

PRIMEFOCUS

Tri-Valley Stargazers



March 2013



Meeting Info

What:

Bernhard Schmidt and his Camera

Who:

Dr. Kenneth Lum

When:

March 15, 2013

Doors open at 7:00 p.m.

Show & Tell at 7:30 p.m.

Featured Speaker at 8:00 p.m.

Where:

Unitarian Universalist
Church in Livermore
1893 N. Vasco Road

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March Meeting

Bernhard Schmidt and his Camera

Dr. Kenneth Lum

Bernhard Schmidt invented what is now called the Schmidt camera in 1930 while working for the Hamburg-Bergedorf Observatory in Germany. With its introduction, a whole new revolution in optical design came into being, greatly expanding the way optical designers thought about how to develop and configure telescope systems which previously was locked into thinking about telescopes mostly as variations on the old refractor-Newtonian-Cassegrain theme and had not fundamentally changed since the late 17th Century. This talk will be about how this happened and about the life of this unusual and original thinker. I will also bring a sample Celestron Schmidt camera which had been manufactured in the 1980s during the heyday of its use as a photographic instrument by amateurs.

Dr. Kenneth Lum is a retired emergency room physician who has had an interest in astronomy and the history of astronomy and optical instruments since high school. During the 1990s he took many astrophotos with film cameras with a special emphasis on deep sky objects and comets. Although he is no longer doing astrophotography, he is still interested in telescopes and owns 6 of them that he still uses mostly for visual observation for educational purposes. He also travels frequently with the Antique Telescope Society which annually tours different observatories in the US or in Europe to look at and through historic instruments. This included a trip last fall to the Hamburg-Bergedorf Observatory in Germany to see Herr Schmidt's original instruments. Currently, he is interested in using a photomultiplier (night vision) eyepiece to enhance the visual observing experience to show objects with small telescopes in light-polluted observing environments traditionally requiring large telescopes and remote dark skies to see. He also manages the BayAstro Yahoo Group which sends out weekly posts of astronomy and physics related events in the Bay Area.

Urgent: TVS Needs a New Program Director and Vice-President

The Program Director position is extremely important for the viability of the club. The main duty of the Program Director is to solicit speakers for the monthly meetings. The main duty of the Vice-President is to fill in for the President, when the President is unavailable. This could include opening the church for our monthly meeting, and hosting of said meeting.

Anyone interested in either (or both) of these positions is encouraged to contact any of the club officers via email or at the monthly meeting. All are encouraged to take an active role in TVS, including influencing the changing vision of the club.

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
Mar. 15	Mar. 18	
Apr. 19	Apr. 22	Mar. 29
May 17	May 20	Apr. 26
Jun. 21	Jun. 24	May 24
Jul. 19	Jul. 22	Jun. 28
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 November 16, 2012 the TVS account balance is:

Checking \$11,857.26

Journal Club by Ken Sperber

Henny Penny, The Sky is Falling Down

Last month's column on dung beetles preempted my plans to write a column on the Sutter's Mill, CA meteorite fall that occurred on April 22, 2012. If I'd have published the meteor article last month, it might have seemed prophetic given that on one day, February 15, 2013 (the last TVS monthly meeting), a huge meteor detonated as it crossed the Russian sky, another burned up in the Californian sky, and Asteroid 2012 DA14 passed within about 17,000 miles of Earth. Actually, it is estimated that on average 40 tons of extraterrestrial material falls to the Earth each day.

While folks in the vicinity of Chelyabinsk, Russia are presently scooping up meteorites from this latest fall, an exhaustive search for other meteorite fragments took place in the Sierra Nevada foothills last April. As described in Jenniskens et al. (2012), on April 22, 2012 four weather radars picked up a daytime fireball passing over Nevada and California. This data, in conjunction with pictures and video indicated that the bolide (bright meteor) was initially detected at an altitude of 90km as it was moving to the west. It reached peak brightness at about 56km, and detonated at 47.6 +/- 0.7km, with individual fragments visible down to 30km. The peak brightness was estimated to be -18 to -20 magnitude! Furthermore, the bolide had a record high entry speed of 28.6 kilometers per second (64,000 miles per hour), twice that of typical

falls. Given the observations, the orbit of the Sutter's Mill bolide was estimated to have an aphelion near Jupiter, and perihelion near Mercury. The projected orbit of the bolide is intermediate to that of the asteroids and the Jupiter family of comets. The Sutter's Mill meteorites were determined to be CM-type carbonaceous chondrites. Evidence that it may belong to the comet category is that CM-like micrometeorites have been linked to the Jupiter family of comets, possibly Comet 2P/Encke. Alternatively, the low inclination of the orbit is also consistent with Asteroid (495) Eulalia, which has been suggested to the source of C-class asteroids. Also, its reflectance spectrum is similar to that measured for other asteroids (1999 JU₃).

Eyewitnesses to the Sutter's Mill event also heard sonic booms as the meteor passed through the atmosphere. Lower frequency sound waves, not detectable by the human ear, were also detected by two infrasonic detectors of the International Monitoring System that was set up to detect clandestine nuclear explosions. The monitoring sites were about 770 and 1080km distant from the bolide. The data indicated that the bolide had the energy equivalent of 4 kilotons of TNT. This was the most energetic bolide since the impact of Asteroid 2008 TC3 over Sudan, which had the energy equivalent to 1.2 kilotons of TNT. By contrast, the Chelyabinsk bolide had the kinetic energy equivalent to 440 kilotons of TNT!!! With knowledge of the meteorites' energy and velocity, the mass of the Sutter's Mill bolide was estimated to be about 40,000 kilograms (44 tons). By contrast, the Chelyabinsk bolide is estimated to have had a mass of 7,000 - 10,000 tons!!!

With the multiple detections of the Sutter's Mill bolide, it was possible to estimate the area where fragments (meteorites) of the meteor actually fell to the ground. Three meteorites were recovered on April 24, before heavy rain hit the area. One of these pieces fell near Sutter's Mill, where the California gold rush was initiated. Within two months, 77 fragments were recovered with a total mass of 943 grams (about 2 pounds). The largest single meteorite weighed in at 205 grams. The density of the meteorites was measured to be about 2.27 grams per cubic centimeter (by comparison, the density of water is 1 gram per cubic centimeter). With knowledge of the mass and the density, the Sutter's Mill bolide was estimated to have been 2.5-4.0 meters in size, whereas the Chelyabinsk bolide was estimated to be 17-20 meters in size.

The Sutter's Mill meteorites are regolith breccias (rock composed of fragments of small rocks and minerals that are cemented together by fine-grained material). From concentrations of radioactive elements and the elements to which they decay (daughter products), the meteorites parent object was formed 4.56667 +/- 0.00066 billion years ago, thus dating back to the formation of the solar system. One key radioactive element, ²⁶Al, forms from exposure to cosmic

Header Image: Comet Hale-Bopp photographed by Ken Sperber in 1997. In mid-late March look for Comet PanSTARRS (C/2011 L4) in the western sky after sunset. It might be visible with the unaided eye, but use binoculars or a telescope if necessary.

Journal Club (continued)

rays. The ratio of this element to its daughter product is used to calculate the cosmic ray exposure (CRE) age, which is an indication of how long ago the meteor was broken off of its parent object, probably by a collision. In this case the CRE age was only about 100,000 years, at the low end for CM2 chondrites.

Based on the minerals present, the interior of the meteor never reached temperatures above 400-500°C (750-932°F). However, the outer surface of the meteor was heated to about 750°C (1400°F) for about 1.5 seconds due to friction with the Earth's atmosphere. Most interesting and insightful was the comparison of the three Sutter's Mill fragments that were recovered on April 24, before it rained, with other fragments that were recovered after it rained. The pre-rain fragments contained a mineral made of calcium-sulfate called oldhamite. In moist conditions, this mineral decomposes, and it was not found in the meteorite fragments that were recovered after it rained. Other components that were present in much higher quantities in the pre-rain fragments included formate, acetate, sulfate, and chloride. Quoting from Jenniskens et al. (2012): "The SM meteorite demonstrates that the complexity of C-class asteroid surfaces is greater than previously assumed. Rapid terrestrial alteration probably erases many vestiges of the internal and external processes on the asteroid that remain to be explored in spacecraft sample-return missions."

On April 8 at 7:30pm, see Dr. Jenniskens talk about the Sutter's Mill meteorites at the California Academy of Science!

For more information see: Jenniskens et al. (2012, Science 21 December 2012: Vol. 338 no. 6114 pp. 1583-1587, DOI:10.1126/science.1227163), <http://www.sciencedaily.com/releases/2012/12/121220144153.htm>, http://en.wikipedia.org/wiki/Cosmic_dust and http://en.wikipedia.org/wiki/2013_Russian_meteor_event

Calendar of Events

March 11, 7:30pm

What: Where Will Curiosity Take Us? Following the Mars Science Laboratory Rover as it Explores the Red Planet

Who: Jennifer Blank, Bay Area Environmental Research Institute, NASA/Ames Research Center

Where: California Academy of Science, 55 Music Course Dr., Golden Gate Park, San Francisco, CA

Cost: Adults \$12, Seniors \$10, Academy members \$8. Reserve a Space Online or call 1-877-227-1831

NASA's most recent visitor to Mars, "Curiosity," touched down last August in Gale Crater. Curiosity is a rolling, robot geologist, carrying high resolution cameras and a suite of sophisticated analytical instruments which make up the Mars Science Laboratory. Blank is a member of the MSL Science Team, whose main goal is to discover clues in the rocks and soils on Mars that will indicate whether Mars once was capable of supporting life. Come hear Dr. Blank talk about Curiosity's first few months on Mars, the first discoveries, and the drive toward Mount Sharp, the rover's ultimate destination.

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

March 12, 7:00pm

What: A Different Universe

Who: Robert Laughlin, Stanford

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Officers

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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.

Journal Club (continued)

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

Cost: Free

Abstract unavailable.

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

March 16, 11:00am

What: Cloudspotting at Saturn and Titan: Learning
About Weather from a Billion Miles Away

Who: Dr. Máté Ádámkovics, UC Berkeley

Where: UC Berkeley, Genetics and Plant Biology Building,
Room 100 (northwest corner of campus)

Cost: Free, limited hourly pay parking on/nearby cam-
pus. The venue is within walking distance of BART
and bus lines.

The weather is a daily reminder of the changes in our environment, and can inspire the search for a deeper understanding of our physical world. From the local weekly weather forecast, to knowledge of regional and seasonal conditions, to predicting the global climate response of our atmosphere in the coming decades due to significant anthropogenic changes, there are intriguing challenges in understanding our atmosphere. Since the Cassini mission to the Saturn system, it has become possible to evaluate the physics and models that we use to address these challenges on Earth by applying our understanding to exotic environments with fascinating meteorology. Saturn's largest moon, Titan, is the one place in the Solar System beyond our planet where fluids on a rocky surface interact with dense atmosphere, forming clouds, fog and rain, in a strangely familiar hydrological cycle that operates at 290 degrees below zero. In these frigid conditions, the role of water is played by methane, the dominant component of natural gas. I'll describe how measurements from telescopes on Earth, the Cassini spacecraft that is still orbiting the Saturn system, and the Huygens probe that landed on surface of Titan all inform our knowledge of weather in the Saturn system.

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

March 19, Noon - 1:00pm

What: A new perspective on the driver of space weather:
the Sun's corona as a globally coupled system

Who: Karel Schryver, Lockheed Martin

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

Cost: Free

The Sun's dynamic magnetic field is the origin of all of the variability in the heliosphere and in geospace that we refer to as space weather. This variability occurs on a hierarchy of

time scales ranging from the full 11-year solar cycle that determines the Sun's global dipole field down to less than the few hours on which a large solar flare or coronal mass ejection occurs.

The full-sphere observations of the Sun that are enabled by the Solar Dynamics Observatory and the STEREO spacecraft stress the globally-connected nature of the coronal magnetic field and its coupling into the heliosphere. With expanding observational coverage of the dynamic solar atmosphere, supported by growing modeling capabilities that move towards data-driven assimilation, a new realization unavoidably dawns: understanding the solar corona requires that we learn how to deal with a continually evolving system, always relaxing from the evolution of its surface boundary and from explosive coronal mass ejections, but rarely in a state that our current modeling capabilities would have it.

Dr. Schryver will illustrate the recent lessons about the solar corona with image sequences obtained by the Solar Dynamics Observatory, the STEREO spacecraft, and the Hinode mission that together enable us to trace the Sun's magnetism from the surface into the space between the planets.

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

March 22 16, 6:00pm-7:30pm

What: Future Fridays

Who: Prof. Alex Filippenko, UC Berkeley

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

Cost: \$20 Members, \$23 Guests, \$29 at the Door, Tickets
available online or (510) 336-7373

Alex Filippenko was a member of both teams whose leaders were awarded the 2011 Nobel Prize in Physics for discovering the accelerating Universe. Voted the "best professor" on the UC Berkeley campus a record nine times, and the 2006 National Professor of the Year, he is frequently featured in "The Universe" series on The History Channel.

Mysterious dark matter and dark energy are aspects of our Universe that we cannot see, taste, or feel, but they are very important: dark matter keeps galaxies gravitationally bound, and dark energy is accelerating the expansion of the Universe. We wouldn't exist without dark matter, or if dark energy were much stronger than it is!

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

March 26, Noon-1:00pm

What: Updating Policies for Space Exploration and Use--
Balancing Science, Technology and Activities in
the coming Decade

Who: Margaret Race, SETI Institute
Where: SETI Headquarters, 189 N. Bernardo Ave.,
Mountain View, CA
Cost: Free

Currently, the UN is studying questions of long-term sustainability of space activities-- but there is scant focus beyond Earth Orbit as they deliberate updated policies. Most space activities have occurred in LEO and GEO over the past 5 decades--and have involved a variety of activities and launchers...BUT...On the moon and other celestial bodies, governments and scientists have had essentially exclusive use. Considering the increased numbers of commercial stakeholders, new spacefaring countries, and diverse plans for uses of planetary surfaces and resources, there are many issues ahead that will require thinking about stewardship and use of space environments. The space science community is key to generating new information and understanding--but also is a very active stakeholder interested in continued studies of 'pristine' and natural space environments. How do we all work together in planning effective and justifiable space policies for the decades ahead?

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

March 29, 7:00pm-8:00pm

What: To the Moon
Who: Chabot Staff
Where: Chabot Space and Science Center, 10000 Skyline Blvd. Oakland, CA 94619
Cost: Included with General Admission. Tickets available online or by calling (510) 336-7373.

From imagination to realization, NASA's Apollo program is packed with bold vision, engineering elegance, and tales of courage and sheer human toil. In this Café Conversation, we will take a trip down memory lane and visit the Moon. With colorful images we will look back at the physics and challenges of landing astronauts on the lunar surface. How did we do it? In a play-by-play review, find out the necessary steps we took that put us on the Moon.

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

April 2, Noon-1:00pm

What: Characterizing the Atmospheres of Low-Mass Low-Density Transiting Exoplanets
Who: Jonathon Fortney, UC Santa Cruz
Where: SETI Headquarters, 189 N. Bernardo Ave., Mountain View, CA
Cost: Free

NASA's Kepler Mission has revealed that the most common size of planet in our galaxy may be those from 2-3 Earth

radii. Such medium-sized planets are significantly more common on close-in orbits than Neptune and Jupiter-class giant planets. We have no analog for these planets in our solar system. What are they made of? An example relatively close to home is planet GJ 1214b, which is 2.6 Earth radii and 6 Earth masses, and orbits an M star near the Sun. This planet has been extensively studied with the Hubble and Spitzer Space Telescopes. In this talk I will discuss our current understanding of the composition and atmospheric physics of GJ 1214b, which is potentially the prototype for this class of low-mass low-density planets.

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

April 8, 7:30pm

What: Small Worlds in Collision: Recent Meteorite Falls in California
Who: Peter Jenniskens, SETI Institute
Where: California Academy of Science, 55 Music Concourse Dr., Golden Gate Park, San Francisco, CA
Cost: Adults \$12, Seniors \$10, Academy members \$8. Reserve a Space Online or call 1-877-227-1831

On April 22, 2012, a small asteroid impacted close to home in California—at Sutter's Mill, the site where gold was first discovered in 1848, leading to the California Gold Rush. Meteor astronomer Dr. Peter Jenniskens kept a tally of finds and mobilized NASA Ames Research Center into leading the recovery effort from the air and the ground. 77 meteorites were found. He will summarize research results reported in a recent 70-author Science article, and also discuss a second meteorite fall that happened in Novato and Sonoma on October 17 and was recovered thanks to an ongoing all sky video surveillance of meteor showers in the Bay Area. If you are interested in having your potential Sutter's Mill or Novato meteorite validated, please bring it to the meeting.

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

April 9, Noon-1:00pm

What: Engineering the emergence of life through convection, serpentinization and the first metabolic pathway
Who: Michael J. Russell, Jet Propulsion Laboratory
Where: SETI Headquarters, 189 N. Bernardo Ave., Mountain View, CA
Cost: Free

The alkaline hydrothermal theory for the emergence of life holds that the endergonic (thermodynamically uphill) reactions vital for life's origin and continued existence require free energy converters (nano-engines) fueled by various disequilibria. The first two primary engines were i) a carbon fixation engine to generate the organic building blocks

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

Pacific Standard Time until March 10, Pacific Daylight Time thereafter.

March

- 7-10 Thu- Comet PanSTARRS (C/2011 L4) visible in binoculars, and possibly with the unaided eye. Look low in the west shortly after sunset. See p.50 of the March issue of S&T
- 10 Sun Daylight Saving Time Begins (turn clock ahead 1 hour at 2am); Neptune 6 degrees south of Moon
- 11 Mon **New Moon (12:51pm)**
- 12-18 Tue **Comet PanSTARRS (C/2011 L4) expected to be brightest this week. On the 12th it will be to the left of a thin crescent Moon**
- 17 Sun Jupiter close to crescent Moon, Aldebaran, the Hyades, and the Pleiades (Evening and Night)
- 19 Tue **First Quarter Moon (10:27am)**
- 20 Wed Spring begins (4:02am)
- 27 Wed **Full Moon (2:27am)**
- 28-29 Thu- The Moon is to the upper-right (below) Saturn on the 28th (29th)

April

- 2 Tue **Last Quarter Moon (9:37pm)**
- 6 Sat Neptune 6 degrees south of the Moon
- 10 Wed **New Moon (2:35am)**
- 13 Sat Jupiter close to crescent Moon, Aldebaran, the Hyades, and the Pleiades (Evening and Night; see p.40, April S&T)
- 14 Sun Jupiter 2 degrees north of the Moon
- 18 Thu **First Quarter Moon (5:31am)**
- 22 Mon Lyrid Meteor shower peaks before dawn (see p.50, April S&T)

of life by reaction between hydrothermal CH₄ and H₂ with the CO₂ and NO in atmosphere and ocean, ii) a proton pyrophosphatase engine exploiting the natural pH gradient between alkaline hydrothermal solution and acidulous ocean to drive biosynthesis by condensations of these same building blocks.

To this end there occurred on the early Earth and other such rocky bodies, inorganic prebiotic molecules that would have been precipitated at the interface between a submarine alkaline hydrothermal solution and the metal-bearing acidulous ocean.

Dr. Russell will show how these metals, especially iron, occurred as ready-made nano-scale sulfides and oxides with the same structures and valences as the active centers of those biotic metalloenzymes shown to be present in the Last Universal Common Ancestor of all life.

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

April 16, 7:00pm

What: Clicks, whistles and pulses: what can SETI learn from the parallel challenges of dolphin communication research?

Who: Denise Herzing, Research Director, Wild Dolphin Project

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

Cost: Free

The search for signals out of noise is a problem not only with radio signals from the sky but in the study of animal communication on Earth. Like SETI radio signal searches, dolphin sound analysis includes the detection, recognition, analysis, and interpretation of signals. Dolphins use three main types of acoustic signals and many of these sounds have been a challenge to measure and categorize due to their graded and overlapping nature. The goal of this talk is to provide perspective from dolphin communication studies and lessons learned about signal detection and recognition.

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



The Art of Space Imagery

By Diane K. Fisher

How does NASA get its ideas for new astronomy and astrophysics missions? It starts with a Decadal Survey by the National Research Council, sponsored by NASA, the National Science Foundation, and the Department of Energy. The last one, *New Worlds, New Horizons in Astronomy and Astrophysics* was completed in 2010. It defines the highest-priority research activities in the next decade for astronomy and astrophysics that will “set the nation firmly on the path to answering profound questions about the cosmos.” It defines space- and ground-based research activities in the large, midsize, and small budget categories.

The recommended activities are meant to advance three science objectives:

1. Deepening understanding of how the first stars, galaxies, and black holes formed,
2. Locating the closest habitable Earth-like planets beyond the solar system for detailed study, and
3. Using astronomical measurements to unravel the mysteries of gravity and probe fundamental physics.

For the 2012-2021 period, the highest-priority large mission recommended is the Wide-field Infrared Survey Telescope (WFIRST). It would orbit the second Lagrange point and perform wide-field imaging and slitless spectroscopic surveys of the near-infrared sky for the community. It would settle essential questions in both exoplanet and dark energy research and would advance topics ranging from galaxy evolution to the study of objects within the galaxy and within the solar system.

Naturally, NASA's strategic response to the recommendations in the decadal survey must take budget constraints and uncertainties into account.

The goal is to begin building this mission in 2017, after the launch of the James Webb Space Telescope. But this timeframe is not assured. Alternatively, a different, less ambitious mission that also address the Decadal Survey science objectives for WFIRST would remain a high priority.

The Astrophysics Division is also doing studies of moderate-sized missions, including: gravitational wave mission concepts that would advance some or all of the science objectives of the Laser Interferometer Space Antenna (LISA), but at lower cost; X-ray mission concepts to advance the science objectives of the International X-ray Observatory (IXO), but at lower cost; and mission concept studies of probe-class missions to advance the science of a planet characterization and imaging mission.

For a summary of NASA's plans for seeking answers to the big astrophysics questions and to read the complete

Astrophysics Implementation Plan (dated December 2012), see <http://science.nasa.gov/astrophysics/>. For kids, find lots of astrophysics fun facts and games on The Space Place, <http://spaceplace.nasa.gov/menu/space/>.

This article was provided by the Jet Propulsion Laboratory, California Institute of Technology, under a contract with the National Aeronautics and Space Administration.



Caption: Clusters of galaxies collide in this composite image of “Pandora’s Cluster.” Data (in red) from NASA’s Chandra X-ray Observatory show gas with temperatures of millions of degrees. Blue maps the total mass concentration (mostly dark matter) based on data from the Hubble Space Telescope (HST), the European Southern Observatory’s Very Large Telescope (VLT), and the Japanese Subaru telescope. Optical data from HST and VLT also show the constituent galaxies of the clusters. Such images begin to reveal the relationship between concentration of dark matter and the overall structure of the universe.

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.