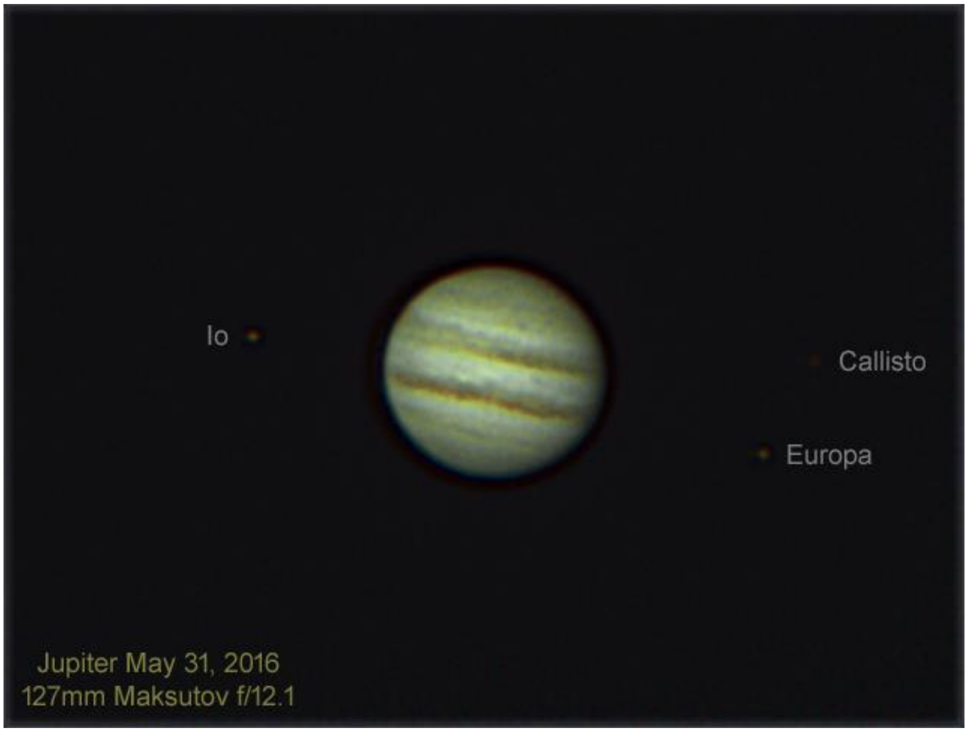
SkyWAAtch



Jupiter

Larry Faltz took this photo of Jupiter about 9:50 pm on May 31st from the brightly lit front parking lot at the Quaker Ridge School on Weaver Street in Scarsdale. The night had good transparency. He used an Orion Apex 127mm f/12.1 Maksutov, iOptron MiniTower, and Celestron NexImage 5 color camera, best 293 of 2935 avi frames (640x480). To stack and process, Larry employed Autostakkert!2, Registax 6.1, and Photoshop Elements 2.0. Jupiter shines at mag -2.1 with a disk 37.2” in diameter. The three closest moons are visible: Io mag 5.7, Europa mag 5.9, Callisto mag 6.3. The Red Spot is just barely visible at 10 o’clock right on the planet’s limb, on the edge of the Southern (upper) Equatorial cloud band.

Notes Larry: Small Maksutovs are capable planetary and lunar scopes, and they are easy to carry and use. Some patience is required: because of the thickness of the corrector plate, it takes a little time for the scope to come to thermal equilibrium.

In This Issue . . .

Events for July

Upcoming Lectures

Pace University, Pleasantville, NY

There will be no lectures for the months of July and August. Lectures resume on September 16th.

Starway to Heaven

Saturday July 30th, Dusk.
Ward Pound Ridge Reservation,
Cross River, NY

This is our scheduled Starway to Heaven observing date for July, weather permitting. Free and open to the public. The rain/cloud date is August 6th. **Important Note**: By attending our star parties you are subject to our rules and expectations as described here. Directions and Map.

New Members. . .

Lisa Walker - Thornwood

Renewing Members. . .

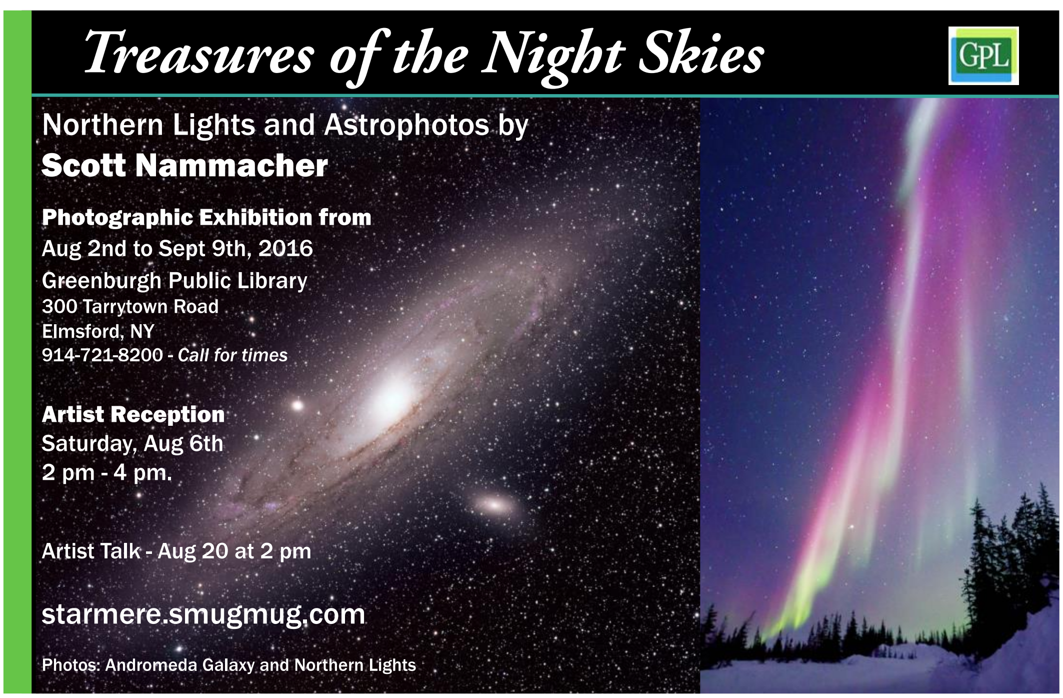
Frank Jones - New Rochelle
William Newell - Mt. Vernon
Charlie Gibson - Scarsdale
Erik & Eva Andersen - Croton-on-Hudson
Deidre Raver - Wappingers Falls
Gary Miller - Pleasantville
John Paladini - Mahopac
Glen & Patricia Lalli - White Plains
Roman Tytla - North Salem
Barry Feinberg - Croton on Hudson
Mark Korsten - Hastings on Hudson
Sushil Khanna - Katonah

RAC SUMMER STAR PARTY
July 29th through August 7th

The Rockland Astronomy Club is sponsoring its summer star party July 29th thru August 7th. RAC holds the longest and most exciting star party, geared to both the serious observer, imager, and the whole family. Our location in the Berkshires is known for its pristine dark skies, and gorgeous arching Milky Way. Don't miss the Opening Festival and StarBQ with live music. For details go to:

http://www.rocklandastronomy.com/ssp.html.

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



Almanac
For July 2016 by Bob Kelly

Jul 4 Jul 12 Jul 19 Jul 26

One of our ongoing goals as astronomers is to see the unseeable. Usually that entails teasing out details on distant planets or finding faint fuzzies. This month, Venus crawls out of the glare of the Sun. It really is a slow crawl; not even out past 10 degrees from the Sun by mid-month.

Around the 16th, Venus draws up aside Mercury, another denizen of the solar glare. They are barely above the horizon 30 minutes after sunset, and the only way to see this conjunction is if you block out the Sun with a solid, immovable object and know exactly where to look with a good telescope kept in the shade.

In August, there will be another chance to see Venus with a fellow planet as Jupiter falls behind the Sun from our point of view. Venus passes Jupiter on August 26, with Mercury lingering in the neighborhood while they stand 23 degrees following the Sun.

Even harder target to see is Pluto. In July, Pluto is at its brightest for the year at magnitude +14, which is hard to reach, even in larger scopes. But we can point out where Pluto lives, since in summer 2016, Pluto passes through the 'teaspoon' to the upper right of the 'teapot' made by the stars of Sagittarius.

Then, we have a disappearing moon. Iapetus, Saturn's two-faced moon, passes north of Saturn on the 12th, coming in from the west and diming as its dark side starts to show. After mid-month, Iapetus is harder to find as it approaches its eastern elongation on the 30th, when its dark side is turned toward up and Iapetus is dimmest, so catch it early in the month, along with Saturn's brightest moon, Titan.

Saturn itself is well up in the southern sky after dark, preceded by Mars. Saturn's rings continue to put on a great show, tilted 26 degrees toward us. Mars shrinks noticeably by 20 percent, but still offers details on a steady night to the observer who can use higher power. The Martian equinox on the 4th starts northern hemisphere's autumn.

In July, Earth pulls another 50 million miles away from Jupiter, as the Juno spacecraft prepares to enter orbit on July 4th. Jupiter is 4 percent smaller by the end of the month, but worth watching to see if the Great Red Spot keeps its recent brightening and if the darker belts vary.

On the 29th, the crescent Moon rises just before 2am EDT and we find it in the middle of the Hyades cluster. As the cluster rises into the pre-dawn sky, you can see stars in the cluster disappearing and reappearing behind the Moon.

Just after the Sun rises, the Moon covers 1st magnitude Aldebaran and the reddish star reappears about 40 minutes later, but in bright sunshine. Can you track Aldebaran into daylight and, later, see it reappear on the invisible dark limb of the Moon? I'm thinking the earthshine on the Moon will be swamped by the sunshine in our atmosphere. The 23 percent lit Moon will be 57 degrees ahead of the Sun in our sky.

Lunar perigee occurs on the 27th, near the Moon's last quarter phase, visible in the morning. July's perigee is the farthest out of 2016's monthly perigees. Not exactly a supermoon, or even a last quarter supermoon.

The International Space Station returns to our skies, in the morning from the 6th through the 28th; and graces the evening sky from the 25th through the end of the month.

No substantial meteor showers in July for the northern hemisphere, but some early Perseids start showing up later in the month.

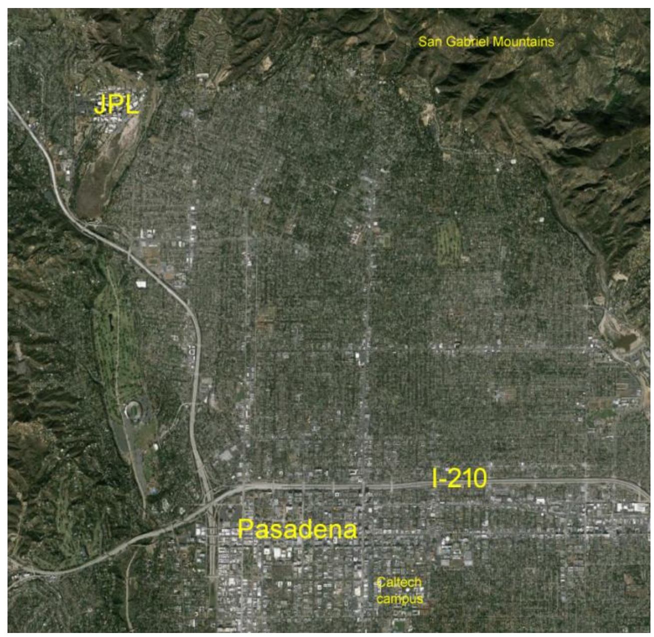
July 4th, at our local noon, the Sun is furthest from the Earth for 2016. Doesn't that make you feel cooler?

Westchester
Amateur Astronomers

We Visit the Jet Propulsion Laboratory
Larry Faltz

In October 2015, WAA was privileged to hear a spectacular lecture on the cosmic microwave background radiation by Dr. Charles Lawrence, the Chief Scientist of the Astronomy, Physics, and Space Technology Directorate at the Jet Propulsion Laboratory and Project Scientist for the US Planck Project. Dr. Lawrence graciously responded to my interest in a tour of the JPL, and we were able to schedule one during a visit to California in April 2016. This was a special honor, since public visits to JPL are limited to one weekend a year. So Elyse and I found ourselves early one morning at the JPL Visitors Center in Pasadena. Dr. Lawrence arranged for his colleague Dr. Varoujan Gorjian, a member of the Spitzer Telescope team, to show us the facility. We were joined by Helen, an old high-school friend of Varoujan's and her three children, the oldest a high-school senior. Varoujan provided us with a vast amount of information about the history, personalities, science and functioning of JPL.

The Jet Propulsion Laboratory is a unit of the California Institute of Technology. The history of Caltech is intimately associated with astronomy. The institution was founded in 1891 as Throop University, a vocational school. George Ellery Hale, the builder of gigantic telescopes at Yerkes, Mt. Wilson and Mt. Palomar, came to California in 1904 to do solar research. With the backing of the Carnegie Institution of Washington, Hale founded Mt. Wilson Observatory (which we visited two days later and will be the subject of next month's Sky*WAA*tch newsletter). In 1907 he joined the board of Throop. The 60-inch telescope on Mt. Wilson saw first light in 1908 and propelled the audacious and tireless Hale into the public's consciousness as the quintessential modern astronomer. In 1911, President Theodore Roosevelt gave a speech at the school in which he asked the faculty to develop scientists "with the kind of cultural scientific training that will make him and his fellows the matrix out of which you can occasionally develop a man like your great astronomer, George Ellery Hale." The same year, perhaps in response to Roosevelt, the State of California voted to publicly fund Throop as a research university. It took on the Caltech name in 1920. It has attracted some of the greatest astronomers and physicists to its faculty, including Nobelist Robert Millikan (discoverer of the charge of the electron and the institution's director from 1921 to 1945), Fritz Zwicky, Murray Gell-Mann and Richard Feynman. A visiting scholars program in the 1920's brought Paul Dirac, Erwin Schrödinger, Werner Heisenberg, Hendrik Lorentz, Niels Bohr, and, in 1931, Albert Einstein. Caltech was quickly recognized as the west coast's MIT.



The Pasadena area from Google Earth. The image is 5 miles on a side.

In the 1930's some Caltech students, led by Professor Theodore von Kármán of the Guggenheim Aeronautical Laboratory at the California Institute of Technology (GALCIT), began experimenting with rockets, the technology of which was in its infancy. After an unfortunate but I would imagine hardly unexpected explosion, the group was relocated to an isolated area northwest of the campus in a tract of land at the foothills of the San Gabriel Mountains, there to continue their research while lowering the possibility of destroying the lovely city of Pasadena. As the crow flies, the site is about 5 miles away from the Caltech campus, officially in the city of La Cañada Flintridge. The reason that the facility is called "Jet Propulsion Laboratory" and not "Rocket Propulsion Laboratory" is because the founders felt that the word "rocket" suggested science-fiction, while "jet" implied practicality. A parallel commercial enterprise involving many of the same individuals was the Aerojet Corporation, which made Jet-Assisted Take-Off (JATO) devices for the military during WWII. The Army sponsored the lab until NASA's founding in 1958, on the heels of Explorer 1, built by JPL. It was the first successful US satellite, although 4 months after Sputnik.

One of JPL's founders was the brilliant and bizarre John Whiteside Parsons, better known as Jack Parsons. A gifted but mostly self-educated rocket engineer and chemist, Parsons essentially invented solid fuel rocket engines as we think of them today. He was also a socialite, Marxist, religious cultist, advocate of free love and friend of L. Ron Hubbard, the founder of Scientology, at least until Hubbard ran off with Parsons' wife (while Parsons was having an affair with her 17 year-old sister). Among the many interesting aspects of Parsons' life was his death, in 1951 at age 37, which was caused by a chemical explosion in his home laboratory in Pasadena. Although officially ruled an accident, conspiracy theories abound, with the FBI, anti-Zionists (Parsons was contemplating working for Israel) and even competitor Howard Hughes mentioned as possible assassins. Parsons is barely mentioned in the official on-line histories of JPL, but wags at the lab suggest that "JPL" really stands for "Jack Parsons' Lab." Scientists and engineers are usually a calm and rational bunch, but I imagine JPL'ers take hidden pride that one of their founders was such an outrageous personage.

The Administration building from the JPL quad (LF)

After getting our ID badges, we entered the main quad of the 177-acre JPL campus. The urban park-like square leads off to the lab's streets, with names like Mariner Road, Surveyor Road and Pioneer Road. The practical and generally architecturally modest buildings (there are plenty of large trailers tucked away around the campus as well) house JPL's various operational and management functions. We started out in the Administration Building, the tallest of the structures on the campus. JPL staffers point out wistfully that its 1960's starkness and practicality bears no resemblance to the lavish JPL headquarters depicted in the movie *The Martian*. On the wall, JPL's motto "Dare Mighty Things" is displayed in large metal type. This line was also delivered by Theodore Roosevelt, in a speech in 1910 at the Sorbonne.

> Far better it is to dare mighty things, to win glorious triumphs even though checkered by failure, than to rank with those timid spirits who neither enjoy nor suffer much because they live in the gray twilight that knows neither victory nor defeat.

JPL is a Federally Funded Research and Development Center (FFRDC). There are 42 of these public-private partnerships; JPL is the only one funded by NASA, under a contract with Caltech. All the other NASA sites (Goddard, Ames, Johnson, etc.) are fully owned by the government. At JPL, the physical plant and materials belong to the space agency but the staff, including scientists and engineers, is on the Caltech payroll rather than being civil service employees. There are other institutions that can receive NASA contracts. For example, the New Horizons probe to Pluto was developed by the Southwest Research Institute and built and managed by the Johns Hopkins Applied Physics Laboratory. But there is always some connection to one or more of the main NASA institutions.

NASA's space projects come about in one of two ways. They are either *directed*, where NASA has a scientific objective in mind and asks for specific proposals within overall budget constraints ("here's some money, can you land a rover on Mars?"), or *competed*, where the proposals' goals are developed by the contractor ("we're Johns Hopkins and we'd like to send a probe to Pluto...how about some money, NASA?"). Even within the NASA community, the entities have to compete in some way for projects. The amount of planning, coordination and testing is enormous.

NASA now concentrates on developing "programs," where each mission relates to the next, and in a sense carries a "responsibility" to prepare for future scientific and technical progress.

Dr. Gorjian explaining Mars Science Laboratory (Curiosity) to our group

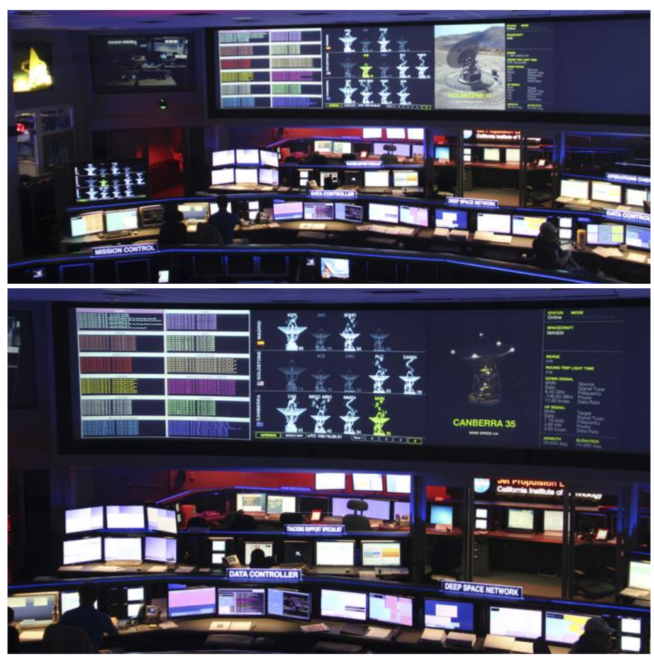
Among the objects displayed in the Administration Building lobby is a full-scale model of the Mars Scientific Laboratory, better known as "Curiosity," which was a JPL project with participation by Lockheed-Martin. It's part of the Mars program, following on smaller rovers and landers and utilizing uplink capabilities of Mars orbiters. We spent some time exploring the rationale for the design of the instruments on the rover, and got some interesting tidbits from Dr. Gorjian. For example, holes on Curiosity's 6 wheels exist to permit the operators to assess how far the craft has moved and to allow them to observe if the wheels are slipping in loose soil by visual detection of the pattern using the on-board cameras. The holes spell "JPL" in Morse code.

Although we think of JPL as focusing on construction and operation of robotic space missions, which is its primary function, some of its work involves Earth-monitoring satellites. We were shown data from Aquarius, a satellite in polar orbit that measured the salinity of the Earth's oceans. A joint project of NASA and the Argentine space agency, JPL managed the development of the mission. The Aquarius probe was built by Argentina's Comisión Nacional de Actividades Espaciales (CONAE) and assembled in the JPL clean room. The in-flight mission operations were managed by NASA's Goddard Space Flight Center in Maryland and JPL was responsible for data archiving and distribution. This kind of multi-agency and multi-center cooperation is typical of space projects today.

A group of NASA's earth-observing satellites are closely bunched on an identical polar orbital track, called the "A-train," short for "Afternoon Constellation". These satellites cross the equator heading north about 1:30 pm local time, and thus can observe the same terrestrial areas using their various instruments. As the Earth turns under their polar orbit, the satellites cover consecutive strips of the surface, gathering data and building up a map that can be continually updated. Periodically new probes are added to the train while others cease operating and are removed.

We then went to the mission control center of the Deep Space Network, sometimes genially called the "center of the Universe" and surely the Holy of Holies for enthusiasts of robotic space research.

All of the data from deep space comes through the Deep Space Network, which is managed by JPL (data from earth-orbiting missions downloads to other facilities, primarily the Goddard Space Flight Center in Maryland). DSN consists of three groups of large parabolic dish antennas situated approximately 120° apart on the Earth's surface: in Canberra (Australia), Madrid, (Spain) and at Goldstone near Mojave (California). The geographical arrangement allows signals to be received continuously from any mission, although the various probes have to share access to the receivers when they are overhead. A complex schedule is followed that allocates downlink and uplink time, depending on the events. For example, an orbital insertion, trajectory correction or landing takes precedence, while data from Voyager 1 and 2 are now received just a couple of times a week.

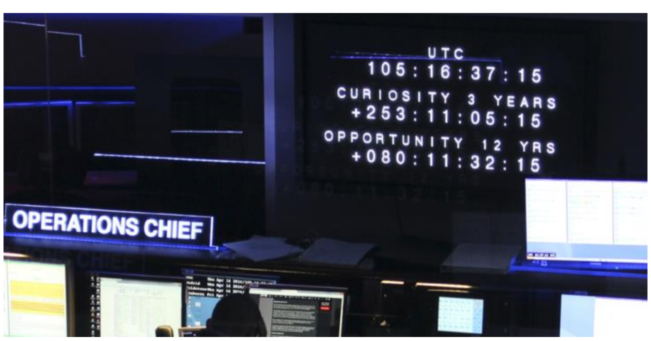


Two views of the DSN control room (it extends on both sides of the photos)

DSN mission control is a large, darkened room with rows of video displays and desks stretching from one side to the other and several other control rooms with computer workstations separated by large windows. On the front wall are a series of large projections, including instructions or data for the various probes, icons for each antenna and information as to whether they were transmitting or receiving (and to which probe), and images of the antennas that cycle among the currently active instruments in all three locations. There were only a dozen or so staff members in attendance during what appeared to be a routine day, but when critical mission activities occur, the place is nuts with people. Nuts is not just a metaphor. There's a JPL tradition that started with Ranger 7 in 1964, in which "lucky peanuts" are passed out at high-tension moments of a particular mission. A bottle of the peanuts, from the historic and technically astonishing touchdown of Mars Curiosity on August 5, 2012, is on display outside the entrance to the visitor's gallery.

Lucky Peanuts.

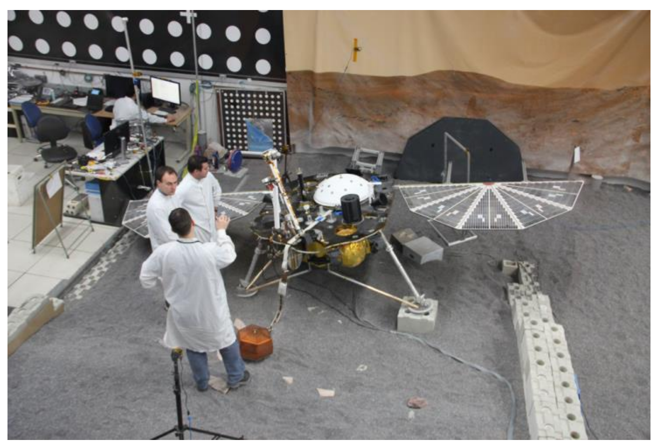
That the Mars missions hold a place of particular pride at JPL is evidenced by a display that showed the operational time of the Opportunity and Curiosity rovers (Spirit, the other component with Opportunity of the Mars Exploration Rover mission, ceased functioning in 2011).



Mars mission display

As we walked around the campus, Varoujan pointed out the different buildings that house various aspects of mission development, planning, financing, and operations, as well as scientific studies. The buildings range from late 1940's-era quasi-deco to modern 21st century neo-Bauhaus, constructed over the decades in response to ever-growing research, planning and construction space. That JPL is a small city unto itself was made clear when JPL fire truck and ambulance appeared, fortunately for a required fire drill and not an emergency. Staff members poured out into the California sunshine, but they seemed eager to get back to work as soon as the "all clear" was given.

Flight Projects Center



Testing the Insight mission

We stopped by the In-Situ Instrument Laboratory, which houses the "Mars Yard," a large room that simulates the Martian surface so that engineers can work out issues with landers and rovers. A group of seemingly perplexed technicians and engineers were working on an engineering version of the Insight mission ("Insight" standing for Interior Exploration using Seismic Investigations, Geodesy and Heat Transport), a surface lander that will detect and map seismic activity on the red planet. Apparently there were problems with the seismic detector that required a delay of the mission, and this device was being tested as it sat on the gravelly pseudo-Martian surface. In one corner of the space was the engineering model of the Spirit/Opportunity rover, covered alas in dust since it undoubtedly hasn't see much activity recently, at least since Spirit finally failed.

On our way out of the building we ran into Frank Hartman, one of the engineers who actually drives the Curiosity rover on the surface of Mars. He was nattily dressed in a white shirt and tie, which did not seem to be the common dress code at JPL. It's a relatively informal place, the casualness of staff dress standing in distinct opposition to the importance and technical sophistication of what is being done.

Frank Hartman

We moved next to the Space Assembly Building, where many of the actual probes are put together. There was nothing being assembled and there hadn't been for a while. There was a small mock-up of the Juno probe to Jupiter, which was launched in 2011 and is scheduled to arrive at the giant planet on July 4, 2016, standing next to a full-size replica of one of the probe's three solar panels. On the wall were plaques commemorating all of the probes that had been assembled at JPL, beginning with Explorer 1, the United States' first successful satellite in 1958.

The Spacecraft Assembly Facility's sign shows its late 1950's provenance

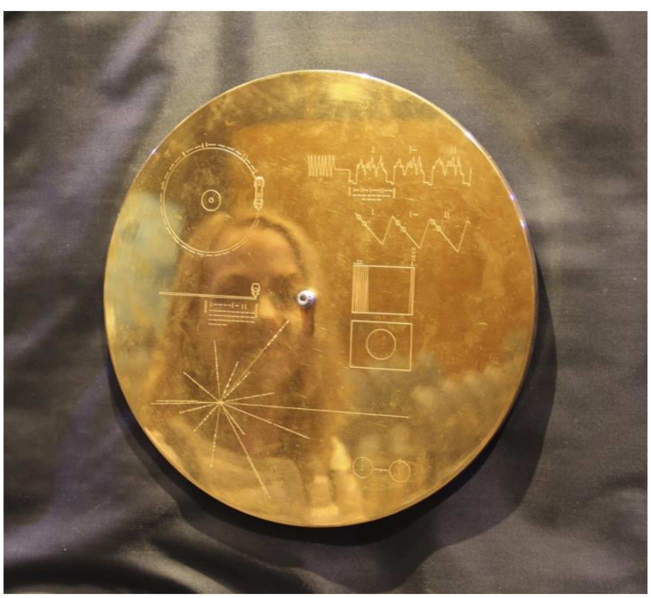
A small part of the Space Assembly Building, a "clean room" (note the garbed mannequin)

We ended our tour in the JPL museum, which spills over to the auditorium. That space may be familiar to some readers from the many press conferences that have taken place there over the years. There are models of many of the most important spacecraft made at JPL, starting with a full-scale model of Explorer 1. Among the most impressive was a full-scale model of Voyager 1, complete with the case for the Golden Record and a copy of the record itself. This was the actual prop used as "V-ger" in *Star Trek, The Movie*. A half-scale Mars Reconnaissance Orbiter and half scale Cassini were among the most impressive spacecraft. There was a moon rock, of course, but plenty of those are around at various planetariums. I was excited to see a piece of Surveyor 3 that was brought back from the moon by the Apollo 12 astronauts.

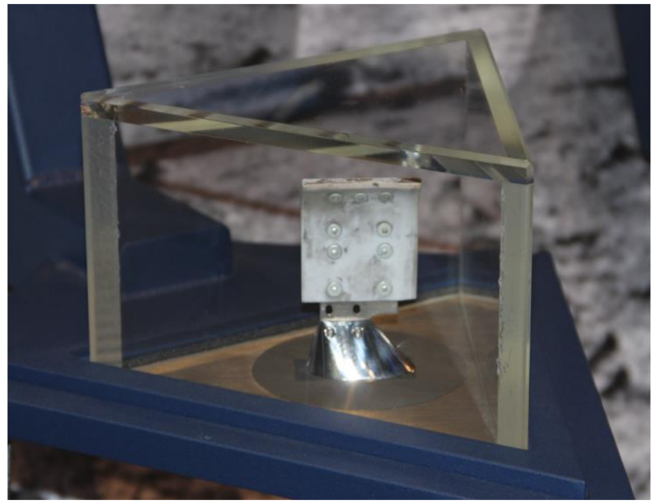
The full-scale Voyager model in the JPL Auditorium

In the museum, we ran into Heidi, another high-school classmate of Varoujan's. She was heading home after spending the night operating the Juno spacecraft heading for Jupiter. Heidi was a ballet dancer in her youth, which is actually excellent training for space mission operations. Ballet dancers have a fantastic ability for focus and perseverance.

Half-scale model of Galileo



Elyse reflected in the cover of the Golden Record on the side of Voyager



A piece of Surveyor 3, about 3” on a side

The museum also had displays about space science, and one that Varoujan was particularly excited about was an infrared camera that recorded body heat. Varoujan works on the Spitzer Space Telescope, the infrared instrument that was launched in 2003 into an Earth-trailing orbit. Typical of JPL space probes, it has vastly exceeded its operating lifetime, originally expected to be 5 years, and is still operating, although in a “warm” mode because its liquid helium coolant has run out. Spitzer was the final member of the NASA “Great Observatories” program, 4 space telescopes that covered the full range of electromagnetic wavelengths. The other members of this quartet are Hubble Space Telescope (1990-present), the Compton Gamma Ray Observatory (1991-1999) and the Chandra X-Ray Observatory (1999-present).

Infrared and visual images

The list of JPL-constructed and flown robotic missions includes almost all of the important probes from the dawn of the space program. Besides the Explorer satellites, JPL was responsible for all the Mariner, Pioneer, Viking and Voyager planetary spacecraft, Surveyor landers on the moon, Magellan (Venus), Galileo (Jupiter) and Ulysses (Sun). Missions to comets and asteroids included Stardust, Genesis, Deep Space 1 and Dawn (currently being operated), and JPL has an instrument on the European Space Agency's Rosetta mission.

At present, JPL is responsible for Mars Science Laboratory mission (Curiosity), Cassini–Huygens mission at Saturn, Mars Exploration Rover Opportunity, Mars Reconnaissance Orbiter, the Dawn mission to Vesta and now in orbit at Ceres, the Juno spacecraft soon to reach Jupiter, the NuSTAR X-ray telescope, and Spitzer. Its scientists participate in a variety of other projects, it runs the Deep Space Network and it maintains the Small Body Database of asteroids and other sub-planetary solar system bodies (sorry, Pluto fans, but your favorite solar system object is in the Small Body Database).

A good deal of NASA's public outreach comes from JPL, through entities such as NASA Space Place (which provides an occasional article for our newsletter) and the "What's Up?" video podcast. A couple of days later on our trip we met Jane Houston Jones, the person responsible for "What's Up?" at a sidewalk astronomy event near our hotel in Monrovia, California.

Obviously we couldn't see most of the goings-on at JPL. Planning and operations of space missions are among the most, if not the most, complex and detailed endeavors of the human race. Everything about space exploration has to be meticulous, whether it's the design and manufacture of a scientific instrument on a spacecraft or the budgetary planning in advance of a mission proposal. An entire building houses the experts dedicated just to evaluating the proposals for space missions and scientific research at the lab. Then there are research laboratories, design workshops, construction facilities like the Spacecraft Assembly Building, testing facilities like the In-Situ Instrument Laboratory (the Mars Yard), offices for the scientists who are working with the data from space missions, and of course all of the things that a small city needs to function, among them the fire department, first aid, security, a cafeteria and even a souvenir shop (I bought a shirt).

Our tour lasted almost three hours, and when it was over we met up with Dr. Lawrence, who had promised to take us to the Palomar telescope, a drive of almost 3 hours from JPL. Although this was our next adventure, it makes more sense for historical and scientific reasons to tell you first about our visit two days later to the Mount Wilson Observatory, and that will be the subject of next month's article. ■

Dr. Varoujan Gorjian with the model of Explorer 1

Dr. Varoujan Gorjian and Dr. Charles Lawrence

Treasures of the Night Skies

Northern Lights and Astrophotos of Scott Nammacher will be on Exhibition at the Greenburgh Public Library August 2nd to September 9th, 2016

Deep Space and Northern Lights photographer Scott Nammacher, a Westchester based amateur astrophotographer, will be exhibiting his photos in The Howard and Ruth Jacobs Exhibition Hall at the Greenburgh Public Library. The exhibition opens August 2nd and extends to September 9th. It is called "Treasures of the Night Skies."

The Artist Reception will happen August 6th between 2 and 4 pm, and is open to the public.

Mr. Nammacher's photographs are taken from his up-state observatory (Starmere) and two remotely operated observatories (one in Australia and the other in New Mexico). He has been photographing nebulas, galaxies, along with cloud and gas regions, and more local solar system targets since the early 2000s. He became more seriously involved after he designed and built his own fully automated observatory near Catskill, NY in late 2008. He has shown earlier works at locations in the Hudson Valley area, including the Hudson Opera House in Hudson, NY, The Somers Library, and The Pound Ridge Library. He has also given talks and presentations around the region on astrophotography.

He recently photographed a spectacular show of the aurora borealis (northern lights) from Churchill, Manitoba, just south of the Arctic Circle. The best of these will be shown first, at this show. His prints are created using a unique process that involves printing on a coated piece of thin aluminum, which enhances the color and vibrancy of the photos.

He will also give a talk on his photographs on August 20th, at 2 pm. Weather permitting, he will set up a solar telescope for attendees to get amazing views of the sun.

Greenburgh Library information:	300 Tarrytown Road, Elmsford, NY 10523 Phone: 914-721-8200 Website: www.greenburghpubliclibrary.org
Artist Information:	Website: Starmere.smugmug.com Email: snammacher@msn.com

Scott's image of the Horsehead nebula in Orion.

Hubble's Bubble Lights up the Interstellar Rubble

Ethan Siegel

When isolated stars like our Sun reach the end of their lives, they're expected to blow off their outer layers in a roughly spherical configuration: a planetary nebula. But the most spectacular bubbles don't come from gas-and-plasma getting expelled into otherwise empty space, but from young, hot stars whose radiation pushes against the gaseous nebulae in which they were born. While most of our Sun's energy is found in the visible part of the spectrum, more massive stars burn at hotter temperatures, producing more ionizing, ultraviolet light, and also at higher luminosities. A star some 40-45 times the mass of the Sun, for example, might emits energy at a rate hundreds of thousands of times as great as our own star.

The Bubble Nebula, discovered in 1787 by William Herschel, is perhaps the classic example of this phenomenon. At a distance of 7,100 light years away in the constellation of Cassiopeia, a molecular gas cloud is actively forming stars, including the massive O-class star BD+60 2522, which itself is a magnitude +8.7 star despite its great distance and its presence in a dusty region of space. Shining with a temperature of 37,500 K and a luminosity nearly 400,000 times that of our Sun, it ionizes and evaporates off all the molecular material within a sphere 7 light years in diameter. The bubble structure itself, when viewed from a dark sky location, can be seen through an amateur telescope with an aperture as small as 8" (20 cm).

As viewed by Hubble, the thickness of the bubble wall is both apparent and spectacular. A star as massive as the one creating this bubble emits stellar winds at approximately 1700 km/s, or 0.6% the speed of light. As those winds slam into the material in the interstellar medium, they push it outwards. The bubble itself appears off-center from the star due to the asymmetry of the surrounding interstellar medium with a greater density of cold gas on the "short" side than on the longer one. The blue color is due to the emission from partially ionized oxygen atoms, while the cooler yellow color highlights the dual presence of hydrogen (red) and nitrogen (green).

The star itself at the core of the nebula is currently fusing helium at its center. It is expected to live only another 10 million years or so before dying in a spectacular Type II supernova explosion.

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!

Image credit: NASA, ESA, and the Hubble Heritage Team (STScI/AURA), of the Bubble Nebula as imaged 229 years after its discovery by William Herschel.