SkyWAAtch

The Sun Disappears

Rick Bria captured this image of the August 21st solar eclipse using a Televue 76mm refractor and Canon 60Da. Rick observed the solar eclipse from Menan, Idaho, less than 4 miles south of the shadow center. The eclipse duration at that location was 2 minutes 16 seconds; the sky was crystal clear. Notes Rick: It's a very short exposure intended to show Baily's Beads. Baily's Beads occur at the beginning and end of totality, when shafts of the Sun's photosphere shine through valleys and craters on the Moon's limb.

We are dedicating our October SkyWAAtch newsletter to the August 21st solar eclipse as experienced by our WAA members, their families and friends. WAA'ers observed totality from locations across the US. Tell us your story. Please send your report, up to 750 words (Microsoft Word attachment or plain text in the email is OK) and attach up to three photographs that you took (the eclipse or the crowd, JPEG format, at least 800x600 pixels but not larger than 2000x1200 pixels, maximum file size 3 MB) to us at eblasts@westchesterastronomers.org.

In This Issue . . .

Events for September

WAA September Lecture

“Member Presentations Night”
Friday September 8th, 7:30pm
Leinhard Lecture Hall,
Pace University, Pleasantville, NY

WAA members will showcase their photos, equipment and astronomy insights. So if you've done something interesting astronomically this summer, gotten a new piece of equipment, or made some images and would like to talk to fellow club members about it, contact Pat Mahon, WAA Vice President for Programs, Directions and Map.

Upcoming Lectures

Leinhard Lecture Hall
Pace University, Pleasantville, NY

Our speaker for October 6th will be Professor Georgia Karagiorg of Columbia University. She will speak on neutrinos.

Starway to Heaven

Saturday September 16th, Dusk.
Ward Pound Ridge Reservation,
Cross River, NY

This is our scheduled Starway to Heaven observing date for September, weather permitting. Free and open to the public. The rain/cloud date is September 23rd. **Important Note**: By attending our star parties you are subject to our rules and expectations as described here. Directions and Map.

New Members. . .

Michelle Maerov - Mount Kisco
Scott Levine - Croton On Hudson
Diann Buro - Scarsdale

Renewing Members. . .

Deidre Raver - Mahopac
Scott Nammacher - White Plains
Cathleen Walker - Greenwich
Michael & Ann Cefola - Scarsdale
Gene Lewis - Katonah

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

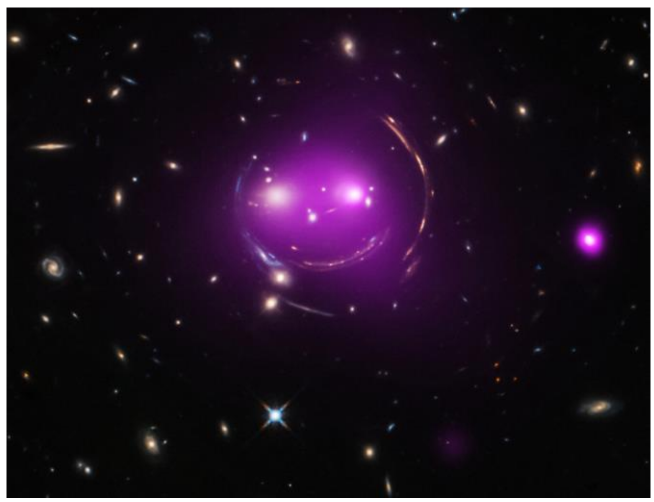
Wanted Assistant Editor

The WAA newsletter (the *SkyWaatch*) is seeking an Assistant Editor. If you can help, please let us know. Your participation in editing, compositing and proofreading tasks or submitting articles or images will be much appreciated. If you’re interested, please email Tom at waa-newsletter@westchesterastronomers.org.

Vendors of Interest

- Adirondack Public Observatory is conducting an astrophotography workshop on October 19-22, 2017. For details consult their website.
- Stratum Technologies provides telescope mirror coatings. For further details consult their website or contact info@stratum-technologies.com.

Please Note: The above vendors are unaffiliated with WAA. WAA does not endorse their services and references them for informational purposes only. Please check directly with the vendor for applicable fees.



Albert Einstein's general theory of relativity, published over 100 years ago, predicted the phenomenon of gravitational lensing. And that's what gives these distant galaxies such a whimsical appearance, seen through the looking glass of X-ray and optical image data from the Chandra and Hubble space telescopes. Nicknamed the Cheshire Cat galaxy group, the group's two large elliptical galaxies are suggestively framed by arcs.

Image Credit: X-ray - NASA / CXC / J. Irwin et al. ; Optical - NASA/STScI

Credit: APOD.

ALMANAC
For September 2017 by Bob Kelly


Sep 6

Sep 13

Sep 20

Sep 28

Sunrise moves later from 6:30 to 7am in September. It helps us see the morning machinations of Leo's rising in the east, seeming to bring three planets with it. Mercury makes its best excursion of the year into the dawn sky and Mars starts its slow trip out from behind the Sun. Venus is the only one of the three visible at the start of September, with Mercury coming on-stage the second week of the month, followed by Mars at middle-month.

Venus is actually sinking toward the solar glare, which will take to the end of the year to complete. Around the 16th, can you believe Mercury at magnitude minus 0.5 shows us how to find plus 1.5 Mars? They pass half a degree apart from each other. The Moon completes the scene on the 18th, running down the planets and Leo's Regulus for the far side of the world.

Mercury's greatest swing out from the Sun is on the 12th, but it's brightest on the 19th on its way back into the solar glare. Venus will be at home low in the morning sky to the upper right of the sunrise point for the rest of the year. Venus and Regulus meet this month to exchange stories of the total solar eclipse that made them famous in the daytime sky for 2 minutes. They will be less than a degree apart on the 20th.

Earlier in the month, we'll have a front row seat to the hit and run of Aldebaran by the Moon, but we'll be blinded by the light of the morning Sun, so telescopes will be required to document the event. *Alpha Tau* disappears behind the Moon on the sunlit side just before 9am and pops back out on the dark limb at 10:07am. It's also a great time of month to look for the Apollo 15 landing site in the Apennine Mountains. Our Moon is closest to the Earth for September at last quarter phase.

Take the Labor Day weekend to see the final time Jupiter is up after the end of evening twilight. Saturn will still be high in the south-southwest after sunset. Jupiter will be gone, gone, gone, into the Sun, Sun, Sun in October, while Saturn will hold tight in the evening sky into early December. Saturn's two-faced moon Iapetus scoots south of the planet around the 23rd. The ¾ full Moon's rugged south polar region tips a bit further into view that weekend.

Neptune All-Night is back in September. Get a finder chart for directions. Uranus pulls the all-nighter next month in Pisces. The rest of the year is prime time to find them. The Canadian Observer's Handbook notes the fourth magnitude star *Omicron Piscium* is only a degree or so from Uranus; closest near mid-month and making the seventh planet easier to find.

The International Space Station is visible in the morning sky through the 23rd, and in the evening sky afterwards.

The Moon's best photo ops are with Saturn on the 26th, and with the morning menagerie on the 17th and 18th.

The equinox occurs at 4:02 pm EDT on the 22nd. There is no truth to the rumor that you can balance a person on their head at the moment of equinox.

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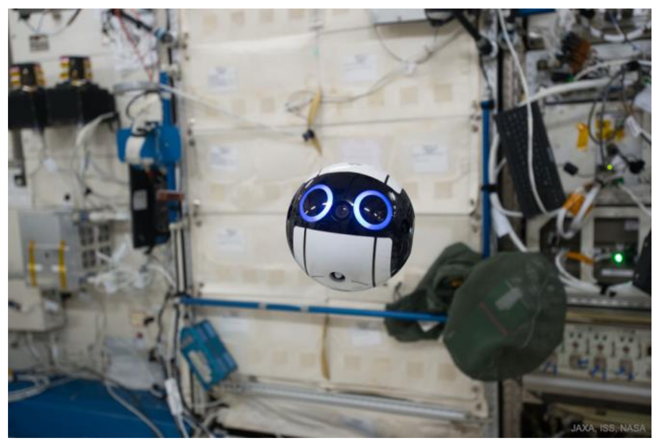


What if you were followed around by a floating ball that kept taking your picture? Then you might be an astronaut on today's International Space Station (ISS). Designed by the Japan Aerospace Exploration Agency (JAXA), the JEM Internal Ball Camera -- informally "Int-Ball" -- is a bit larger than a softball, can float and maneuver by itself but also be controlled remotely and can take high resolution images and videos.

Image Credit: JAXA, ISS, NASA

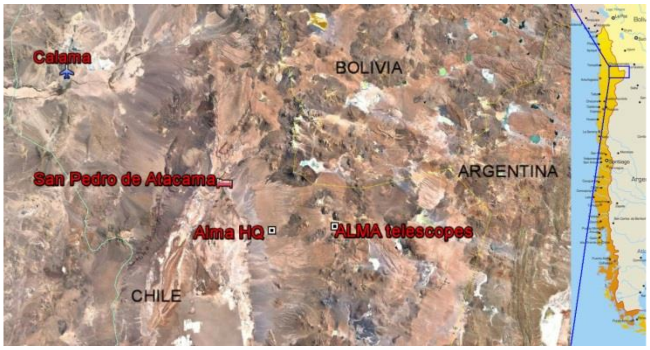
Credit: APOD

An Astronomy Trip to Chile – Part 5: San Pedro de Atacama and SPACE

Larry Faltz

The previous articles in this series are in the May, June, July and August 2017 SkyWAAtch newsletters.

On the 6th day of our Sky & Telescope trip to Chile, our plane from La Serena touched down 500 miles north at the modern El Loa Airport in Calama, a city of 150,000 at elevation of 2,260 meters (7,400 feet). We were in the center of the Atacama Desert, the driest place on Earth. Calama has an annual rainfall of just 0.20 inches. For comparison, each year in Westchester we receive an average of 49.35 inches of rain. It was another exquisite sunny, temperate day, the third day of autumn in the southern hemisphere.



We boarded a small bus that just held our group of 26. It was a more primitive vehicle than what we had earlier in the trip. It couldn't even accommodate our luggage, so Gustavo, our enthusiastic guide for this part of the tour, had arranged for a large pickup truck to meet us at the airport. All of our bags were loaded onto it with remarkable geometric efficiency, like those amazing supermarket baggers who seem to be able to pack your groceries with topological perfection, leaving no free space in the bag. The truck went on ahead as we drove 100 km (62 miles) on a nicely paved 2-lane highway to the quaint town of San Pedro de Atacama, where we would be based for 3 days. We stopped along the way for obligatory photographs as well as a presentation by Gustavo on the geology of the Atacama region and the volcanic Andes range to the north and east. The enormous stratovolcano Licancabur, 5,916 meters (19,409 feet) in elevation, marked the border with Bolivia and was a constant feature on the horizon wherever we went in the area. Licancabur means "hill of the people" in the Kunza language of the ancient Atacameño inhabitants who managed to live in this nearly barren land.

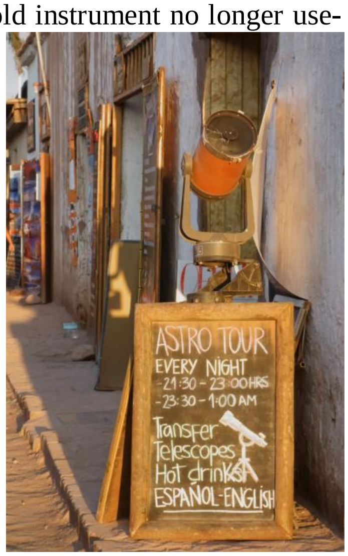
We marveled at the Martian landscape (NASA even does testing for Martian exploration in the Atacama). Vast stretches of dirt, with a few (*very* few) tiny drought-tolerant plants stretched out to snow-capped volcanoes or salt flats far in the distance. There are some years when this area receives no rainfall at all, although occasionally in winter (June-September) there are downpours and even rarely snow. Although the landscape is monotonously brown, there are broad stretches of white salt. A good bit of the Atacama is a "salar" (salt flat). Most of the salt is actually underground, the residuum of ancient inland seas, but the rare rainstorms saturate the ground, dissolving the subterranean salt, which rises to the surface and crystallizes as the moisture evaporates in the sun.

Elyse and me with Licancabur in the background

It's not snow, it's salt

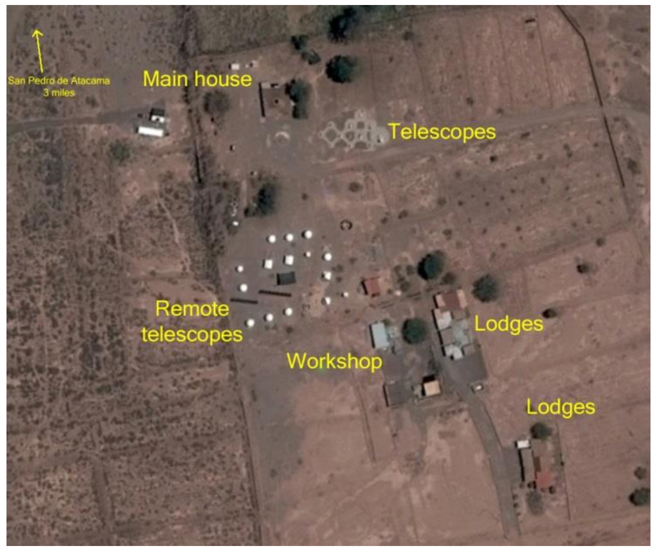
San Pedro de Atacama is a small village of about 4,000 people at an elevation of 2,407 meters (7,900 feet). Its climate is officially "cold desert", so even in the summer it's usually temperate, while in the winter the night-time temperatures can drop below freezing. Annual precipitation is less than 2 inches. The town attracts a young international crowd looking to explore the various natural geologic wonders in the area and visit pre-Columbian archeological sites. We heard many languages spoken. The only large professional observatory in the area is ALMA, the Atacama Large Millimeter Array, but astronomy has become an important element of San Pedro's adventure tourism economy, taking advantage of the dark, clear skies.

The town's unpaved streets are lined with inexpensive restaurants, shops, markets and money exchanges. Many feral but polite dogs wander about or sleep on the sidewalk or right in the middle of the street. Some of the shops contained offices of local tour companies, and almost all offered an evening of astronomy viewing. As a come-on, these usually had a telescope on display, often a beat-up old instrument no longer useful for viewing. An old fork-mounted orange tube C8 with a cracked corrector plate stood guard in front of one of the agency offices. It reminded me of the dead Foreign Legion soldiers propped up in the crenellations of Fort Zinderneuf by the sadistic Sergeant Markoff (Brian Donleavy) in the great 1939 film *Beau Geste*. Lifeless, but still on duty.



We stayed at the 3-star La Casa de Don Tomas, a pleasant hacienda about a quarter mile from the center of town. Many of the properties in San Pedro are surrounded by high walls, a holdover from the days when cattle from the high plains in Argentina were driven west through the Andean passes through San Pedro to abattoirs in Calama.

We walked around town and then had dinner at La Delicias de Carmen, recommended by Gustavo. We chose the Chorrillana, a dish for two economically priced at 19,000 Chilean pesos, about $28. It included two glasses of Chilean wine. The Chorrillana turned out to be a mountain of sliced beef, sausages, chicken and fried onions on top of a pile of soggy French fries, topped with a fried egg. Sadly, it wasn't all that good, but at least there was a lot of it.



SPACE from space (Google Earth)

Our observing that night took place at [SPACE](), which stands for San Pedro de Atacama Celestial Explorations. SPACE is owned and run by Frenchman Alain Maury, a former professional astronomer. Alain was an expert on astronomical photography in the film days. He worked on large telescopes in France, and then established the photographic procedures for the second Palomar Observatory Sky Survey (POSS II) survey in the 1980's. During this time he discovered Comet 115P/Maury. He was particularly interested in asteroids. He came to Chile to work on several projects but "got bored" with professional astronomy (and many of the people in it). He fell in love with the Chilean skies. SPACE was opened in 2003 and Alain made it something far beyond the usual tourist observatories in the area. SPACE has lodge accommodations for visiting astronomers. It's not a hotel, but each lodge has a kitchen, dining area, bedroom and bath. Alain will rent time on his telescopes for use after the tours have gone (around midnight). He also hosts 15 robotic telescopes on the property and has several domes for larger instruments. Alain is building a 45" telescope and told me he had a 60" blank and to figure it he's thinking about building a large-scale polishing machine. The scopes used for the sky tour ranged from 12" Meade SCTs to a 28" Dobsonian.

The telescopes at SPACE

While an earlier group was at the telescopes, we heard Alain's introduction to the southern sky, which he pitched to our group's above-average astronomic understanding. His sense of humor, professional astronomy background and vast experience made it not at all repetitious of what we heard before. Then we went to the observing area, where Alain and his assistants pointed the various scopes to a whole bunch of objects. Even though we were only 3 miles from the center of San Pedro and some of Alain's neighbors have installed outside lights, the sky was dark. The slight light dome from San Pedro was not a problem. Alain pointed out lights from the ALMA headquarters, some 15 miles to the southeast and 1500 feet higher in elevation. They didn't add much to the minimal light pollution, but it was nice that they were switched off just before midnight.

Photo by Dan LaPorte (Santa Barbara, CA)

Alain apologized for a slight degree of moisture in the atmosphere, which reduced the transparency a little. It frustrated him but our people hardly noticed. Being northerners, we again gazed excitedly at the wonderful transposition of the familiar spring constellations in the northern half of the sky: Orion standing on his head high overhead; Leo relaxing on his back; Sirius near the zenith rather than just a third of the way up from the horizon. And of course our new friends: the Magellanic Clouds, Capella shining brightly above them, and the glorious southern Milky Way with α and β Centauri, the Southern Cross and the Coal Sack and above them the η Carinae nebula. The Milky Way crossed from east to west right across the zenith. Large apertures, excellent 2" eyepieces and filters (particularly OIII for emission nebulas) made now-familiar objects like Omega Centauri and 47 Tucanae, the incredible Tarantula Nebula and η Carinae come alive. Jupiter was truly an astonishing sight in one of the 24" telescopes.

Alain is a fantastic guide to the night sky. He knows where everything is, and he found objects with ease. His finding technique is simple: he points a 200 mw laser into the eyepiece. The beam shoots out the front of the telescope into the night sky to exactly where the scope is pointed and then he moves the instrument to the desired position. No aligning or fiddling with finder mounts, star-hopping or any other distraction. I think if we had been on our own with these monster scopes, we wouldn't have found anything.

After our observing session, the group sat with Alain, drinking hot chocolate (the temperature had dropped into the low 50's by then), to hear more about life and astronomy in Chile. About 12:30 am it was time to go back to the hotel, but we had other plans. We had taken up an offer Alain had made to the group a couple of weeks before the trip started to allow us to stay for the night if we rented one of the lodges. Elyse and I figured this was a good deal. Even though there was a hotel room waiting for us in San Pedro, $135 for the lodge would allow us to stay up all night and then get some sleep in the morning before taking a taxi back to San Pedro, where the next adventure wasn't to begin until 2 pm. Joining us were fellow tour members Eric Johnson, Craig Nelson and John Gossett. So after the bus took everyone else back to the hotel, Alain joined the five of us at the larger telescopes for the rest of the night. And what a night it was!

We used the three largest telescopes on the observing pad: two 24" Dobsonians and the 28" monster that required climbing a ladder to reach the eyepiece. Our decision to stay was rewarded when the high haze completely disappeared around 1 am and the Sky Quality Meter read 21.56. The sky was splendid, with stars from horizon to horizon. Alain showed us that the Milky Way cast a shadow by placing his hand above one of the white plastic patio chairs on the observing pad.

Photo by Eric Johnson (Medina, WA)

There were many highlights. Two planetary nebulas stand out: NGC 3918, the 8th magnitude Blue Planetary in Centaurus, and NGC 6302, the 12th magnitude Bug Nebula in the crook of the tail of Scorpius, which in the 28" showed a good bit of the same structure, albeit smaller and less detailed, as in the famous Hubble photo of this object. It was amazing to see its two lobes and the filaments of gas jetting from them.

As Scorpius rose we took a look at some of the riches towards the center of the Milky Way galaxy that we might glimpse, but just barely, from our northern latitudes. We took quick looks at the open clusters M6 and M7. M8, the Lagoon Nebula, took up the entire field of the 28" telescope with its open cluster and profusion of gas clouds. M20 was similarly impressive. M17, the Omega (or Swan) Nebula was fantastic and even better when Alain put the OIII filter in the optical path. Even the famous nebulosity of M16, the Eagle Nebula, was visible. For us it's only an image sensor object, and this was the first time I have ever seen its photons directly. NGC 6520, an open cluster off the tip of the Sagittarius teapot, is separated from a lovely yellow star by a small but dense dark nebula.

We spent some time among the galaxies of the Virgo cluster, which was high overhead. The galaxies of Markarian's Chain were everywhere. Each field held at least two of them, with M84, M86, M87 and M90 the most prominent. NGC 6397 is a wonderful globular cluster in Ara, just below the tail of Scorpio and thus never visible to us up north. Alain was fond of pointing out that at magnitude 5.73 it's brighter than our glorious M13 (5.78), showpiece of the northern summer sky, which is actually the 8th brightest globular cluster.

By 3 am, Saturn was 30 degrees above the horizon, easily showing 3 moons (and a couple more if we spent time studying it at the eyepiece). The planet's disk showed several bands and crisp rings in the 24". The Cassini Division was a perfect black band and, since Saturn was very near maximum ring tilt, the planet's shadow on the far side of the rings was dramatic.

For a final look, we again aimed at Omega Centauri, now not far from the zenith. What an extraordinary sight! An infinitude of stars filled the eyepiece from edge to edge. Omega seems different from other globular clusters. A comparison with 47 Tucanae, the second brightest GC, suggests they are similar objects.

	Omega Centauri	47 Tucanae
Magnitude	3.9	3.95
Diameter (min)	55	50
Distance (LY)	17,300	14,700

(Data from *Southern Gems* by Stephen James O'Meara, Cambridge Univ. Press, 2013)

Omega seems to lack the central condensation and gradient of star density that other globular clusters display. It is the largest (182 light-years) and most massive (5 million solar masses) globular in the Milky Way. Some observers posit that it is not an actual globular cluster at all but the remnant of a small satellite galaxy of the Milky Way that was tidally disrupted but whose core managed to stay intact. It's not an unreasonable idea, since its mass is close to that of known dwarf galaxies. In addition to the expected Population II stars in a globular cluster, there are several stellar populations with higher metallicity, suggesting bursts of star formation more typical of a galaxy than a globular cluster. The only other globular that may be a former galaxy core is M54 in Sagittarius. It's the most distant Milky Way globular (70,000 light years) and is thought to actually be part of the Sagittarius Dwarf Elliptical Galaxy.

Omega Centauri (L) and 47 Tucanae (NASA)

In the *Almagest*, Ptolemy catalogued Omega as a star "on the horse's (Centaurus) back." This was a pretty good observation, since from Alexandria (Egypt) Omega never gets more than 12-13 degrees above the horizon. Bayer in his 1603 *Uranometria*, with some observations from the southern hemisphere available by then, gave it the rank of Omega in his Greek-alphabetical list of stars in each constellation in order of (approximate) decreasing brightness. We owe to Edmond Halley the first description of Omega Centauri as a non-stellar object, when he observed it in 1677 from St. Helena (he went there voluntarily, unlike Napoleon!).

Omega is potentially visible from our area from late April to early June. It is less than 2 degrees above the southern horizon at its optimal altitude, but a clear view is rare around here what with pollution and atmospheric moisture. I tried it once at the seashore on eastern Long Island, but there wasn't a star to be seen below about 10 degrees altitude. Even if it was clear, the airmass of about 20 would dim it by up to 6 magnitudes, making it purely a telescopic object.

By 4 am we were getting pretty tired and so we released Alain from his duties and walked the 200 yards to our lodge. We went right to bed and fell asleep instantly. Alain had told us that in the morning we should come over to the main house where his housekeeper would call a taxi to take us back to San Pedro, 3 miles away. At about 8 am, there was a knock on the door. Craig and John told us that they had called a cab and it was coming, but we said we had just gotten up and so would get one later. We caught another hour's sleep. At 9:30 am we packed up and went to find the housekeeper, but no one was around. It occurred to me that she must have figured we had taken that early cab and so she had gone off somewhere. Using the wi-fi connection in the lodge I found our hotel's phone number, called and spoke to the desk clerk. "I'm here at SPACE and I need a cab," I said. "OK, what's the address?" she replied. "I don't know the address…it's SPACE!" "Well, if I don't know the address, how can I send a cab for you?" Now, not thinking that all the taxicab companies in San Pedro must know where SPACE is, I panicked. But along came a man on a horse! I flagged him down and, although unable to communicate directly since he spoke no English and we *no habla español*, I handed him the phone. After some back and forth with the clerk, he handed me back the phone and indicated that a cab was coming. Indeed 10 minutes later it did. We found out the rider's name was Sergio when Alain stopped by the WAA booth NEAF in April, just two weeks after our night at his observatory. When the moon is full Alain doesn't offer observing sessions. His daughter lives in New York so he'll take the opportunity visit and catch some culture. On this trip he was manning a NEAF booth for a French telescope-control software company and he and his wife later took in two performances at the Metropolitan Opera. Sergio does maintenance work at SPACE on occasion. I never found out the name of the horse.

Sergio on his horse at SPACE

Alain Maury and Elyse at NEAF

We got back to San Pedro in plenty of time for lunch and then we left at 2 pm for ALMA, the subject of next month's article.

WAA's John Paladini Wins Major Award at Stellafane

WAA member and creative telescope maker John Paladini was awarded the *1st Place Innovative Component Award* at the 2017 Stellafane Convention in Springfield, Vermont.

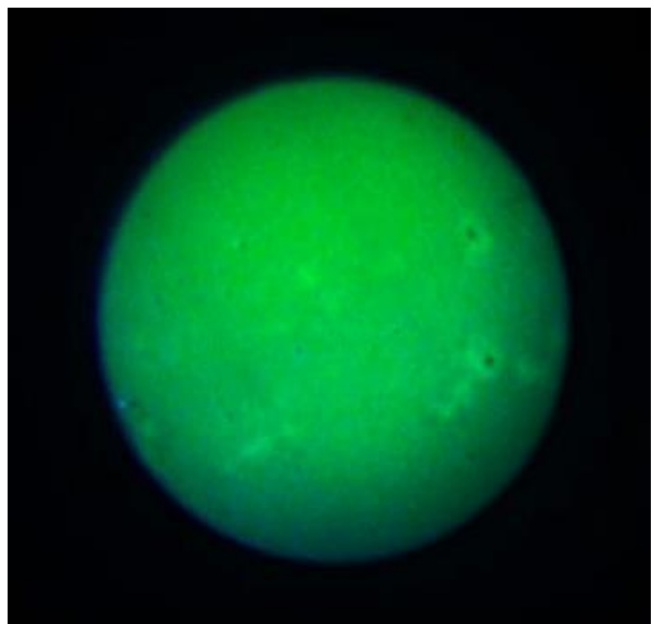
John's project was an eyepiece to view the sun at the Ca-K wavelength (393.4 nm) without requiring a camera or electronics. Using a special phosphor and fiberoptic bundles, the near-ultraviolet Ca-K wavelength, to which the eye is very insensitive, is converted to green wavelengths perfect for human vision. The Ca-K emission line, generated from the cooler, lower edge of the chromosphere, displays features that are brightest and strongest in areas of high magnetic fields, such as sunspots.

John described this invention in an article in the October 2014 WAA Sky*WAA*tch newsletter. John lives in Mahopac, NY. He's a recently retired microwave engineer.

John Paladini with another of his inventions, a high-resolution visual solar spectrograph.

The Ca-K eyepiece

John's award and first-place ribbon



The visual image of the sun with the Ca-K eyepiece. Photo using the afocal method.

Two of John's projects that have been featured in the SkyWAAtch newsletter are a 90 mm hydrogen-alpha telescope (September 2014) and a spectroheliograph (April 2017). Among John's other creations are a radio telescope, a magnetometer that detects charged particle emissions from the sun, and a multi-mirror telescope. John's home-made image intensifier eyepiece ultimately inspired WAA's Doug Baum and Russ Lederman of Denkmeier Optics to invent the BiPH (Binocular Photon machine).■

Project Blue – First Visible Light Imaging of an Earthlike Planet in the Alpha Centauri Star System

From the Editor:

Astronomical research in the USA depends substantially, perhaps nearly exclusively, on support from the Federal budget through appropriations to NASA or the National Science Foundation. There's never enough money to go around, and many innovative and important projects have to go unfunded. Large projects like the James Webb Telescope sometimes divert resources from other worthy efforts, especially when there are cost overruns, unintended as they might be. Remarkably productive missions like Voyager and New Horizons almost fell victim to the budgetary axe.

We recently heard about a new organization that is trying to foster smaller, highly creative SPACE research and exploration that won't count on Federal investment. The BoldlyGo Institute (the origin of the name should be obvious) was founded by a group of space researchers and former NASA scientists. It is headed by Dr. Jon Morse, who has over a decade of leadership in space organizations. Dr. Morse was Director of Astrophysics in the Science Mission Directorate at NASA Headquarters, Senior Policy Analyst in the White House Office of Science & Technology Policy, and Project Scientist for the Cosmic Origins Spectrograph aboard the Hubble Space Telescope.

We invited Dr. Morse to speak at a WAA meeting, and we are happy to announce that he will be talking to us on Friday, March 2, 2018. We are intrigued and excited about this unique venture that supports space science and space travel, and we agreed to publish information from BoldlyGo about their first endeavor, Project Blue. We think you too will be intrigued.

A Quest to See Blue

Finding the first planet like Earth beyond our solar system would transform how we think about our place in the universe.

Ten years ago, we didn't know if planets like Earth were common in the universe. Then NASA's *Kepler* mission launched in 2009 and everything changed. Using an indirect method called "transit photometry," *Kepler* discovered thousands of small planets similar in size to the Earth orbiting other stars in a relatively small region of our galaxy. Some of these planets orbit at a distance where liquid water could exist on the surface; this Goldilocks distance from the star is called the "habitable zone." An Earth-sized planet orbiting in the habitable zone of its parent star could be very "Earthlike" in its composition and environment. Extrapolating the *Kepler* results, it's now estimated that there are more Earthlike planets in our Milky Way galaxy than people alive today. But we've never actually seen one directly.

Thanks to recent breakthroughs, the technology now exists to capture a direct image of an Earthlike planet outside our solar system. That's what Project Blue aims to do. Project Blue brings together a consortium of leading space and research organizations who will work with NASA and experienced aerospace companies to design, build, launch and operate a small, state-of-the-art space telescope to observe planets around our nearest stellar neighbors: Alpha Centauri A and B (now also known as Rigil Kentaurus). Project Blue's goal is to capture an image in light visible to the human eye of orbiting planets. Seeing a "pale blue dot" could indicate the presence of oceans and an atmosphere on such a planet — and the potential to support life. It would be our first view of another world like our own.

With a modest budget compared to other frontier space missions and a planned launch by 2020, this goal is tantalizingly close.

Science Reach & Observatory Description

Project Blue is a mission to study Alpha Centauri exoplanetary system. NASA's *Kepler* mission has been wildly successful in compiling over 2,300 confirmed exoplanets, telling us about their orbits and sizes, some of which have Earthlike potential. But to know more about a planet's properties, such as whether it hosts water or oxygen, we need direct detection methods. With advanced optics technology, we'll use a direct imaging technique called "coronagraphy" — i.e., an advanced version of the "coronagraph" invented in 1931 to see the sun's corona, normally only visible during a solar eclipse — to dim the light from the stars in Alpha Centauri, enabling us to see any surrounding planets. By working in visible light, we hope to gather key details about their properties. Capturing an image of a planet, actually seeing it in visible light, will help us begin to characterize its atmosphere and surface characteristics, especially its potential for oceans. If the planet appears blue — similar to the "pale blue dot" image of Earth taken by the Voyager spacecraft from the edge of our Solar System in 1990 — it could suggest the presence of liquid oceans and a substantial atmosphere. We'll be able to discern the first indications about its capacity to support life.

Advanced Science and Technology Program

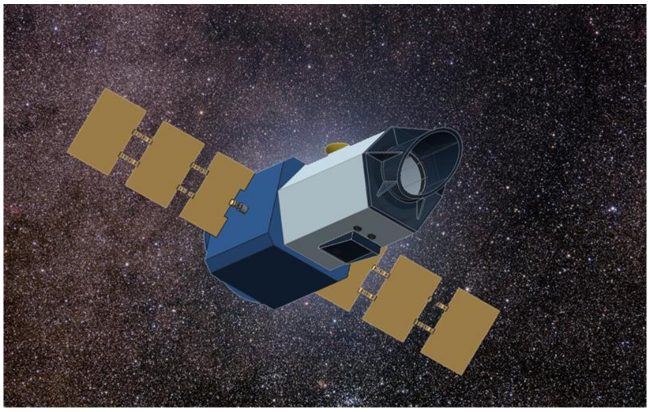
Project Blue will advance our knowledge about the presence or absence of terrestrial-class exoplanets in the habitable zones around the nearest Sunlike stars, and will provide on-orbit demonstration of high-contrast coronagraphic imaging technologies and techniques that will be useful for planning and implementing future space missions by NASA, ESA, and other space agencies.

The investigation carried out with Project Blue aligns with the highest priority science questions described in recent reports by NASA and the National Research Council. These reports emphasize the search for life elsewhere in the cosmos, staking out a path of increasingly more ambitious measurements, from identifying candidate Earthlike planets to assessing their atmospheric composition for so-called biomarkers.

Project Blue will make the initial historic leap of being the first space telescope system capable of identifying an Earthlike planet in the Alpha Centauri system. Its observations will also tell us about the environment in which any such planets orbit, such as how dusty it is. The rocky inner terrestrial planets in our Solar System are embedded in a tenuous cloud of "zodiacal dust," which forms a noticeable background in the Voyager and Cassini images of Earth taken from far away. Besides detecting exoplanets around Alpha Centauri A and B, Project Blue will also directly measure the brightness of the zodiacal dust around each star, which will aid future missions in planning their observational surveys of exoplanets.

Observatory Description

In order to spatially resolve the habitable zones around the stars in Alpha Centauri, the Project Blue mission needs to fly a space telescope only 45-50 cm in aperture, small enough to fit on a coffee table. As our name suggests, observations will be made in blue light and one or two longer wavelength bands to capture the hue of any planets discovered. Light passing through the telescope feeds into a coronagraphic instrument that forms the heart of the mission. The coronagraph will block the light from the parent star, and the resulting field is imaged onto a state-of-the-art detector. Then special image processing techniques will be employed to reveal the associated faint planets from the residual glare of the star.



Artistic rendering of the Project Blue mission concept featuring an off-axis telescope and commercial spacecraft bus.

How faint? An Earth-sized planet orbiting in an Earth-type orbit around one of the stars in Alpha Centauri will be over a billion times fainter in visible light than the parent star. That's like trying to see a small bead two feet away from the spotlight at the top of a lighthouse from 100 miles away! Fortunately, largely due to government funding during the past two decades, the technology for suppressing the parent starlight has progressed to the point that such a measurement is possible.

The Project Blue mission will house a specialized starlight suppression system consisting of (1) a "deformable mirror" that modifies the wavefront of the incoming light through the telescope (i.e., controls where the residual light from the parent star goes in the optical system), (2) a coronagraph to block the parent starlight, and (3) an image processing methodology, called "orbital differential imaging," to enhance the signal from faint objects in the vicinity of the bright parent star. (This specialized system is how Project Blue will be able to search for exoplanets better than the Hubble Space Telescope, even though Hubble's mirror is about 5 times larger in diameter.) These components of the imaging system, data acquisition and post-processing work in tandem to achieve our planet imaging goals. For example, we baseline the coronagraph to achieve contrasts of $\sim 10^{-8}$ in the raw data, and believe that post-processing can wring an additional 10^{-2} out of the data. An essential aspect of our approach is that we plan to observe Alpha Centauri for two full years, obtaining a vast database of imagery that will allow scientists to retrieve the faint signal of any planets by beating down the residual noise from the optical system, and to see the planets move in proper motion with their parent star as well as in their orbits. Like the Hubble Space Telescope, Kepler and other NASA missions, we plan to make the raw and processed data publically available through an online archive that will allow scientists and citizens to engage in their own analyses.

Researchers working on Project Blue through the Science & Technology Advisory Committee (STAC) have significant experience developing and using these technologies in laboratory experiments and even with suborbital sounding rocket and balloon payloads. These experiments have demonstrated starlight suppression using deformable mirrors, precision pointing control (i.e., holding the field of view of the telescope extremely steady so that the starlight can be accurately blocked), nulling interferometer coronagraphy, and post-processing of the data. Moreover, because Alpha Centauri is a binary system, Project Blue will suppress the light of both stars. There are several ways to attack this challenge, one of which is through a technique published by scientists at NASA's Ames Research Center called "multi-star wavefront control."

Finally, in order for Project Blue to accomplish such an amazing scientific challenge, we will take full advantage of the space environment, where it can operate outside the distorting effects of Earth's atmosphere. The mission will launch on a rocket provided by one of several candidate vendors (e.g., Virgin Galactic, SpaceX), placing it into a low-Earth orbit designed to provide stable conditions required for making its high-precision measurements.

Project Blue is intended to be the first high fidelity space-based coronagraphic imaging system, providing vital complementary capabilities to other ground- and space-based facilities and initiatives such as NASA's upcoming James Webb Space Telescope (JWST) and Wide-Field Infrared Survey Telescope (WFIRST) missions, Atacama Large Millimeter Array (ALMA), VLT-Breakthrough Watch, and long-term exoplanet imaging space telescopes such as NASA's LUVOIR and HabEx concepts.

The Target: Alpha Centauri

Put simply, Alpha Centauri presents the best opportunity to directly image the first Earthlike planet. The principal reasons are its:

- *Proximity*: At only 4.37 light years away, Alpha Centauri A and B are our closest neighboring stars. A small, lightweight telescope only a half meter in diameter can resolve the habitable zones around these stars. The next closest Sun-like star is 2.5 times further away and would require a telescope 2.5 times larger in size!

- *Binary system*: Alpha Centauri contains not just one, but two stars similar to our Sun — giving us two chances to find planets in either of their habitable zones. Because of this, there's an estimated ~85% probability that the Alpha Centauri system harbors at least one potentially habitable planet that we may be able to see.

- *Sun-like characteristics*: Alpha Centauri A is a yellow "G2" type star whose temperature and color closely match the Sun's, increasing the probability that a planet in its habitable zone is analogous to Earth. Alpha Centauri B is a little cooler and redder than our Sun, but scientists still consider stars like it to be good candidate hosts for Earthlike planets.

What We Will Learn

While Project Blue's modest space telescope will not resolve surface features like continents on any planets we discover, our studies, in conjunction with complementary observations by other facilities, can reveal a remarkable amount of information about a planet, including:

- *Orbit*: Obtaining a sequence of images at different times can determine its orbit and establish whether it is in the habitable zone.

- *Size, mass, surface & atmospheric properties*: We can infer these characteristics from a planet's brightness and color. A pale blue dot in the habitable zone could indicate a small "Earth" or a larger "Neptune" (about 4× Earth), but if the planet is also 10 billion times dimmer than its star, it would have to be implausibly dark (low albedo) if it were as large as Neptune. A blue hue could also indicate the presence of oceans and a transparent atmosphere similar to Earth's. Other colors could indicate a thick, cloudy atmosphere (orange) or significant ice cover (white).

- If they can be measured, periodic short-term variations in brightness might disclose the length of the planet's day, long variations its seasons, and chaotic ones its weather. Future large telescopes could eventually detect patterns of clouds, land masses or oceans, indicated by a planet's varying brightness and polarization as it rotates and moves in its orbit. Obtaining spectra of exoplanets will reveal physical conditions such as atmospheric composition and potential biomarkers (e.g., oxygen, water vapor, methane). But we need to take the first steps in direct imaging of Earth-like planets in order to progress to these more ambitious goals.

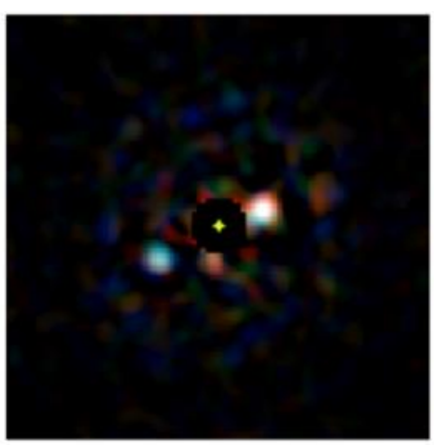
Opportunities for Space Enthusiasts

On September 6th 2017, the Project Blue team will be launching a crowdfunding campaign on IndieGoGo to raise seed funding for the equivalent of a NASA Phase A study and to make space enthusiasts and the general public part of this endeavor from the very beginning. Opportunities to engage with the mission such as live discussions, perspective pieces, profiles and Reddit AMA will be organized during the campaign so stay tuned! Join our Community Newsletter to receive mission updates and be notified when we launch.

Project Blue website: http://www.projectblue.org/

Facebook Page: https://www.facebook.com/prjblue/

Twitter: https://twitter.com/proj_blue?lang=en



(Left) Voyager 1's pale blue dot photo of Earth from the edge of the solar system (distance 40.5 A.U., 3.762 billion miles, Feb. 14, 1990).

(Right) A simulated image of the photo Project Blue aims to take of an Earthlike planet. The simulation shows what Earth (blue) and Venus (yellow-white) would look like if they were placed at the distance of Alpha Centauri and observed by a modest space telescope with a high fidelity coronagraph. (Credit: NASA JPL/ Jared Males, Univ. of Arizona)

Paul Alimena at Harrison Library

Paul Alimena, WAA's Vice President for Membership, gave a number of presentations about the solar eclipse in the weeks before the August 21st event. In addition to this talk at the Harrison Library, Paul spoke at well-attended events in Rye, Greenwich and Mahopac. In addition to giving scientific and observing information about the eclipses, Paul presented video and audio records of his experiences at actual eclipses over the past 20 years. (Photo by Jordan Webber)

⬅M27 Dumbbell Nebula

Mauri Rosenthal shot the colorful Dumbbell Nebula from his yard in Yonkers. The Dumbbell is the remnant of a dying star which collapsed but left these glowing gases some 15,000 years ago. Visible through small telescopes as a grey bowtie or dumbbell, astrophotography reveals the bright red and blue regions and shows the full structure to be more of a football shape. It's a great summer target for anyone who is getting started with deep sky imaging. This was taken with a portable imaging rig featuring a Borg 71 FL lens and a ZWO ASI1600MC astro camera mounted on an iOptron CubePro mount.