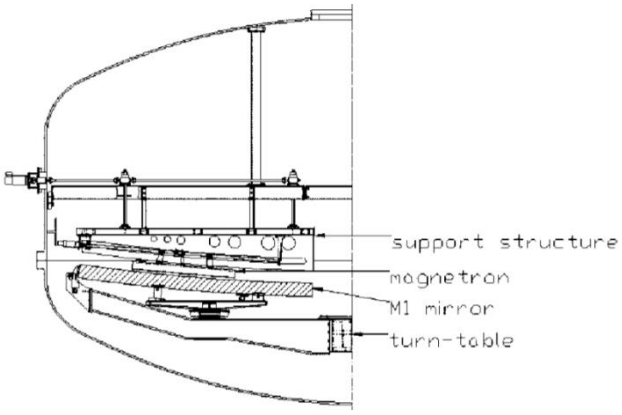
Manuel slewed the telescope for us, rotated the Instrument Support Structure and opened and closed the dome louvers. After a group picture in front of the telescope, we headed downstairs to the coating chamber. Like most very large telescopes, the mirror has to be recoated every few years. A hoist in the dome low-

ers the mirror through the floor into a gigantic stainless steel vacuum chamber. "It looks like a UFO" said someone when we first spied it. The coating chambers at both Gemini telescopes were contracted to the Royal Greenwich Observatory. The units are 9 meters in diameter and 6 meters high, with an interior volume of 150 $m^3$. The chambers can be evacuated to $3x10^{-7}$ millibars using cryopumps. A magnetron is used to deposit the 4 layers that make up the coating.

| | Material | Function | Thickness |
|---|---|---|---|
| Layer | Silicon nitride | Protector | 15 nm |
| | Nickel/chromium nitride | Adhesor | 0.8 nm |
| | Silver | Reflector | 200 nm |
| | Nickel Chromium Nitride | Adhesor | 5 nm |
| | Substrate (glass) | | |

http://www.gemini.edu/media/pr_images/websplash2004-12/paper_SPIE04.pdf

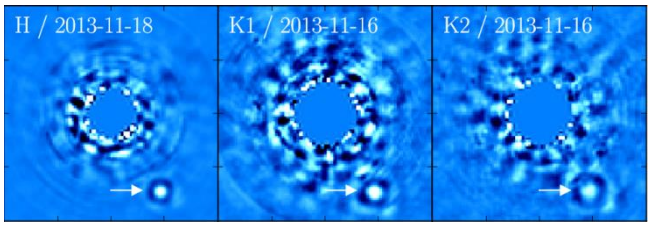
Outside the coating chamber




Cross section of the coating chamber (Gemini)

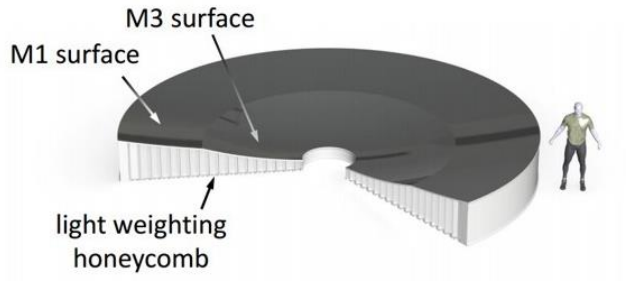
The scientific output from the two Gemini telescopes is prodigious. Lately, the study of exoplanets has occupied a lot of scope time as it has for many of the large research telescopes around the world but astrophysics, stellar evolution, galaxy dynamics and other subjects are not ignored. There is a vast amount of information and many spectacular images on the Gemini web site (http://www.gemini.edu/). They show the huge range of objects that the Gemini telescopes are capable of studying.

Reflection nebula GGD 27 in Sagittarius taken with FLAMINGO-2




β-Pictoris b in three different bands, acquired by the Gemini Planet Imager. Mass ~13 Jupiters, surface temperature 1700 K (taken from Chilcote et. al., arXiv:1703.00011, paper accepted by Astrophysical Journal Letters)

We emerged into the sunshine and walked around the outside of the dome until we could look across to the construction site of the Large Synoptic Survey Telescope. The alt-az mounted LSST will be a 3-mirror design: an 8.4-meter primary, a 3.4-meter secondary and a 5.0 meter tertiary meter that will direct the light back into a camera located on the optical axis behind the secondary (most 3-mirror designs have the tertiary mirror direct the light path 90 degrees to a focus outside the telescope tube). The primary and tertiary mirrors will be made from a single piece of glass with two curvatures inscribed on it.




The combined primary/tertiary mirror of LSST (LSST)

Light path at the LSST (LSST)

The LSST's field of view will be 9.62 square degrees, 49 times the area of the full moon. The 3.2 gigapixel camera will be the largest in the world (only until the Apple iPhone 9, perhaps?). It is sensitive from the near ultraviolet to the near infrared. It will be the size of an SUV and weigh 6,200 lbs. There are three corrector lenses and a number of rotatable filters in front of the camera. The largest corrector lens, at 1.55 meters diameter, is 50% larger than the objective of the 40" Yerkes refractor, the world's largest. Each observing night, 1,000 paired images will be acquired, amounting to 30 terabytes of data per night. Over the 10 year period of the initial science plan, it is expected that 200 petabytes of data will be available for analysis. Science operations are expected to start in 2023.

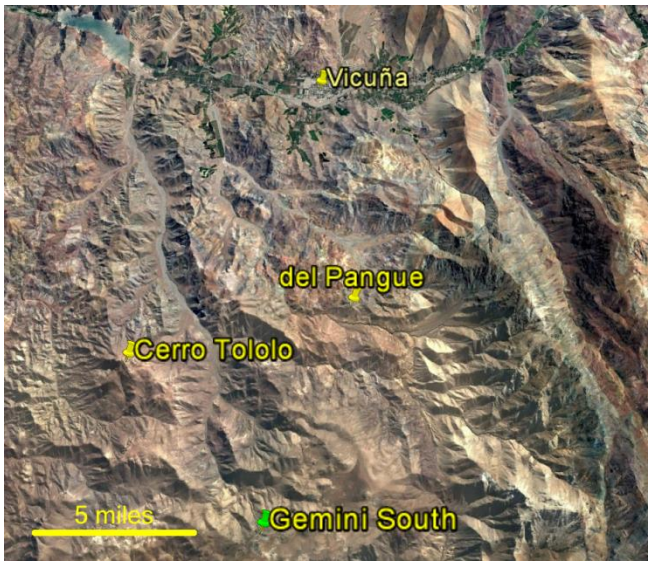
LSST construction site from Gemini South

The goal of the telescope is protean: understanding dark matter and dark energy, looking for transient deep sky events and variability in objects from neutron stars to active galactic nuclei and examining the solar system to look for potentially hazardous asteroids as well as understanding its evolution. Financial support for LSST comes from the National Science Foundation, the Department of Energy and private funding raised by the LSST Corporation. Central management is by AURA.

We boarded our bus for the trip back down to the road junction and the Sydney Wolff monument, mentioned in last month's article, and everyone had their picture taken at the direction sign.


The domes of SOAR and Gemini South and the LSST construction site are on the ridge behind us.

We arrived back at the Hotel Terral in Vicuña in time to drink some wine and have dinner before we boarded three 10-person vans for the drive to the Del Pangue tourist observatory for the night's viewing session.




Observatories south of Vicuña

It was pitch-black along the graded dirt road that led into the mountains south of Vicuña. As soon as we got

half a mile south of town, there wasn't a single light to be seen. The road was not quite as well maintained as those that led to Cerro Tololo and Gemini even though it was billed as the "main road to Hurtado," a tiny hamlet in the next river valley 30 miles south of Vicuña. It's not the "main" road, it's the "only" road. There were many switchbacks, washboards and sharp rocks scattered about, and one of the cars in our caravan got a flat tire. But after about 50 minutes of fearless (on his part) driving by our young chauffeur we arrived at the Observatorio del Pangue around 9 pm.

Observatorio del Pangue is at 1478 meters (4,850 feet) elevation, 11 miles south of Vicuña as the crow flies and about 7 miles east of Cerro Tololo and Gemini South. With no neighbors or traffic along the road, the sky was very dark, registering 21.51 on the Sky Quality Meter at around 11 pm. Del Pangue is directed by French astronomer Eric Escalera. Two telescopes were made available to us. The larger was a 25" Obsession housed in a roll-off building (the whole building rolls off, uncovering a large patio that accommodated our group) and a 16" Meade LX200 ACF.

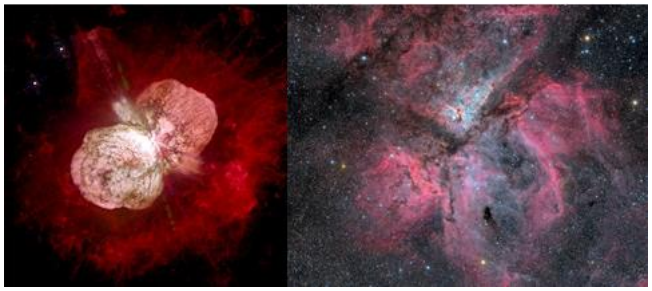
Christian Valenzuela Videla at the 25" Obsession (El Pangue)

We observed a number of deep sky objects with the 25", mainly southern sky gems that we had seen the previous two nights, but with the larger aperture the views were even more amazing. Eric put a UHC filter on the telescope, and in my notebook there is a whole line of asterisks after the entry "Tarantula."

16" Meade LX200 (El Pangue)

The 16-inch Meade was manned by Cristian Valenzuela Videla. Cristian had made a list of faint deep sky objects, and when we saw his inventory Elyse and I decided to stick with him for the remainder of the evening. The scope's go-to functioned perfectly, and with high-quality eyepieces and some excellent filters the viewing was utterly absorbing. We looked many objects. Among the most interesting were the open cluster M46, containing the planetary nebula NGC 2438 (M46 is never more than 30 degrees above the horizon in Westchester, and then only in frigid February); Thor's Helmet (NGC 2361); the Eskimo (NGC 2392) and Ghost of Jupiter (NGC 3242) planetaries, both showing internal structure; the Pencil Nebula (NGC 2736, a faint part of the Vela supernova remnant); and a number of small galaxies that I was too excited about to write down. The hit of the evening was our opportunity to study the Eta Carina nebula at high power. We were actually able to see the lobes of the Homunculus, the expanding blob of gas ejected in the 1841 outburst from this very active star. Kelly Beatty from *Sky & Telescope* came over and was as excited as we were to see it. It's the subject of one of the most iconic Hubble photographs. I never thought that it would be visible in a small optical telescope, but there it was, a small (around 7"), discrete struc-

tured bubble surrounding the star, encased in an enormous expanse of nebulosity. The Hubble photos only show the central Homunculus, and wide-angle views aren't detailed enough to pick it out of the swirliness of the surrounding dust and gas.



Narrow- and wide-field views of Eta Carina (Hubble; José Joaquín Pérez, astro-austral.cl)

This object is changing size perceptibly as the years pass. Hubble has captured the expansion and there's an animated gif file showing the Homunculus' evolution in images from 1995, 2001 and 2008. See it at https://apod.nasa.gov/apod/image/1412/CarinaExpanding_Hubble_750d.gif.

Early in the evening I made a wide angle image with my DSLR, as did a couple of other folks. The best shot of the evening was by John Gossett, below.

We reluctantly left for Vicuña about 12:15 am. The next morning was less hectic. We checked out of the hotel and were taken over to the large Capel pisco distillery in Vicuña to see how the liquor is made (fermented Madeira grapes, double distilled and aged) and to have a taste, although I thought it was a bit early in the day to drink 40% alcohol. Then we drove back through the Elqui Valley to the La Serena airport for a plane to the northern desert city of Calama, and then on by bus to San Pedro de Atacama and the ALMA observatory. More about that next month. ■

Photo from Observatorio Del Pangue by John Gossett (Garden Grove, CA). The 16" Meade is on the right.

## "Starway to Heaven" Star Party July 15th

The view at sunset, with about half the observers already at Ward Pound

We had heavenly weather for our July star party, with crystal clear skies, pleasant temperatures and not too many biting insects. There were at least 18 telescopes ranging from 2½ inches to 14 inches (and some binoculars). Many members, friends and guests showed up to look at Jupiter and Saturn and the usual summer deep-sky highlights in the near-perfect conditions. Around midnight the Sky Quality Meter registered 20.36, about as dark as it gets at Ward Pound. The Milky Way was visible crossing the zenith.

Well before dark, Mike Lomsky set up his 14" Orion go-to dob while a friend launched a drone to make a movie for a video project. The drone buzzed around the observing field like a mad cicada as we set up our equipment. It will be fun to see the final production. I arrived early for the usual 50 minute set up of Locutis (8" SCT) for Mallincam video, what with all the wires, devices, computers, video screens and power supplies. During twilight I walked around the field and handed out bunches of eclipse glasses for those people who needed them for the coming August 21st total solar eclipse. In the gloaming, groups of WAA members chatted excitedly about upcoming travel plans for the event. Once it got dark enough, Jupiter and Saturn were the main targets. The Mallincam gave wonderful views of deep sky objects and I explained some of the science to the many people who stopped by. The Whirlpool Galaxy (M51) and its companion and the Eagle Nebula (M16), with its famous "Pillars of Creation" within the glowing nebulosity were my favorites this night, but the Dumbbell (M27), Omega (M17) Lagoon (M8) and Crescent (NGC6888) were all magnificent objects on the screen. When new groups came by I could easily go back to the most interesting and beautiful objects with the CPC800's accurate go-to.

I captured images to demonstrate the live video screen appearance of M16 and M51.

--Larry Faltz

## Twenty Years Ago on Mars…

Linda Hermans-Killiam

On July 4, 1997, NASA's Mars Pathfinder landed on the surface of Mars. It landed in an ancient flood plain that is now dry and covered with rocks. Pathfinder's mission was to study the Martian climate, atmosphere and geology. At the same time, the mission was also testing lots of new technologies.

For example, the Pathfinder mission tried a brand-new way of landing on Mars. After speeding into the Martian atmosphere, Pathfinder used a parachute to slow down and drift toward the surface of the Red Planet. Before landing, Pathfinder inflated huge airbags around itself. The spacecraft released its parachute and dropped to the ground, bouncing on its airbags about 15 times. After Pathfinder came to a stop, the airbags deflated.

Before Pathfinder, spacecraft had to use lots of fuel to slow down for a safe landing on another planet. Pathfinder's airbags allowed engineers to use and store less fuel for the landing. This made the mission less expensive. After seeing the successful Pathfinder landing, future missions used this airbag technique, too.

Pathfinder had two parts: a lander that stayed in one place, and a wheeled rover that could move around. The Pathfinder lander had special instruments to study Martian weather. These instruments measured air temperature, pressure and winds. The measurements helped us better understand the climate of Mars.

The lander also had a camera for taking images of the Martian landscape. The lander sent back more than 16,000 pictures of Mars. Its last signal was sent to Earth on Sept. 27, 1997. The Pathfinder lander was renamed the Carl Sagan Memorial Station. Carl Sagan was a well-known astronomer and science educator.

Pathfinder also carried the very first rover to Mars. This remotely-controlled rover was about the size of a microwave oven and was called Sojourner. It was named to honor Sojourner Truth, who fought for African-American and women's rights. Two days after Pathfinder landed, Sojourner rolled onto the surface of Mars. Sojourner gathered data on Martian rocks and soil. The rover also carried cameras. In the three months that Sojourner operated on Mars, the rover took more than 550 photos!

Pathfinder helped us learn how to better design missions to Mars. It gave us valuable new information on the Martian climate and surface. Together, these things helped lay the groundwork for future missions to Mars. Learn more about the Sojourner rover at the NASA Space Place: https://spaceplace.nasa.gov/mars-sojourner

**This article is provided by NASA Space Place**. With articles, activities, crafts, games, and lesson plans, NASA Space Place encourages everyone to get excited about science and technology. Visit **spaceplace.nasa.gov** to explore space and Earth science.

The Mars Pathfinder lander took this photo of its small rover, called Sojourner. Here, Sojourner is investigating a rock on Mars. Image credit: NASA/JPL-Caltech.

## Photos from Summer Star Camps

From the Medomak Astronomy Retreat: WAA members Eric and Katherine Baumgartner at their 7" TMC refractor.

Also from the Medomak Astronomy Retreat: Elyse Faltz at Celestron 8" SCT . This one done in the dark, 13 second exposure "painted" with a red light.

From the Rockland Astronomy Club Summer Star Party: A couple of pictures of parts of the observing field.