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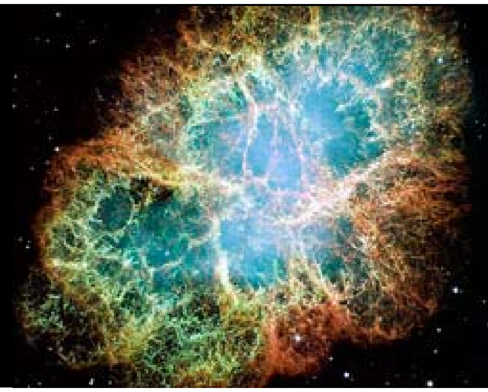
Tri-Valley Stargazers

October 2010

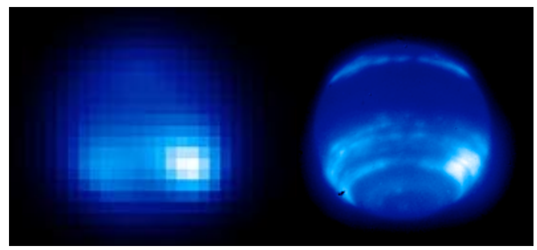


October Meeting

Improving Astronomical Image Quality: Image Post-processing and Adaptive Optics

Dr. Lisa A. Poyneer

The earth's turbulent atmosphere fundamentally limits the imaging performance of ground-based telescopes. This effect is particularly severe for large (8-meter class) telescopes operating in the visible and near-infrared, but it also can limit backyard telescopes (8-inch class). In this talk Lisa will review the fundamentals of atmospheric turbulence and how it degrades both short- and long-exposure images. She will then discuss two different approaches to improving image quality: image post-processing and adaptive optics.



Images of the planet Neptune with the Keck II telescope, without [left] and with [right] Adaptive Optics, clearly demonstrate the increase in resolution that Adaptive Optics can provide. Images courtesy of Bruce Macintosh, Lawrence Livermore National Lab, from Max et al. (2003 ApJ, 125, p364).

Post-processing of a time series of short exposure images can be very effective; some techniques are already ubiquitous in amateur astronomy. Lisa will describe the algorithms of lucky imaging and speckle imaging and discuss the benefits and drawbacks of these approaches. Real-time optical correction using the technique of adaptive optics (AO) is also very effective; most current large telescopes have AO systems. Lisa will discuss the key components of an AO system, and highlight cutting-edge research and AO-enabled science.

Though this talk will draw on research for large astronomical telescopes, the material will be presented with a slant towards what can be applied in your own backyard.

Lisa works at the Lawrence Livermore National Laboratory and is an internationally recognized expert in adaptive optics. She specializes in wavefront sensing, reconstruction and control for astronomical high-contrast imaging. She is the adaptive optics control lead on the Gemini Planet Imager (GPI) project, http://planetimager.org/ a new instrument to be commissioned in 2011 that will directly image hundreds of exoplanets around other stars.

Lisa earned the SB and M.Eng from MIT in Electrical Engineering and Computer Science. A Rhodes Scholar, she read Modern History at Oxford. She completed the Ph.D. at UC Davis concurrently with her research position at LLNL, winning the 2008 Marr Prize for the most distinguished doctoral dissertation at the university. For more information see: http://www-eng.llnl.gov/bios/bios_poyneer.html

Meeting Info:

What: Improving Astronomical Image Quality: Image Post-processing and Adaptive Optics

Who: Dr. Lisa A. Poyneer

When:
October 15, 2010
Doors open at 7:00 p.m.
Lecture at 7:30 p.m.

Where:
Unitarian Universalist Church in Livermore
1893 N. Vasco Road

Inside

News & Notes

2010-2011 TVS Meeting Dates

The following lists the TVS meeting dates for 2010-2011. 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
Oct. 15	Oct. 18	
Nov. 19	Nov. 22	Oct. 29
Dec. 17	Dec. 20	Nov. 26
Jan. 21	Jan. 24	Dec. 31
Feb. 18	Feb. 21	Feb. 01
Mar. 18	Mar. 21	Feb. 28
Apr. 15	Apr. 18	Oct. 29
May 20	May 23	Nov. 26
Jun. 17	Jun. 20	Oct. 29

Money Matters

Treasurer David Feindel indicates that as of the May 17, 2010 the TVS account balances are:

Checking	$5,130.32	
CD #1	$3,761.41	rolled over 5/17/2010
CD #2	$2,654.36	rolled over 2/27/2010

Volunteers Needed for H2O Observatory Maintenance - October 23

Volunteers are needed on Saturday, October 23 for a work/painting party at H2O. Our plan is to meet at 10:00AM at the "old Nob Hill grocery store" parking lot (at the corner of Pacific and South Livermore). We need access to a pick-up truck to transport plywood to the site that day. Paint, scraping tools, and battery powered vacuums are needed in addition to the usual painting supplies, hammers, and cordless drill/drivers. Bring lunch and beverages, as you are sure to work-up an appetite.

Please monitor the TVS website and the TVSYahoo users-group website for more details on needs and arrangements to ensure a successful outing. You can also volunteer assistance through the TVS e-mail address, which can be found on p.3.

TVS Volunteers Needed

We still need a volunteer to take on the duties of the club Secretary. We also could use more members on the Board of Directors. If you wish to help with any of these positions, please contact any officer or board member.

European Southern Observatory Image Processing Challenge

Test your image processing skills on data taken by the telescopes of the European Southern Observatory. Search their database for hidden gems, download the FITS files, and see if you can best the professionals. Submit your finished product by 30 November 2010, and you might just win a prize, and be published on the ESO website. Good Luck!!! For more information, see: http://www.eso.org/public/outreach/hiddentreasures/instructions.html

Journal Club by Ken Sperber

boom, Boom, BOOM! (Part III)

In the past two newsletters I've discussed supernovae explosions. In this column I'll discuss the formation of heavy elements and highlight some recent findings about supernovae.

Nucleosynthesis (or, and then there were rocky planets): When the first stars formed, there were no rocky planets. Why?-because only hydrogen, helium, and a bit of lithium were formed in the Big Bang. As (superficially) described in this column in the past 2 months, the elements up to and including iron are formed in stars though the process of fusion. Elements heavier than iron are formed at the end of the lives of massive stars. The processes involved in heavy element formation were elucidated in 1957 in a 104-page paper by Margaret Burbidge, Geoffrey Burbidge, Willy Fowler, and Fred Hoyle. (Willy Fowler shared the 1983 Nobel Prize in Physics with S. Chandrasekar. WF won "for his theoretical and experimental studies of the nuclear reactions of importance in the formation of the chemical elements in the universe," and SC won "for his theoretical studies of the physical processes of importance to the structure and evolution of the stars"). The r-process and the s-process are the most important pathways for heavy element formation, and they contribute nearly equally to heavy element abundances. The "r" stands for rapid, and the "s" stands for slow, referring to the time-scale of neutronization. Neutronization is the process of a nucleus capturing a neutron. The r-process is favored in supernovae, where the flux of neutrons is high (~10^{22} neutrons passing though a square centimeter in one second) while the s-process is prevalent in asymptotic giant branch stars where the flux of neutrons is at least 100 billion time smaller. The r-process operates for mere seconds as the star explodes, while the s-process can operate for thousands of years. With the addition of neutrons, the nucleus may become unstable and undergo beta-decay. Beta-decay is when a neutron in a nucleus turns into a proton by ejecting an electron. Since an element is defined by the number of

Header Image: This is an image from the HST of the Crab Nebula, M1, a supernova remnant that contains a pulsar. The pulsar, a rapidly spinning neutron star, rotates 30 time per second. The supernova explosion was recorded by Arab and Chinese astronomers in 1054AD.

protons in its nucleus, beta decay results in a nucleus with one additional proton, and thus a new element is created. In the s-process neutrons are captured infrequently compared for the time it takes for the added neutron to undergo beta decay. Thus in the s-process new elements with one additional proton are created. In the r-process, neutrons are captured more quickly than the time it takes for beta decay to occur. Thus, in the r-process multiple added neutrons may undergo beta-decay, and the new element can have 2, 3, or more protons than the original nucleus. The number of neutrons that a nucleus can capture depends on the neutron flux and the probability that a nucleus will absorb a neutron. But a nucleus cannot absorb an arbitrarily high number of neutrons since the temperatures are so high that gamma-ray induced nuclear photodisintegration can occur. In the r-process a nucleus can also fission if the nucleus is sufficiently excited. Examples of r-process created element include gold, silver, and platinum, while s-process elements include strontium, barium, and lead. For more information, see: Burbidge et al. (1957) Reviews of Modern Physics, 29, 547-650; Cowen and Thielemann (2004) Physics Today, October, 47-53; http://nobelprize.org/nobel_prizes/physics/laureates/1983/.

Type Ia Brightness vs. Progenitor Age: As discussed in this column 2 months ago, a Type Ia supernovae arises when a white dwarf star accumulates ~1.4 solar masses, thus reaching the Chandrasekar limit, and explodes. There are slight differences in the brightness of Type Ia supernovae, and empirical corrections based on brightness and how long they remain luminous make them useful as “standard candles” for measuring cosmological distance. Using a numerical model of Type Ia supernovae explosions, Krueger et al. (2010) find that Type Ia supernovae vary in brightness based on how old the progenitor star is at the time it goes supernova. Their age at time of supernova can vary based on how massive the white dwarf is initially, how long it takes the white dwarf to accumulate enough matter from its companion to reach the Chandrasekar limit, and the mass transfer rate. As a white dwarf ages, it cools, and the core becomes denser. The authors found that denser (and hence older) white dwarfs produce less Ni_{56} when they go supernova. (As you may recall the radioactive decay of Ni_{56} is what gives rise to the visible light of the explosion.) The amount of Ni_{56} produced is related to the process of neutronization. The more dense the core of the progenitor, the greater is the likelihood that a nucleus will capture multiple neutrons (the r-process). In this situation Ni_{58} (with 2 more neutrons in the nucleus than Ni_{56}) is preferentially created compared to Ni_{56}. Ni_{58} is not radioactive, and with less Ni_{56} the supernova is dimmer. For more information, see: Krueger et al. (2010) Astrophysical Journal Letters, 719, L5–L9.

Supernovae Type vs. Shape: Recall that Type Ia and pair-instability supernovae completely destroy the progenitor star, while core-collapse supernovae leave behind either a neutron star (progenitor mass ~8-40 solar masses) or a black hole (progenitor mass ~40-100 solar masses). When caught in the act of exploding, Type Ia and core-collapse supernovae can be identified by how long they remain bright. But, how can you identify what type of supernovae gave rise to existing supernova remnants for which you have no direct observations of the explosion? From studying 17 supernovae whose types were previously known, Lopez et al. (2009) have determined that the shape of a supernova remnant is a key indicator of explosion type. They found that Type Ia supernovae are more symmetrical in shape than core-collapse supernovae based on the analysis of the X-Ray emission of silicon. For example, Figure 1 shows that the core-collapse supernova

continued page 4

Journal Club (continued)

G292.0+1.8 (on the left) is dominated by many fine tendrils with lots of structure, while Kepler's Supernova (on the right) has a much smoother appearance.

For more information, see: Lopez et al. (2009) The Astrophysical Journal, 706, L106–L109.

<u>More "pop" than "boom," till now:</u> For nearly 50 years astrophysicists have been making numerical models of supernovae, with the result being that the vast majority of the models fail to produce an explosion. Rather, in most cases, the shockwave (that is generated when in-falling material bounces off of the stiffened collapsing core) stalls and a supernova does not develop. Prospects were improved when the outflow of neutrinos was considered, as this reinvigorated the shockwave helping to produce a supernova. The main concern was that there was missing physics that was not considered in the models. In modeling supernovae, there is a very broad range of spatial scales and physical scales that need to be considered, so most simulations have only considered one or two spatial dimensions. By running models in one or two dimensions one assumes symmetry in the missing spatial dimension, and it takes less computing power to produce a simulation. For example, in a two dimensional simulation the spatial domain considered would be equivalent to one-quarter of a circle drawn on a flat surface. Here there are 2 levels of symmetry assumed: (1) if you rotate the wedge about the x-axis you get half a circle, and (2) if you rotate the half-circle about the y-axis you get a sphere. Nordhaus et al. (2010) have used the same physics in 1-d, 2-d, and 3-d models, finding that the asymmetry present in the 3-dimensional model is essential for being able to generate a robust supernova explosion. The fact that the blast wave can be asymmetrical in the 3-dimensional model is crucial for the generation of the explosion. For more information, see: http://www.sciencedaily.com/releases/2010/09/100916113417.htm and Nordhaus et al. (2010) The Astrophysical Journal, 720 (1), 694. (doi: 10.1088/0004-637X/720/1/694).

Calendar of Events

October 13, 12:00 - 1:00 pm

What: A New Look at What Life is and How it Began
Who: Nick Woolf, Arizona State University
Where: New SETI Headquarters, 189 N. Bernardo Ave., Mountainview
Cost: Free

Life has two unique processes. The first is precision assembly, in which the shape of a molecule is selected, and it is "glued" to another precisely selected molecule. The second is when the assembler-glue-selector device exactly copies itself. The system requires the development of two different polymers, one for structures, the other for information transfer. It is explored why the assembler-glue-selector becomes RNA and ATP. Nitrogen provides the key NH bonds that are broken for "gluing" in both nucleic acids and amino acids. The requirements for the process, abundant availability of the nitrogenous organic materials from space, freshwater for the origin of membranes, and high temperatures and pressures for natural condensation reactions seem to uniquely select terrestrial geyser regions about 4.4 Gy ago as the site of the origin of terrestrial life.

This lunchtime talk is part of the SETI Institute Colloquium Series. For more info, visit their web site http://www.seti.org/csc/lectures, e-mail info@seti.org, or phone 650-961-6633.

October 14, 2:00-4:30 pm

What: Exoplanets Galore
Who: Dr. James E. Hansen
Where: Chabot Space & Science Center
Cost: General: $25, Members: $15, Stellar Society: Free

Come join us for a fascinating discussion and provocative presentation with renowned atmospheric physicist James E. Hansen, author of Storms of my Grandchildren: The Truth about the Coming Climate Catastrophe and our Last Chance to Save Humanity.

The Chabot Space and Science Center is located at 10000 Skyline Blvd, Oakland. For more info, visit their web site http://www.chabotspace.org/events.htm or call (510) 336-7373.

October 20, 12:00 - 1:00 pm

What: Dark Matter: The Other Universe
Who: Chung-Pei Ma, UCB
Where: New SETI Headquarters, 189 N. Bernardo Ave., Mountainview
Cost: Free

A startling discovery in science in the past few decades is most mass in the universe is in "dark matter" -- some very clever form of matter capable of speeding up the motion of stars and galaxies while eluding direct detection at the same time. Dr. Ma will summarize the evidence for the existence of dark matter, discuss what it can and cannot be, and describe ongoing research on this mysterious component of the universe.

This lunchtime talk is part of the SETI Institute Colloquium Series. For more info, visit their web site http://www.seti.org/csc/lectures, e-mail info@seti.org, or phone 650-961-6633.

October 27, 12:00 - 1:00 pm

What: New Search Strategies for SETI
Who: Seth Shostak, SETI Institute

Where: New SETI Headquarters, 189 N. Bernardo Ave., Mountainview
Cost: Free

SETI continues to embroider the search strategy pioneered by Frank Drake, a half-century ago. Although the technology of the search has enormously improved, are we being too conservative in our choice of targets? In this talk, we'll consider some of the other places we might look for ET.

This lunchtime talk is part of the SETI Institute Colloquium Series. For more info, visit their web site http://www.seti.org/csc/lectures, e-mail info@seti.org, or phone 650-961-6633.

November 1, 7:30 pm

What: Determining the Age of the Universe
Who: George V. Coyne, S.J., Vatican Observatory
Where: California Academy of Science, 55 Music Concourse Dr., Golden Gate Park, San Francisco, CA
Cost: Adults $12, Seniors $10, Academy members $6. Reserve a Space Online or call 800-794-7576

Assuming that the Universe originated in a Big Bang, one can imagine various ways in which we could measure the time elapsed since the Big Bang occurred. Rev. Coyne will describe a number of approaches and techniques for measuring the Universe's age, and explain which ones are doable and which technique is a proven one.

For more information please see: http://www.calacademy.org/events/lectures/

November 3, 12:00 - 1:00 pm

What: Computer simulations of convection and magnetic field generation in planets
Who: Gary Glatzmeier, UCSC
Where: New SETI Headquarters, 189 N. Bernardo Ave., Mountainview
Cost: Free

Dr. Glatzmeier will describe his studies of fluid flows and the magnetic fields they generate in the electrically conducting interiors of terrestrial planets, like the Earth, of giant planets, like Jupiter, and of satellites, like Europa, that orbit around giant planets. Dr. Glatzmeier develops computer models that solve a set of coupled nonlinear differential equations that describe the main physics of the problem in order to simulate the 3D time-dependent evolution of the flows and fields. He will show computer graphical movies of several simulations and discuss what we learn from them.

This lunchtime talk is part of the SETI Institute Colloquium Series. For more info, visit their web site http://www.seti.org/csc/lectures, e-mail info@seti.org, or phone 650-961-6633.

November 10, 12:00 - 1:00 pm

What: Statistical Equation for Habitable (SEH) and the Statistical Fermi Paradox
Who: Claudio Maccone, IAA
Where: New SETI Headquarters, 189 N. Bernardo Ave., Mountainview
Cost: Free

In this lecture Dr. Maccone will provide a statistical equation that we call Statistical Equation for Habitables (SEH) as well as its relationship to the Statistical Fermi Paradox. He will start by noting that the statistics of habitable planets may be based on a set of ten (and possibly more) astrobiological requirements first pointed out by Stephen H. Dole in his book "Habitable planets for man" (1964). He will then provide the statistical generalization of the original (too simplistic) Dole equation by replacing a product of ten positive numbers by the product of ten positive random variables. This is called the "Statistical Equation for Habitables" or SEH. His proof is based on the Central Limit Theorem (CLT) of Statistics, stating that the sum of any number of independent random variables, each of which may be arbitrarily distributed, approaches a Gaussian (i.e. normal) random variable (Lyapunov form of the CLT). Dr. Maccone will then discuss the implications of this derivation, including a practical example of how the equation can be used to find the average distance between Habitables. Finally, this result will in turn be used to discover the statistical extension of the Fermi Paradox, namely the Fermi paradox re-read in terms of probability distributions.

This lunchtime talk is part of the SETI Institute Colloquium Series. For more info, visit their web site http://www.seti.org/csc/lectures, e-mail info@seti.org, or phone 650-961-6633.

November 11, 7:00 - 8:30 pm

What: Extreme Environments on Earth & Search for Life in the Universe
Who: Lynn Rothschild, Ph.D., NASA Ames Research Center
Where: Smithwick Theatre, Foothill College, 12345 El Monte Road, Los Altos Hills, CA 94022
Cost: Admission: Free; Parking: $2

Dr. Rothschild has gone from the Bolivian Andes to the Rift Valley of Kenya searching for the hardiest of organisms in the most extreme environments for life. By getting to know life forms on Earth that can occupy the most hostile niches, we can begin to understand the survival requirements for life in general. She will describe her quest for "life at the edge" and how such discoveries shape our search for life in the Solar System and beyond.

An astrobiologist, she specializes in evolutionary microbiology and the use of molecular and cellular techniques to understand DNA damage and photosynthesis in nature. As a consulting professor at Stanford University, she teaches the popular Astrobiology & Space Exploration course.

For more information see http://www.foothill.edu/news/newsfmt.php?words=astronomy or call (650) 949-7888.

November 17, 12:00 - 1:00 pm

What: Status of the James Webb Telescope and its Capabilities for Exoplanet Science
Who: Mark Clampin, Goddard
Where: New SETI Headquarters, 189 N. Bernardo Ave., Mountainview
Cost: Free

No abstract available for this talk.

This lunchtime talk is part of the SETI Institute Colloquium Series. For more info, visit their web site http://www.seti.org/csc/lectures, e-mail info@seti.org, or phone 650-961-6633.

What's Up by Ken Sperber (adapted from Sky and Telescope)

All times Pacific Daylight (Standard after November 7) unless otherwise noted.

October

10-11	Sun-	The moon is to the lower-right (upper-left) of Antares on the 10th (11th)
14	Thu	First-Quarter Moon (2:27pm)
22	Fri	Full Moon (6:37pm)
23	Sat	Algol, an eclipsing binary, is at minimum brightness, magnitude 3.4 for ~2 hours centered at 9:10pm
23	Sat	Europa and Ganymede shadow transits of Jupiter from 6:40pm to 8:04pm
25	Mon	The Pleiades are within 2 degrees of the Moon
26	Tue	Algol, an eclipsing binary, is at minimum brightness, magnitude 3.4 for ~2 hours centered at 8:58pm
30	Sat	Last-Quarter Moon (5:46am)
30	Sat	Europa and Ganymede shadow transits of Jupiter from 9:16pm to 11:59pm

November

1-18	Mon-	Taurid Meteor Shower
6	Sat	New Moon (9:52am)
7	Sun	End of daylight savings time (2:00am)
12	Fri	Algol, an eclipsing binary, is at minimum brightness, magnitude 3.4 for ~2 hours centered at 9:52pm
13	Sat	First-Quarter Moon (8:39am)
15	Mon	Algol, an eclipsing binary, is at minimum brightness, magnitude 3.4 for ~2 hours centered at 9:41pm
17-18	Wed	Leonid Meteor Shower best viewed after moonset (3-4am through predawn)
21	Sun	Full Moon (9:27am)

Image and Caption: Hilary Jones. This is a picture of NGC 6946. I first became interested in this target when I (accidentally) photographed the supernova SN2000et on 10/03/04, just a few days after it was first reported on 09/27/04. It is also known as the Fireworks galaxy because it has had nine supernovae in the last 60 years. This makes it the most active known galaxy, with the runners up (M61 and M83) having had only six supernovae each. For comparison, the Milky Way has only had four supernovae in the last 1000 years. The picture shows many star forming regions (the red areas); so there are many young stars that are prone to becoming supernovae.

It is not known why the galaxy is so active. There are no galaxies in the neighborhood which are large enough to have disrupted it, and no signs of tidal tails. One theory is that the galaxy passed thru a region of primordial low-mass neutral hydrogen gas clouds, which triggered star formation.

The galaxy is about 10 million light years away, and it was once considered to be part of the Local Group. It is smaller than the Milky Way, having about half as many stars. The galaxy is very close to the plane of the Milky Way, so it is highly obscured by dust. This causes the image to have a somewhat muddy appearance. Many of the stars in the image are foreground stars located in the Milky Way.

The pictures for this image were taken on three nights in early September. The image was constructed using 305 minutes of luminosity data and 30 minutes each of red, green and blue data, all done using an exposure time of 5 minutes per frame. In addition, the image contains 240 minutes of hydrogen alpha data using an exposure time of 20 minutes per frame. So the total exposure time was about ten and a half hours. To make the final image, I combined the hydrogen alpha data with the red data in equal weights to create a "pseudo-red" image, which I then combined with the other data to create an LRGB image. To enhance the image, I used a number of tricks that are described in Adam Block's Photoshop tutorial.

The Hunt is On!

by Carolyn Brinkworth

The world of astronomy was given new direction on August 13, 2010, with the publication of the Astro2010 Decadal Survey. Astro2010 is the latest in a series of surveys produced every 10 years by the National Research Council (NRC) of the National Academy of Sciences. This council is a team of senior astronomers who recommend priorities for the most important topics and missions for the next decade.

Up near the top of their list this decade is the search for Earth-like planets around other stars—called "extrasolar planets" or "exoplanets" —which has become one of the hottest topics in astronomy.

The first planet to be found orbiting a star like our Sun was discovered in 1995. The planet, called "51 Peg b," is a "Hot Jupiter." It is about 160 times the mass of Earth and orbits so close to its parent star that its gaseous "surface" is seared by its blazing sun. With no solid surface, and temperatures of about 1000 degrees Celsius (1700 Fahrenheit), there was no chance of finding life on this distant world. Since that discovery, astronomers have been on the hunt for smaller and more Earth-like planets, and today we know of around 470 extrasolar planets, ranging from about 4 times to 8000 times the mass of Earth.

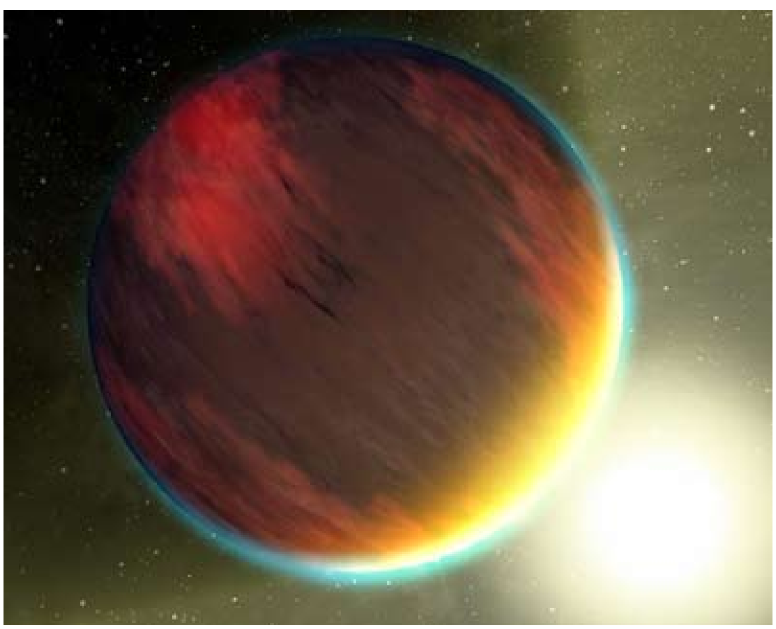
This explosion in extrasolar planet discoveries is only set to get bigger, with a NASA mission called Kepler that was launched last year. After staring at a single small patch of sky for 43 days, Kepler has detected the definite signatures of seven new exoplanets, plus 706 "planetary candidates" that are unconfirmed and in need of further investigation. Kepler is likely to revolutionize our understanding of Earth's place in the Universe.

We don't yet have the technology to search for life on exoplanets. However, the infrared Spitzer Space Telescope has detected molecules that are the basic building blocks of life in two exoplanet atmospheres. Most extrasolar planets appear unsuitable for supporting life, but at least two lie within the "habitable zone" of their stars, where conditions are theoretically right for life to gain a foothold.

We are still a long way from detecting life on other worlds, but in the last 20 years, the number of known planets in our Universe has gone from the 8 in our own Solar System to almost 500. It's clear to everyone, including the Astro2010 decadal survey team, that the hunt for exoplanets is only just beginning, and the search for life is finally underway in earnest.

Explore Spitzer's latest findings at http://www.spitzer.caltech.edu. Kids can dream about finding other Earths as they read "Lucy's Planet Hunt" at http://spaceplace.nasa.gov/en/kids/storybooks/#lucy.

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



Artist's rendering of hot gas planet HD209458b. Both the Hubble and Spitzer Space Telescopes have detected carbon dioxide, methane, and water vapor—in other words, the basic chemistry for life—in the atmosphere of this planet, although since it is a hot ball of gas, it would be unlikely to harbor life.

Tri-Valley Stargazers
P.O. Box 2476
Livermore, CA 94551

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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.