

PRIMEFOCUS

Tri-Valley Stargazers



July 2013



Meeting Info

What:

Workshop and Observing
How Does This Work/What Is This?

Who:

Gert, Chuck, You

When:

July 19, 2013
Meeting at 7:30 p.m.

Where:

Lake Del Valle
7000 Del Valle Road
Livermore, CA

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July Meeting

LAKE DEL VALLE: Workshop and Observing How Does This Work/What Is This?

We want to try something new for our July meeting. In lieu of having yet another speaker at the Church, we thought to have a "How Does This Work/What Is This?" workshop, held at our Del Valle observing site. This would allow club members to bring equipment they aren't sure how to use or if it works, and use the collective wisdom and experience of club members to help them out. Other clubs have called these types of meetings "Fix It" or "Learning" meetings. The moon rises at 5:30pm and sunset is 8:25pm. So we should have a fair amount of time with enough light to see and study things, and then some "semi-dark" time to observe. There is NO PARKING on the paved road that leads into the park. But there is a gravel covered, off-the-road area next to the gate where you can park. From there it's a short walk into the observing site. If you are bringing equipment, driving access to the site will be given on a first come-first serve basis up to the limit prescribed observing agreement with the park. It may be possible to ferry equipment to the observing site in Chuck's van. As a holder of an observing permit for the Del Valle site, Gert Gottschalk will be the official host of the workshop. Chuck Grant will carry out his usual presidential duties. Check the TVS website for more details!

Calendar of Events (overflow)

Group Observing at Lick Observatory

There is an opportunity for group observing at Lick Observatory on July 20, August 3, August 17, August 31, and September 21. The group rate is \$1000 for 30 people. Groups will have the opportunity to observe a variety of astronomical objects through both the historic 36" Lick Refractor using its eyepiece and the 40" Nickel Reflector equipped with a CCD direct imaging camera; the camera has a 6.3x6.3-arcminute field of view and B, V, R, and I filters. Groups will be able to request the objects they would like to observe and will have access to that night's digital images from the Nickel Telescope. Participants may also bring their own telescopes to this prime viewing site. Communicate through the TVS yahoo users group to express your interest.

TVS June BBQ

The June BBQ was a great success. Special thanks to Jill Evanko for providing the hamburgers, free-range hot dogs, sausages, and all the fixing's you could ever want. Thanks also to Chuck and other club members who helped with the set-up, provided additional food, cooked, and cleaned up. I can't wait until next year's BBQ!

News & Notes

2013 TVS Meeting Dates

The following lists the TVS meeting dates for 2013. The lecture meetings are on the third Friday of the month, with the Board meetings on the Monday following the lecture meeting.

Lecture Meeting	Board Meeting	Prime Focus Deadline
Jul. 19	Jul. 22	
Aug. 16	Aug. 19	Jul. 26
Sep. 20	Sep. 23	Aug. 30
Oct. 18	Oct. 21	Sep. 27
Nov. 15	Nov. 18	Oct. 25
Dec. 20	Dec. 23	Nov. 29

Money Matters

Treasurer David Feindel indicates that as of July 13, 2013 the TVS account balances are:

Checking \$12,296.97

TVS Needs YOU!!!

TVS needs your help. Please consider taking on the role of Vice-President or Program Director. Anyone interested in either (or both) of these positions is encouraged to contact any of the club officers via e-mail or at the monthly meeting.

H2O Open House

Our next open house is tentatively scheduled for August 10th at the club's dark sky site, Hidden Hill Observatory, aka H2O. Anyone can come to our open houses, not just club members; but you cannot go there without an escort. We will meet at the corner of Mines and Tesla Roads at 6:30 PM, then caravan to the site on a drive that takes about 50 minutes. There is no gas on the way, so be sure to gas up before leaving. The site is essentially in the wilderness, so there is no electricity and water, and there are only a couple of pit toilets. Cell-phone reception is iffy at best. If you need a flashlight, bring a red LED flashlight, not a white-light flashlight. And use masking tape over your car door and interior lights, or pull the fuse. If you don't have a scope, you can always find someone who is willing to let you look through theirs. And don't forget to bring your binoculars. Expect to stay until about midnight and get back to Livermore at around 1:00 AM.

Check the club website: <http://www.trivalleystargazers.org/> for the latest news on the open house.

Barcroft High Altitude Star Party

The Eastbay Astronomical Society and Tri-Valley Stargazers joint venture are planning this year's Barcroft High Altitude Star Party. The dates are Wednesday, September 4 through Sunday, September 8. The cost is \$65/night, with preference being given to those who sign up for all five nights.

Reservations must be received no later than Tue Aug 20, 2013.

The details of this star party are now posted on the East Bay Astronomical Society website: <http://www.eastbayastro.org/index/Barcroft.htm>. Barcroft Observatory, located in the White Mountains east of Owens Valley, is located at ~12,450 feet so it is not for the faint of heart, but it is the ultimate dark sky experience. It is strongly recommended that participants acclimatize at altitude for at least one night in advance of their stay at Barcroft. Suggested acclimatization locations are Grandview Campgrounds (~8,600 feet), a hotel in Mammoth Lakes (~8,000 feet), or Bridalveil Creek Campground near Glacier Point.

Yosemite Star Party

This year's Yosemite Star Party will be held on Friday and Saturday, August 16 and August 17, at Glacier Point. Tri-Valley members who bring telescopes for public observing will receive free camping at the Bridalveil campgrounds. On these evenings, sunset occurs at about 8pm. On August 16, moonrise is at 4:18pm and moonset is at 2:35am. On August 17, moonrise is at 5:13pm and moonset is at 3:42am.

Those interested in participating should contact Bob McKoon (rmckoon@yahoo.com)

Calendar of Events

July 15, 7:30pm

What: The Once and Future Kepler Mission: Hot on the Trail of Habitable Earth-size Planets
Who: Dr. Jon Jenkins, SETI Institute
Where: California Academy of Science, 55 Music Concourse Dr., Golden Gate Park, San Francisco, CA
Cost: General \$12, Seniors \$10, Academy members \$8.
Reserve a space online or call 1-877-227-1831.

Kepler vaulted into the heavens on March 7, 2009, initiating NASA's search for Earth-size planets orbiting Sun-like stars in the habitable zone, where liquid water could exist on the planetary surface and support alien biology. In the 4 years since, a flood of photometric data on upwards of 190,000 stars of unprecedented precision and continuity has provoked a watershed of 132+ confirmed or validated planets, 2700+ planetary candidates and a resounding revolution in our understanding of the behavior of stars. Recent discoveries include Kepler-62 with 5 planets total of which 2 are in

Header Image: Artist's illustration of the Chandra X-Ray observatory in orbit. Credit: NASA Marshall Space Flight Center.

Calendar of Events (continued)

the habitable zone, and are 1.4 and 1.7 times the radius of the Earth. Dr. Jenkins will highlight key science results from Kepler, and will also discuss the daunting challenges that faced the technical and scientific team as they designed, built and are now operating this amazing observatory. He will also give a brief overview of TESS, NASA's next mission to detect Earth's closest cousins.

See <http://www.calacademy.org/events/lectures/> for lecture and reservation information.

July 16, Noon-1:00pm

What: Atmospheric Polar Warming at Mars
Who: Tamara McDunn, Jet Propulsion Laboratory
Where: SETI Headquarters, 189 N. Bernardo Ave.,
Mountain View, CA
Cost: Free

This talk will cover two active areas of research in the field of martian atmospheric dynamics. The first is polar warming, a temperature enhancement over mid-to-high latitudes that results in a reversed (poleward) meridional temperature gradient.

Dr. McDunn will show observations of polar warming over the ~30-90 km altitude range from the Mars Climate Sounder (MCS) instrument aboard the Mars Reconnaissance Orbiter. She will also present results of ongoing efforts to understand the drivers of this phenomenon (including topography, dust loading, and gravity wave breaking) using the Mars Weather Research and Forecasting global circulation model. The second topic of this talk will be semi-stationary waves masquerading as stationary waves. Stationary waves play a crucial role in the redistribution of heat from the equator to the high latitudes, significantly impact the atmosphere's stability, and

impart acceleration on the mean flow of the middle-to-upper atmosphere.

Using MCS observations, Dr. McDunn will show how the traditional technique used to identify stationary waves from orbital data limited to two local times does not discriminate against a type of wave that displays near-steady behavior on seasonal time scales yet undergoes significant variability on diurnal time scales (here referred to as "semi-stationary")

For more information see: <http://www.seti.org/csc/lectures>, e-mail info@seti.org, or phone 650-961-6633.

July 20, 11:00am

What: Snacking, Gorging, and Cannibalizing: The Feeding Habits of Black Holes
Who: Dr. Steve Croft
Where: UC Berkeley, Dwinelle Hall 145
Cost: Free, limited hourly pay parking on/nearby campus. The venue is within walking distance of BART and bus lines.

A new generation of telescopes is coming online. Operating at wavelengths from radio, through optical, to gamma ray, they are particularly well-suited to time-domain survey science: essentially, making large-format movies of the sky. These telescopes will have the capability to tell us about how black holes grow: through cannibalizing each other in stupendous mergers that shake the very fabric of space-time, through swallowing huge volumes of ten million degree gas, and through shredding and consuming stars that happen to pass too close. The new observations of these processes are helping to transform our understanding of the growth of the enormous black holes that lurk at the heart of almost all galaxies.

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Eyes on the Skies

Eyes on the Skies is a robotic solar telescope run by Mike Rushford (rushford@eyes-on-the-skies.org). You may access it by visiting www.eyes-on-the-skies.org.

TVS E-Group

So how do you join the TVS e-group, you ask? Just send an e-mail message to the TVS e-mail address (trivalleystargazers@gmail.com) asking to join the group. Make sure you specify the e-mail address you want to use to read and post to the group.

Calendar of Events (continued)

Steve is an Assistant Project Astronomer working on large radio surveys, and transient and variable astronomical sources. He helped commission the Allen Telescope Array for science operations and developed data analysis pipelines. He got his PhD from the University of Oxford, working on actively feeding supermassive black holes in galaxy cluster environments. He then worked as a postdoctoral researcher at the Lawrence Livermore National Laboratory, studying distant galaxy clusters, as well as investigating a fascinating burst of star formation triggered by a jet from a nearby black hole. Steve is an expert in the use of data at a wide range of wavelengths from many different telescopes

For more information see: <http://scienceatcal.berkeley.edu/lectures>

July 23, Noon-1:00pm

What: Free Samples from Mars
Who: Paul De Carli, SRI
Where: SETI Headquarters, 189 N. Bernardo Ave., Mountain View, CA
Cost: Free

In the late 70's meteoriticists began to speculate that some oddball meteorites might be from Mars. These meteorites looked more like terrestrial rocks than meteorites, but they were seen to fall- Chassigny in 1815, Shergotty in 1865, and Nakhla in 1911. The big question, how these SNC meteorites got here, seemed to be solved by the "spall mechanism", a combination of high velocity and low shock pressure. Although the "spall mechanism" is shown to be spurious, trapped Martian atmosphere and isotope ratios provide convincing evidence that some 67 (as of 8 June) distinct meteorites are from Mars.

George Wetherill's mechanism, acceleration by the expansion of shock-compressed water is shown to be a viable means of getting meteorites from Mars to the Earth. Since the "spall mechanism" is still generally accepted by the Planetary Science community, it will be discussed in detail and shown to an artifact of computer code calculations. There is also evidence from the shock-induced high pressure phases in some martian meteorites that they were too deep in Mars to have been launched by the "spall mechanism".

For more information see: <http://www.seti.org/csc/lectures>, e-mail info@seti.org, or phone 650-961-6633.

July 30, Noon-1:00pm

What: Mapping Io's Surface Topography Using Stereo Images and Photoclinometry
Who: Oliver White, LPI
Where: SETI Headquarters, 189 N. Bernardo Ave., Mountain View, CA
Cost: Free

No instrumentation specifically designed to measure the to-

pography of a planetary surface has ever been deployed to Jupiter's moon Io, the most volcanically active body in the Solar System. Available mapping techniques that exist to perform such a task in the absence of the relevant instrumentation include stereo and photoclinometry (shape-from-shading) processing of available Voyager and Galileo imagery. These techniques have been successfully applied to the icy moons of the giant planets, but Io is a much more challenging subject due to its complex and changing photometric behavior and the inherent characteristics of the Ionian surface, as well as the inherent nature of Galileo imagery. This presentation will describe our efforts to produce the best quality digital elevation models (DEMs) of Io to date using both techniques, to control these DEMs using Galileo limb profiles (the only true topographic ground data available), and to merge and mosaic the DEMs to form a global topographic map of Io. While our investigation has focused almost entirely on refining our mapping technique, future science objectives that can be addressed by the data in the DEMs will be discussed.

For more information see: <http://www.seti.org/csc/lectures>, e-mail info@seti.org, or phone 650-961-6633.

August 5, 7:30pm

What: Cosmological Intimations of Infinity
Who: Dr. Anthony Aguirre, UC Santa Cruz
Where: California Academy of Science, 55 Music Concourse Dr., Golden Gate Park, San Francisco, CA
Cost: General \$12, Seniors \$10, Academy members \$8. Reserve a space online or call 1-877-227-1831.

During the past two decades astronomers and cosmologists have assembled an extremely successful model that accurately describes and explains the evolution of the observable universe over the past 13.8 billion years, most recently confirmed with amazing accuracy by the PLANCK satellite's observations of the cosmic microwave background. A key component of this cosmological "standard model" is the theory of Inflation, in which at ultra-early times the universe was expanding exponentially. Originally envisaged as an important but brief cosmological epoch, since Inflation's invention cosmologists have realized that in many cases inflation completely upends our picture of the ultra large-scale structure of the universe, and suggests that the universe lasts forever, may not have had a beginning, and has enormous size and complexity that is best described as a 'multiverse'. Aguirre will trace the development of these ideas, as well as look forward to prospects for testing or even confirming the idea of an infinite inflationary multiverse. See <http://www.calacademy.org/events/lectures/> for lecture and reservation information.

August 6, Noon-1:00pm

What: Optics Tricks to Image and Study Habitable Exoplanets
Who: Olivier Guyon, University of Arizona and Subaru

Calendar of Events (continued)

Telescope, HI

Where: SETI Headquarters, 189 N. Bernardo Ave.,
Mountain View, CA

Cost: Free

Directly imaging exoplanets is both scientifically exciting but notoriously challenging. Scientifically, obtaining images of rocky planets in the habitable zones of stars is key to finding if and how life developed outside the solar system. Large-scale biological activity can modify the chemical composition of the planet's atmosphere and its surface properties, both of which can be studied by spectrophotometry. The measurement is however extremely challenging, as the planet light is considerably fainter than the host star's light, and the angular separation between the two objects is about 0.1 arc second or less.

Conventional imaging systems cannot overcome the high star to planet contrast, and unusual optics are required for imaging exoplanets. Dr. Guyon will describe such systems (coronagraphs) and the upcoming scientific opportunities associated with their deployment on ground-based telescopes and in space. He will show that ground-based extremely large telescopes (ELTs) will have the ability to directly image and spectroscopically characterize rocky planets in the habitable zones of nearby M-type stars, thus providing scientific evidence for (or against) the presence of life outside our solar system. Space telescopes operating in optical light are well suited to target Earth-like planets around Sun-like stars.

Dr. Guyon will also describe the PANOPTES (Panoptic Astronomical Networked OPTical observatory for Transiting Exoplanet Survey) project, aimed at supporting a worldwide network of small robotic digital cameras built by citizen scientists and schools to identify a large number of transiting exoplanets.

For more information see: <http://www.seti.org/csc/lectures>, e-mail info@seti.org, or phone 650-961-6633.

August 10, 8:30pm

What: The Lives of Stars

Who: Dr. Ken Crowell, Astronomer and Author

Where: Mt. Tamalpais State Park, Cushing Memorial Amphitheater, more commonly known as the Mountain Theater, Rock Spring parking area

Cost: Free

The stars that speckle the sky have long fascinated humanity, but only in the past century have astronomers figured out how stars are born, live, and die and which stars might have planets with intelligent life.

For more information see: <http://www.mttam.net/astronomy/schedule.html>

August 13, Noon-1:00pm

What: Spectroscopic Monitoring of Pluto's Volatile Ices

Who: Will Grundy, Lowell Observatory

Where: SETI Headquarters, 189 N. Bernardo Ave.,
Mountain View, CA

Cost: Free

Dr. Nesbet will describe (in layman's terms) implications of Pluto's near-infrared reflectance spectrum shows characteristic vibration absorptions of CH₄, N₂, and CO condensed as ices on Pluto's surface. Long term monitoring of Pluto's spectrum from 1995 through present provides constraints on the evolution of these ices driven by seasonal volatile transport cycles. However, seasonal trends must be disentangled from spectral changes caused by continually-changing viewing geometry coupled with the heterogeneous regional distributions of Pluto's ices.

Dr. Grundy is a team member on the RALPH instrument onboard New Horizons and he will give the latest news on observations of Pluto before the upcoming encounter in 2016.

For more information see: <http://www.seti.org/csc/lectures>, e-mail info@seti.org, or phone 650-961-6633.

August 16, Noon-1:00pm

What: Thermal History of Planetary Objects: From Asteroids to Super-Earths, From Plate Tectonics to Life

Who: Tilman Spohn, Director of the Institute for Planetary Research at DLR, Berlin

Where: SETI Headquarters, 189 N. Bernardo Ave.,
Mountain View, CA

Cost: Free

Convection in the interiors of planetesimals (asteroids), planets, and satellites is driving the thermal and chemical evolution of these bodies including the generation of possible magnetic fields. The wide size range induces a wide range of time scales from hundreds of thousands of years for small planetesimals to a few tens of Gigayears for massive super-Earths.

Dr. Spohn will present a model that includes mantle convection, mantle water vapor degassing at mid-oceanic ridges and regassing through subduction zones, continental crust formation and erosion and water storage and transport in a porous oceanic crust that includes hydrous mineral phases.

Dr. Spohn will show how an abiotic world is predicted to have a much drier mantle than the present Earth but may have a similar surface coverage by continents. The reduced rate of continental crust production on the abiotic world would be balanced by a reduced rate of continent erosion. He will suggest that through the effect of water on the mantle rheology, the biotic world would tend to be tectonically

What's Up by Ken Sperber (adapted from S&T and The Year in Space)

All times Pacific Daylight Time.

July

15 Mon First-Quarter Moon (8:18pm)

15 Mon Spica and the First-Quarter Moon are very close together

16-17 Tue- Jupiter and Mars about 2 degrees apart, very low in the east-northeast (Dawn)

22 Mon Mars 3/4 degree above Jupiter (1 hour before sunrise)

22 Mon Full Moon (11:16am)

29 Mon Last-Quarter Moon (10:43am)

August

3 Sat Jupiter to the lower left of the crescent Moon (Dawn)

6 Tue New Moon (2:51pm)

9 Fri Crescent Moon below Venus low in the west (half hour after sunset)

11-13 Sun- The Perseid meteor shower peaks the nights of 11-12, and 12-13; best after midnight

14 Wed First-Quarter Moon (3:56am)

Calendar of Events (continued)

more active and have a more rapid long-term carbon-silicate cycle.

For more information see: <http://www.seti.org/csc/lectures>, e-mail info@seti.org, or phone 650-961-6633.

July 26, 7:00pm

What: The Mercury Seven

Who: Fridays with Faride

Where: Chabot Space and Science Center, Space Cafe, 10000 Skyline Blvd. Oakland, CA 94619

Cost: Included with General Admission. For more information call: (510) 336-7373.

Soon after the newly formed National Aeronautics and Space Administration's (NASA) introduction of the first seven American astronauts, these men became instant celebrities of their time. With each launch of a Mercury capsule, we left the starting blocks and entered into a fierce space race with the then Soviet Union. NASA's Project Mercury was the first step Americans took into the unknown realm of space. The gallant Mercury Seven Astronauts proved that man was capable of surviving space travel, and that we were well on our way and up to challenge of going farther from our home planet.

See <http://www.chabotspace.org/events.htm> for more information.

August 2, 5:00pm and 7:15pm

What: Dinner, a Movie & the Universe

Who: Alex Fillipenko

Where: Chabot Space and Science Center, Space Cafe, 10000 Skyline Blvd. Oakland, CA 94619

Cost: Guests: \$26 Adults/\$18 Children; Members: \$20 Adults/\$15 Children. For more information call: (510) 336-7373.

By popular demand, Dinner, a Movie & the Universe, our unique after-dark offering has returned. Join us for a full-course dinner in our mezzanine, enjoy our live-narrated Planetarium show *Fast & Curious: A Cosmos 360 Live Production* with our featured speaker Alex Fillipenko, and view the night sky through our telescopes (weather permitting). Reservations are strongly encouraged. Surrounded by the majestic Redwoods, stars in the sky, and our beautiful facility, DMU is the ideal destination for a first date or 50th, family gathering or rendezvous with friends. Reserve your space today and let us give you the Universe and dessert. Add a Bottomless Glass of Wine for \$10.

See <http://www.chabotspace.org/events.htm> for more information.



High-Energy Spy

By Dr. Martin C. Weisskopf

The idea for the Chandra X-Ray Observatory was born only one year after Riccardo Giacconi discovered the first celestial X-ray source other than the Sun. In 1962, he used a sounding rocket to place the experiment above the atmosphere for a few minutes. The sounding rocket was necessary because the atmosphere blocks X-rays. If you want to look at X-ray emissions from objects like stars, galaxies, and clusters of galaxies, your instrument must get above the atmosphere.

Giacconi's idea was to launch a large diameter (about 1 meter) telescope to bring X-rays to a focus. He wanted to investigate the hazy glow of X-rays that could be seen from all directions throughout the sounding rocket flight. He wanted to find out whether this glow was, in fact, made up of many point-like objects. That is, was the glow actually from millions of X-ray sources in the Universe. Except for the brightest sources from nearby neighbors, the rocket instrument could not distinguish objects within the glow.

Giacconi's vision and the promise and importance of X-ray astronomy was borne out by many sounding rocket flights and, later satellite experiments, all of which provided years-, as opposed to minutes-, worth of data.

By 1980, we knew that X-ray sources exist within all classes of astronomical objects. In many cases, this discovery was completely unexpected. For example, that first source turned out to be a very small star in a binary system with a more normal star. The vast amount of energy needed to produce the X-rays

was provided by gravity, which, because of the small star's mass (about equal to the Sun's) and compactness (about 10 km in diameter) would accelerate particles transferred from the normal star to X-ray emitting energies. In 1962, who knew such compact stars (in this case a neutron star) even existed, much less this energy transfer mechanism?

X-ray astronomy grew in importance to the fields of astronomy and astrophysics. The National Academy of Sciences, as part of its "Decadal Survey" released in 1981, recommended as its number one priority for large missions an X-ray observatory along the lines that Giacconi outlined in 1963. This observatory was eventually realized as the Chandra X-Ray Observatory, which launched in 1999.

The Chandra Project is built around a high-resolution X-ray telescope capable of sharply focusing X-rays onto two different X-ray-sensitive cameras. The focusing ability is of the caliber such that one could resolve an X-ray emitting dime at a distance of about 5 kilometers!

The building of this major scientific observatory has many stories.

Learn more about Chandra at www.science.nasa.gov/missions/chandra. Take kids on a "Trip to the Land of the Magic Windows" and see the universe in X-rays and other invisible wavelengths of light at spaceplace.nasa.gov/magic-windows.

Dr. Weisskopf is project scientist for NASA's Chandra X-ray Observatory. This article was provided by the Jet Propulsion Laboratory, California Institute of Technology, under a contract with the National Aeronautics and Space Administration.



Caption: Composite image of DEM L50, a so-called superbubble found in the Large Magellanic Cloud. X-ray data from Chandra is pink, while optical data is red, green, and blue. Superbubbles are created by winds from massive stars and the shock waves produced when the stars explode as supernovas.

Tri-Valley Stargazers
P.O. Box 2476
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PRIMEFOCUS

Tri-Valley Stargazers Membership Application

Member agrees to hold Tri-Valley Stargazers, and any cooperating organizations or landowners, harmless from all claims of liability for any injury or loss sustained at a TVS function.

Name _____ Phone _____ e-mail _____

Address _____

Do not release my: _____ address, _____ phone, or _____ e-mail information to other TVS members.

- Membership category:
- _____ \$5 Student.
 - _____ \$30 Basic. You will receive e-mail notification when the PDF version of Prime Focus is available for download off the TVS web site.
 - _____ \$10 Hidden Hill Observatory (H2O) yearly access fee. You need to be a key holder to access the site.
 - _____ \$20 H2O key holder fee. (A refundable key deposit—key property of TVS).
 - _____ \$40 Patron Membership. Must be a member for at least a year and a key holder.
 - _____ \$34 One year subscription to Astronomy magazine.
 - _____ \$60 Two year subscription to Astronomy magazine.
 - _____ \$32.95 One year subscription to Sky & Telescope magazine. Note: Subscription to S&T is for new subscribers only. Existing subscribers please renew directly through S&T.
 - \$ _____ Tax deductible contribution to Tri-Valley Stargazers.
 - \$ _____ TOTAL – Return to: Tri-Valley Stargazers, P.O. Box 2476, Livermore, CA 94551

Membership information: Term is one calendar year, January through December. Student members must be less than 18 years old or still in high school.