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## Laboratory Astrophysics: An Oxymoron No More
**BRUCE PARTRIDGE**

Laboratory astrophysics, the branch of astronomy that attempts to replicate astronomical processes in the laboratory, has taken a new path. Now astronomy offers extremes of physical conditions unavailable in Earthly laboratories.

## 400 Years of Astronomical Discovery
**LYNNE HILLENBRAND**

We've come a long way in 400 years! But from Galileo to today, and on into the foreseeable future, it's clear that advancement in astronomy is driven by the interaction between technology, observation, and interpretation.

## Astronomy in the News

Another meteorite found on Mars, a new ring for Saturn, and a celestial Rosetta stone — these are some of the discoveries that have recently made news in the astronomical community.
How Do You Read Your Mercury?

This issue marks the conclusion of the second year of Mercury as a PDF magazine. How do you like it so far?

My question isn't flippant. The age of digital media is well and truly upon us. Your Society (and every other publisher) is grappling with questions regarding the future of publishing at a time when the demand for digital content is rising even as requirements for hardcopy content are declining. In the case of the ASP, Mercury is small potatoes compared to our Publications of the ASP and the ASP Conference Series. Nonetheless, the digital question is one I ponder on a regular basis.

Moving Mercury to its current state was only a first step. More change is coming; the only question is when and how.

In its current portrait (vertical) format, Mercury isn't particularly reader-friendly when viewed on a computer screen. We try to adhere to Alan Gould's Combined Online and Hardcopy Design style (see his article on page 20 of the Summer 2009 issue), a layout style that minimizes the amount of up-and-down scrolling required to read articles on a monitor. But frankly, Mercury's current format is a holdover from its days as a print magazine.

One step I'm contemplating is going horizontal and turning Mercury into a (PDF) magazine with a landscape layout (each page wider than it is tall). Such a design makes the pages much easier to read on a computer screen, but a hard-copy printout won't look quite as nice as it does now.

But that's an intermediate phase. The ultimate step is to move away from a PDF-based magazine to an HTML one. (HTML is the language/code used to create web pages.) This doesn't mean Mercury would resemble a website — it'll have a substantially different look and feel. And, like a PDF or print magazine, it would be paginated and laid out. One excellent example of what Mercury might become is explorations from the Scripps Institution of Oceanography. It's designed as an on-screen magazine, but several sections are available as PDFs for easy printing.

But before doing anything, I'd really like to know: How do you read Mercury?

A) I print most or all of the issue and read the paper copy.

B) I read some/most of it on screen and print only the pages/articles of interest.

C) I read most or all of the issue on my monitor and rarely print anything.

Drop me a line at my e-mail address below (put “Reading Mercury” in the subject line), and let me know. Please do it soon; your feedback is important. Thank you.

Paul Deans
Editor, Mercury (editor@astrosociety.org)
Following Your “Bliss” in the IYA

My bliss led me to a sweltering late-July day in eastern China.

So — did you “follow your bliss” in 2009?

It was American mythologist and writer Joseph Campbell who coined that phrase to encapsulate the notion of identifying your passion in life and pursuing it. Assuming that astronomy may be one of your passions, as it is mine, have you pursued it in this International Year of Astronomy?

I was fortunate to follow mine to China this past summer as a lecturer on the MWT Tours trip to observe what was the longest total solar eclipse scheduled this century, young as the century may be. (Check out our ASP website for other astronomically laced tours that the ASP co-sponsors with MWT.) Despite iffy weather along parts of the track, eclipse day (July 22) found our river-cruising Victoria Prince anchored at Yichang on the Yangtze, downriver from the Three Gorges Dam — on a sweltering sauna of a morning with the sky nonetheless promising.

First contact, when the Moon took its first nibble of the Sun, was veiled behind a cloud, but the cloud moved east and left a heated haze, but otherwise clear, sky. As our group sweated and squinted behind our neutral-density filters, with some of us aboard ship and others assembled with the local populace at a park on shore, the dragon grabbed hold and slowly swallowed the solar orb. As the Moon slid into place, a final brilliant bead of sunlight flared and faded, the shadow descended, and the corona of the Sun blossomed into view.

We were far from the spot in the Pacific Ocean where totality was longest, but for five glorious minutes and a little more, we sat in the shadow of the Moon, eyes glued to the spectacle above and around — the darkness tinged by a saffron glow ringing the horizon, Venus and other celestial pinpoints visible at midday. There was a hole in the sky fringed by the elongated white gauze of a solar minimum corona, and sharp eyes even spotted two hot-pink prominences around the rim.

And then the laser-bead of the third-contact “diamond ring” blazed, the shadow fled, sunlight returned, and the dragon began to give up its prize.

The day was hot, the crowd was sodden, and most fled back into the bowels of the cool ship to exchange impressions and view the immediate digital-camera pictures of the event. A few of us endured the annoyed Sun, returning with a vengeance, to view the retreating partial phases and watch for the moment the last tiny notch on the limb of the Sun disappeared to officially bring the eclipse to an end. Then everyone else retreated below as well, but I lingered in the heat, slowly packing up, contemplating the experience, enjoying my moment of bliss.

It seemed appropriate this special year for astronomy to be celebrating the Sun, for it was one of the objects of Galileo’s telescopic desire (though later than 1609, it seems). Despite the two prominences seen, the Sun was spotless this day, as it has been for many a day during the past two years in an extended solar minimum. (This has promulgated cries of “What’s wrong with the Sun?” when what’s wrong is that we didn’t know it as well as we thought we did. For more on this topic, see Jennifer Birriel’s column on page 7.)
But it wasn't spotless when Galileo observed it almost 400 years ago, and as he watched and sketched from day to day as the dark blemishes moved across the face of the Sun, he concluded it was the Sun that was doing the moving, turning on its axis.

Apparently Galileo wasn't the first to either observe or conclude this — the father-son team of David and Johannes Fabricius appears to have beaten both Galileo and Christoph Scheiner to the punch on this one, with an earlier publication than either (though Galileo and Scheiner engaged in a long-time feud over priority of observation). But that matters less than the fact that all of them were definitely following their bliss in using the new tools at their disposal to better observe and understand the mysterious sky over their heads.

That's not a bad goal for us, either, in this special year — the International Year of Astronomy.

Are you following your bliss? Have you taken your scope out to view the stars, and have you shared it with others? Jupiter, the planet that surprised Galileo with four satellites during that golden Italian autumn of 400 years ago, shines right now high on the crisp nights of fall. Are you looking? Are you sharing your passion?

The Astronomical Society of the Pacific has been sharing the passion, the discoveries, and the tools and methods for helping people to understand them for a remarkable portion of the time since Galileo's first observations. This year, your Society celebrates 120 years of spreading the word and supporting the effort. Throughout that period, the organization has depended on the support of its members to keep it vital, to keep it moving forward, and to help in the good work that we today define as advancing science literacy through astronomy.

As ASP members, you are part of a long line of scientists, educators, amateur astronomers, and astronomy enthusiasts who have been instrumental in the Society's success. We appreciate your support, and count on it as we begin the next 120 years of passionately serving the causes in which we all believe.

The year isn't over yet. There's still time to follow your bliss. Jupiter's waiting, as are all of the other autumn glories of the sky. Get out under it, bring as many people as you can, and share the sky you love. It's important — this year and in all the years that follow.

JAMES G. MANNING (jmanning@astrosociety.org) is the Executive Director of the Astronomical Society of the Pacific.
The Sun has been getting a lot of media coverage these days. It all started with the “unexpected” delay in the onset of Solar Cycle 24 and a dearth of sunspots. Public interest in the lack of solar activity led to headlines proclaiming some variant on a “something is wrong with the Sun” theme. Worried headlines even prompted a NASA news feature on July 11, 2008, in which NASA solar physicist David Hathaway reassured the public that the Sun is actually behaving quite normally.

The widely known 11-year sunspot or Schwabe cycle, first discovered in 1843 by the German astronomer Samuel Heinrich Schwabe and latter refined in 1848, belies the complexity of solar activity. In reality, the 11-year solar cycle so often quoted in textbooks and lay literature is actually an average that typically varies between 10 and 12 years. In addition, Edward Maunder’s 1904 plot of sunspot latitude with time, the so-called butterfly diagram, revealed that successive cycles actually overlap between one and two years.

Even a fairly cursory examination of the historical sunspot record reveals that the solar cycle varies in period, amplitude, and shape. In point of fact, since Galileo’s first recorded observations of sunspots in 1610, the sunspot cycle has varied from as short as eight years to as long as 17 years! Also evident is the 88-year Gleissberg cycle, an amplitude modulation of the Schwabe cycle.

A team of Pennsylvania State University scientists recently re-examined archival sunspot data spanning nearly 400 years. The team used data available from the National Geophysical Data Center and a NASA compilation of data from both Greenwich Observatory and United States Air Force Solar Optical Observing Network (Swoon). Michael Rogers, Mercedes Richards, and Donald Richards examined sunspot numbers from 1700 to 2005, sunspot areas (the total surface area of the solar disk covered by sunspots at a given time) dating from 1874 to 2005, and the measured length of the sunspot cycle.

Rogers, Richards, and Richards determined the length of the sunspot cycle using time-series analysis of daily, monthly, and yearly data for both sunspot numbers and sunspot areas. They used two different analysis techniques (specifically power spectrum analysis and phase dispersion minimization) to identify periodicities. Both techniques produced very similar results — the average Schwabe cycle from both sunspot number and sunspot area is 10.8 years, give or take a half year. Much more interesting, though, was the suggested presence of a much longer-term periodicity of 90 to 260 years.

The team next examined solar-cycle lengths determined individually from the dates of successive solar minima and the dates of successive solar maxima. They used data from 1610 to 2005 and performed a median trace analysis of the length of the solar cycle derived from both minima and maxima. The median trace analysis technique is designed to identify hidden trends and patterns in data regardless of how the data were obtained. This analysis revealed a long-term variability in the length solar cycle with a period of some 183 to 243 years.

Given the uncertainties in determining the exact times of sunspot minima and maxima, the median trace analysis only provides a rough estimate of the variation in cycle length. To refine their results, the group did a power spectrum analysis of the residuals (i.e. the difference) between the cycle lengths as determined by just the minima, just the maxima, and the combined minima and maxima. This analysis yielded results that were consistent regardless of the method used to define solar-cycle length. It revealed a periodic variation in the length of the solar cycle of 188 years, give or take 38 or so. This analysis also confirmed the Gleissberg cycle (87 plus or minus 13 years).

Rogers, Richards, and Richards note an interesting correspondence between their findings and the historical record. Specifically, all four of the historic minima in sunspot numbers (i.e. the Wolf, Spörer, Maunder, and Dalton minima) correspond to periods in which the length of the solar cycle increased. They conclude that the length of the sunspot number cycle will gradually increase during the next 75 years and should be accompanied by a corresponding decrease in the overall number of sunspots observed in the same time interval. If this prediction holds, the ensuing decrease in global temperatures that seems to accompany such a minimum will only complicate discussions of global-warming issues.

Astrophysicist Jennifer Birriel resides in the Department of Mathematics, Computer Science, and Physics at Morehead State University and has more confidence in solar forecasts than financial ones.
I've written a Mercury column about the planet Mercury (Sept./Oct. 2004). I figure it's about time I wrote a Mercury column about columns!

Actually, I've wanted to highlight this discovery since I first saw a poster presentation on the topic at the annual Lunar and Planetary Science Conference in Houston, Texas, in March 2009. I was strolling through the crowded convention hall during the Thursday evening poster session, browsing the smorgasbord of yummy planetary geology, when a Mars Reconnaissance Orbiter HiRise (High Resolution Imaging Science Experiment) panorama caught my eye.

The exquisitely detailed image on the poster showed the arc-ing rim of an unnamed, 16-kilometer-diameter crater in Marte Vallis. It didn't take many seconds before I realized that the cliff-like crater walls exposed unmistakable signs of columnar jointing. Clear, lovely examples of basalt columns (presumably basalt — the crater is found in an area that displays a history of volcanic activity) along nearly the entire circumference of the crater rim. It was beautiful!

Columnar jointing is a common feature in volcanic rocks and many examples are found all over Earth, some in places that have become well-known natural wonders. The stepping-stone-like tops of the basalt prisms that comprise the Devil's (or Giant's) Causeway in Ireland led from cliff to sea and are probably one of the world's most famous examples of the phenomenon. Devil's Tower, the iconic landmark setting for the end of Close Encounters of the Third Kind, rises more than 1,200 feet above the surrounding Wyoming countryside and climbers routinely ascend the columns that comprise its sheer sides.

Columns like these form when fresh flows of lava or layers of other hot volcanic rock rapidly cool. As the rock cools, it contracts. This shrinkage causes tension in the layer, which is relieved by cracks that propagate through the mass and split it into a multitude of vertical slabs. Many of the slabs have a hexagonal cross section, because that's the most efficient polygonal pattern for stress relief during the contraction, but columns with as few as four and as many as seven sides are commonly seen as well. It's similar to the process that forms honeycomb-like mud cracks in a desiccating puddle of water.

I was so captivated by the clarity of the MRO HiRise images and the fact that I was looking at unequivocal evidence of columns on Mars, that it took a full minute to come out of the world in the poster and realize that its author was Moses Milazzo, a colleague from my days at the University of Arizona. Moses noted that it was Alfred McEwen, the HiRise PI, who first recognized the columns in the MRO imagery when the data hit the ground in late October 2007.

Now I knew the basic story that columnar jointing arises by the cooling of lava flows, but as I discussed these lovely Martian examples with Moses, I rapidly realized that I had never fully internalized a key mechanism responsible for this rapid cooling. While it is impossible to say that every example of columnar jointing on Earth is formed by water cooling, we don't know of any that can be shown to have formed without it. It's the rapid inundation of lots of cooling water flowing through hot cracks in a new lava flow that causes the rapid contraction and leads to the regular jointing that forms columns. In fact, the flow of large quantities of water greatly accelerates the cooling rate of the interior of the lava flow beyond that due to conduction within the rock alone.

In a moment of revelation I realized the true significance of these Martian columns. Billions of years ago, before a small asteroid impacted the red planet and punched a hole in its volcanic surface, a lava flow was cooled and fractured by flowing water. A lot of flowing water! Using what we know of the formation of columnar joints in terrestrial lava flows, Moses and his colleagues calculate that to quench the more than 200 square kilometers of lava flow, and to form the multiple tiers of columns exposed in the wall of this crater, liquid water may have flooded the area in multiple episodes with cycles lasting from months to years.

I find it a bit ironic that we can use features in rocks formed of fire to show evidence of substantial liquid water on a neighboring world. NASA's Martian exploration strategy of "follow the water" has received an unexpected boost by following the columns. 

Daniel D. Durda is a Principal Scientist in the Department of Space Studies at the Southwest Research Institute in Boulder, Colorado.
Ever since the 1930s and the days of Edwin Hubble, galaxies have been classified according to their shape and appearance: spirals (such as the Milky Way and Andromeda galaxies), barred spirals, ellipticals, and irregular galaxies (such as the two Magellanic Clouds). Hubble’s famous “tuning fork” diagram further subdivides these categories. But astronomers have also developed other schemes, based on other criteria, for classifying galaxies. One of these was presented about 50 years ago, by William Wilson Morgan of the Yerkes Observatory, in the Publications of the ASP for August 1958 and October 1959. Parts of this system are still in use today.

In his 1958 paper, Morgan noted that: “A recent investigation has called attention to a rather close correlation between the forms of certain galaxies and their stellar content as estimated from composite spectra.” He then proposed a classification that would take this into account, “to devise a form classification that shall be as closely correlated as possible with the stellar population of the inner, brighter parts of galaxies; the new classification is to be based on the results of the interpretation of composite spectra.” Morgan’s fundamental criterion was “central concentration of luminosity.” Irregular galaxies, and spirals without any central concentration of light, were denoted by population group ‘a.’ The notation was determined by the fact that in these galaxies, most of the light comes from blue, spectral class B, A, and F stars. “At the opposite end of the fundamental sequence lie the giant ellipticals and spirals of most extreme central concentration of light; these are denoted by population group ‘k’; here the spectra indicate that, on the average, the principal contribution to the luminosity...comes from giant K stars.” Other groups then fell between these extremes — ‘af,’ ‘f,’ ‘fg,’ ‘g,’ and ‘gk.’ Morgan emphasized that the designation was determined entirely from the form of the galaxy and not by looking at the spectrum.

A second parameter was then added, for the “form family.” These included Hubble’s four classes: S for spirals, B for barred spirals, E for ellipticals, and I for irregulars. But four others were added: Ep for ellipticals with well-marked dust, D for systems “showing rotational symmetry without pronounced spiral or elliptical structure,” L for systems of low surface brightness, and N for galaxies with small, very bright nuclei. Then an “inclination class” was also defined, to indicate the approximate degree of tilt for flattened systems. For this Morgan used the numbers 1 through 7, similar to what Hubble had done for elliptical galaxies. Thus for example, the Andromeda galaxy became kS5, whereas its Hubble class was Sb.

In his second paper a year later, Morgan made some refinements to this system of classification, and noted that further modifications would likely be made in the future. His justification for proposing such a scheme “lies in the fact that the new classification does effect an approximate separation of galaxies according to their stellar populations... The final decision [on whether to reclassify galaxies in this way] will depend on how useful the new classification proves to be in the future.”

A few aspects of this scheme are still used today, particularly the N designation for small bright nuclei — these galaxies often have highly active nuclei. A modification several years later defined cD galaxies, which have a core like an elliptical galaxy with a very large diffuse cloud of stars around it. They are often found in the centers of clusters of galaxies, where they are the largest members of the cluster, and they may have formed by galaxies colliding and merging together.

W. W. Morgan (1906-94), together with Philip C. Keenan, developed the two-dimensional mK system of classifying the spectra of stars into temperature and luminosity classes. He also was one of the first to trace the spiral arms of the Milky Way galaxy. Morgan’s entire career was spent at the University of Chicago’s Yerkes Observatory; he was awarded the ASP’s Bruce Medal in 1958.

KATHERINE BRACHER (bracher@whitman.edu) taught astronomy at Whitman College in Walla Walla, WA, for 31 years. Retired in 1998, she currently lives in Austin, Texas. Her research focuses on eclipses and the astronomy of the ancient world; her other principal interest is early music.
Was Galileo Really First?

We celebrate Galileo during this IYA, perhaps because he was the first to publish.

This is the International Year of Astronomy, during which we celebrate the 400th anniversary of the telescope. In the popular imagination, credit for this momentous invention usually goes to Galileo Galilei. But was he really the first to use a telescope for astronomical observations?

The short answer is no. He neither invented the telescope, nor was the first to point it to the sky to see celestial objects. However, the oldest existing telescope can be traced directly to Galileo, and anyone fortunate enough to have visited the Franklin Science Center in Philadelphia this summer may have seen it on display. This is the first time Galileo's telescope has ever been allowed outside of its home in Florence, Italy.

It has been well established that the telescope was invented in the Netherlands. The actual patent application by Hans Lipperhey still exists, dated October 2, 1608. But the first verifiable telescope was built by Lipperhey before that and presented to Prince Maurice of Nassau, the leader of the United Provinces in the northern Netherlands.

In late September 1608, Maurice tested the new invention by peering out from the tower of his residence on the grounds of the Binnenhof in The Hague, a 13th-century building that still stands. Immediately grasping its significance for warfare, Maurice sent the telescope to his ministers of state with the message that with its help, “they would see the tricks of the enemy.” Thus did this crude instrument, which magnified about three times, make its debut on the world stage.

Unfortunately for Lipperhey, others claimed to have invented the telescope. Just 15 days after the patent application, Jacob Metius of Alkmaar arrived in The Hague carrying his own telescope! It is not easy to dismiss Metius — his brother was a professor of astronomy who had studied with Tycho Brahe, and Metius claimed to have spent two years making it. With the telescope now common knowledge, Lipperhey’s patent application was denied, and the government awarded money to both Metius and Lipperhey.

We know that by October 1608, some people had turned the telescope to the skies. Thanks to a foreign ambassador in The Hague, we have the first report of its astronomical use: “Even the stars, which ordinarily are invisible to our sight and our eyes, because of their smallness and the weakness of our sight, can be seen by means of this instrument.”

The first serious use of the telescope for astronomy occurred in England the following year. On July 26, 1609, Thomas Harriot made the first sketch of the lunar surface. Even though Galileo later claimed that he initially heard about the telescope in May 1609, modern scholarship indicates he became aware of it by November 1608. He and his friend Paolo Sarpi tried to glean information about it from Paris, where reports of the new invention were already widely known. Indeed, by April 1609, foot-long telescopes were on sale in at least one shop in Paris!

The first mention of the telescope in Galileo’s letters is from late August 1609. The device he famously offered to the Doge of Venice that August magnified eight times, but three months later he had improved it to a magnification of 20. It is with this instrument that he made his lunar observations between November 30 and December 17, 1609, and on January 7, 1610, he discovered the four moons around Jupiter. He rushed these observations into print and by March 13, 1610, had in his hands the book that would launch modern astronomy — The Starry Messenger. It is important to note that Galileo never claimed to have invented the telescope, and if Harriot had published his observations quickly, a major portion of the acclaim now heaped on Galileo would have been his.

We also know that experimentation with lenses was ongoing before this time. The Englishman Thomas Digges, who corresponded with Tycho, wrote around 1570 about “proportional glasses duly situate in convenient angles, not only discovered things far off, but also seven miles away declared what hath been done at that instant in private places.” Since the ability to see clearly so far was not even possible 150 years later, most modern historians have dismissed his claims as fantasy, though he may have built something like a reflecting telescope.

The early study of optics and the development of the telescope have filled entire books. For those interested in learning more, essential reading includes Stargazer by Fred Watson (2004) and Galileo’s Glassworks by Eileen Reeves (2008).
Learning Styles in Astro 101

Should we redevelop our courses to accommodate learning styles?

Not too many years ago, a young girl and her mother were sent to a psychologist because the teachers in the school where the girl was enrolled were tired of her interruptions. She could not sit still (in their minds, “would not” instead of “could not”) and was frequently getting up to spin round and round the room. Needless to say, normal disciplinary measures had little affect on her, and going to the psychologist was the last effort of the school system before expelling the girl.

The psychologist discretely watched the girl for a brief time while interviewing the mother and then took the mother out of his office. He instructed the mother to watch her daughter through a one-way mirror. After a short time, the girl got up and started to sway and spin, causing the mother to sigh hopelessly. The psychologist announced to the mother, “There's nothing wrong with your daughter: she's a dancer.”

The psychologist realized that movement and rhythms were a preferred way for the girl to engage the world around her. Soon after, the girl was enrolled in a dance school, where she excelled. Today, this supposed “failure” of the school system is a successful Broadway choreographer and leads a dance troupe. Modern educators would label her as a kinesthetic learner.

Howard Gardner's model of multiple intelligences claims there are eight intelligences: interpersonal, intrapersonal, kinesthetic, logical (mathematical), musical, natural, spatial, and verbal (linguistic). Most people have all of these aptitudes, but in each of us, some are stronger than others. Gardner's idea of intelligences overlaps with the ideas of learning styles. Learning styles do not describe abilities but rather preferred ways of engaging materials.

David Kolb (Case Western Reserve University) developed his model of learning styles around the ideas of abstraction, reflection, conceptualization, experimentation, and observation. Peter Honey and Alan Mumford popularized this approach in the business world by a simpler schema that described learning styles as Activist, Reflector, Theorist, and Pragmatist. In a different model, Neil Fleming (Lincoln University, New Zealand) characterized learning styles as visual, auditory, writing/reading, and kinesthetic (tactile).

Whether differences in these models are substantial, or even whether such models are scientifically robust, researchers agree that students learn in different ways. Consequently, teachers should have learning models in mind when developing the mechanisms by which students will engage new material. Returning to our dancer above: Would she have excelled as well in the academic setting as she did in dance school if her teachers had paid attention to her differences in learning style? What happens to the intelligent student whose learning style hasn't been understood? These are questions we should ask when we have a student who just doesn't seem to get it.

My conundrum with learning styles is two-fold. How can I possibly tailor my Astro 101 class, containing 140 students, to the myriad learning styles and dominant intelligences in the room? Is it reasonable to expect instructors in large classes to engage students at that level of personalized instruction? If I can produce several different methodologies by which students can engage the material, how many is enough? Two? Three?

But of greater importance, I ask: Do I do my students a favor by letting them learn in their preferred style rather than forcing them to expand the range of learning styles they can employ? Isn't the idea of general education to develop breadth-of-thinking skills, not breadth of factual knowledge?

Do I penalize my students by allowing them to present, for example, a portfolio of artwork representing astronomical concepts in place of taking mid-term exams? If the student's goal is to become a commercial artist or a graphic designer, wouldn't portfolio production better serve their learning and career needs? But if that's my approach, do I consequently prevent them from developing other skills they may need in the corporate world by "letting them off the hook?" The power of Ed Prather and Tim Slater's "Lecture Tutorials" (developed by the Cognition in Astronomy, Physics and Earth sciences Research [CAPER] Team) to increase learning by engaging the different strengths of each student in the collaborative group, clearly demonstrates the need for instructors to pay attention to the learning styles of our Astro 101 students.

My answer to my dilemma is the following compromise. When we enter new material, we provide two or three methodologies that sample common student-learning styles for that topic in order to support their initial learning efforts. But as time goes on, we need to force them to shed the comfortable and think about the material in other ways in order to expand their range of thinking skills and thus achieve long-term growth.

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societal impact

by Bruce Partridge

Tweaking the ASP’s Board

We need to add Board positions; let me know what you think.

It is difficult to imagine a harder working Board of Directors than the one now serving the Astronomical Society of the Pacific — your Society. It is possible, however, to imagine a better structure for the Board. This is the topic I would like to address in this column to you, the members of the ASP. I’ll end by asking for your help.

The Board of Directors is currently composed of 12 members: 10 elected by the membership and two appointed by the Board itself. One of the 10 elected seats is filled from nominations made by amateur astronomers, while the Society’s Nominating Committee puts forward candidates for the other nine elected positions. Judging from the quality of the Board members I have had the pleasure of working with, these nominating groups do an excellent job. Among the Directors are distinguished scientists, outstanding science educators, and amateurs in the best sense of the word — those who love astronomy.

As our Society evolves from a club-based or service-to-members organization toward a cause-based one with a mission “to increase the understanding and appreciation of astronomy by engaging scientists, educators, enthusiasts and the public,” the Board has come to feel that it needs to add to its ranks members with a wider range of experiences and backgrounds. I will cite three of examples, the same ones I used when I presented this issue to the annual members meeting in September: individuals with deep experience in the world of philanthropy; individuals familiar with the world of business and investing; or individuals knowledgeable about, and experienced in, electronic publication.

These particular examples are less important than the general principle: providing the Board with the flexibility to add members with specific skills, interests, or backgrounds as needed by the Society. At the moment, the issues I mentioned above are very much on the mind of the Board; in a few years, it could be a very different topic, such as primary school education. The Board would like the flexibility to fine-tune its membership appropriately.

The Board has discussed its composition on several occasions. At its September 2009 meeting, it unanimously adopted a resolution to add up to four new, Board-appointed positions, pending member-approved changes to the bylaws. Although the resolution does provide for adding “up to four” new members, the current intention of the Board is to add just two, bringing the number of Board-appointed members to four (with no change to the number of elected members).

You may ask why add to the Board? Instead, why not convert two elected positions to appointed ones? The Board considered this alternative but did not favor it for two reasons. First, both the Board and the officers of the Society wanted to maintain a Board in which persons elected by the membership have a prominent and weighty role. Second, our Directors — serving as unpaid volunteers — are being worked hard, and more hands would help. I would add a personal observation that a Board of only 12 members is on the small side for an organization with the reach and ambition of the ASP.

Although the number of Board members you (the members of the ASP) elect would not change, the officers and Board felt it would be both appropriate and important to bring this proposal to the membership for approval. It does involve alterations to the bylaws (specifically, to Article V.2: various subsections). As mentioned earlier, I presented this proposal to the attendees at the members meeting during the ASP’s annual meeting in Millbrae last month, and there appeared to be wide acceptance of the idea. We will hold a formal vote by the membership as a whole later this year, asking for approval of this change to the bylaws (which will allow the Board to appoint up to four additional members, though it is the Board’s current intention to add only two appointed members for now).

Here is where the request for help comes in. I urge you to support this modest yet important change to improve the functioning of your Board, a change unanimously recommended by them. Equally, I urge you to contact me soon if you have reservations or questions. The Board of Directors values both your support and your participation in this process. ☐

BRUCE PARTRIDGE (bpartrid@haverford.edu) is the President of the Astronomical Society of the Pacific.
Every year at the Annual Meeting of the Astronomical Society of the Pacific (held most recently this past September in Millbrae, just south of San Francisco), I present a report outlining some of the numerous programs undertaken by your Society during the previous 12 months. Many of these activities appear on various pages in our website and within the pages of our quarterly publication Mercury.

Since most ASP members were unable to attend the Annual Meeting, the editor of Mercury thought it would be appropriate if I reprised my talk within the pages of this magazine — but not simply as a regular article. So rather than trying to recapture my words and put them to paper, a number of key slides from my PowerPoint presentation are recreated on the following pages.

My focus for this meeting was on our accomplishments for the 2009 International Year of Astronomy, and not every ASP program is included here. Also, in a couple of instances, the contents of two slides have been combined into one. But I hope the following pages will provide a glimpse of some of the amazing things your Society has accomplished during the past year. And I invite you to attend the upcoming Annual Meeting — in Boulder, Colorado, in early August 2010 — for the next update.

JAMES G. MANNING is the Executive Director of the Astronomical Society of the Pacific.
1899 Mission:
“To advance the Science of Astronomy, and to diffuse information concerning it.”

2009 Mission:
The Astronomical Society of the Pacific increases the understanding and appreciation of astronomy by engaging scientists, educators, enthusiasts and the public to advance science and science literacy.
ASP and the IYA: Discovery Guides

Coordinated online resources for use by amateurs in outreach.

Keyed to the NASA IYA Calendar’s monthly themes and objects.

astronomy2009.nasa.gov

Effort includes monthly teleconferences with NASA scientists.

NASA and NSF supported.

1,000+ downloads per month since December 2008.

www.astrosociety.org/iya/guides.html

ASP and the IYA: Cosmic Clearinghouse

Developing a web-based directory linking users to educational resources.

Directory to include links to ASP-developed resources for amateurs, teachers, etc.

www.digitaluniverse.net/cosmiccirclinghouse
ASP and the IYA: Galileo Teacher Training Program

Developing pilot workshops for formal educators using Galileo’s targets and IYA materials to refine a model for teaching the process of science.

Flexible approach incorporating Galileo-related activities, fundamental astronomy concepts, adaptable educational tools, and IYA materials.

www.digitaluniverse.net/gtppusa

IYA Goodie Box

Included IYA banners, buttons, comet chef aprons and hats, moon balls, pins, stickers, posters, fact sheets, and bookmarks.

Distributed 200 Goodie Boxes to Night Sky Network clubs.

Supported by JPL Exoplanet Exploration, Mather Foundation, NASA, AAS, SETI Institute, and the LCROSS mission.
400 Years of the Telescope

Contributed education content to 400 Years PBS web site.

Developed and distributed 175 copies of amateur toolkit — Glass and Mirrors: An Inside Look at Telescopes.

Coordinated Night Sky Network club partnerships with museums, planetariums, PBS stations in eight surveyed markets for special events (Lincoln, NE; Portland, OR; Nashville, Philadelphia, Pittsburgh, Chicago, Denver, Baltimore).

Dark Skies Awareness

Held Dark Skies amateur teleconference in February ’09 for Night Sky Network, online workshop in March ’09 for informal educators. Distributed 55 Dark Skies kits to informal educators and amateurs; amateurs logged 60 GLOBE at Night events to 1,400 participants.

Galileoscope

Distributed 2,000 Galileoscopes to 20 selected informal venues. Will distribute an additional 300 for selected events including early Galileo Teacher Training Program workshops, along with related activities.
Expanding the Informal Universe

Adapted IYA Discovery Guides for use by informal science educators.


Distributed 40 comet kits and 30 Dark Skies kits to selected sites; will distribute 2,000 Galileoscopes to 20 selected sites.

Effort supported by NASA, NSF.

Astronomical Society of the Pacific

For an account of the Society’s performance in 2008, check out our 2008 annual report at:
www.astrosociety.org/support/ar,html

The ASP: Advancing science literacy through astronomy.
Laboratory Astrophysics: An Oxymoron No More

Astronomy offers extremes of physical conditions unavailable in earthly laboratories.

by Bruce Partridge

Editor’s Note: The ASP’s annual conference was opened with presentations by ASP President Bruce Partridge, Caltech associate professor of astronomy Lynne Hillenbrand, and planetary scientist David Grinspoon. A reproduction of Lynne’s excellent talk begins on the next page.

It was an honor and pleasure to have been invited to moderate a discussion at the 2009 ASP meeting on the progress of science since Galileo’s observations made on a dark Italian night 400 years ago.

I was asked to begin by framing the discussion, and I propose to do so by starting with a two-word oxymoron, an oxymoron that for millennia might have seemed blasphemous as well as puzzling. It is this: “laboratory astrophysics.” This is the branch of astronomy that attempts to replicate astronomical processes in the laboratory.

To anyone who believes, as most of Galileo’s contemporaries did, that the heavens are governed by completely different physical laws from mundane, earthly events, the idea of “laboratory astrophysics” would make no sense. Indeed, given that the mechanics of the heavens were supposedly perfect and divine, it would even smell of blasphemy.

But we now know better. The same physical laws that govern motions and change on Earth govern motions and change in the heavens. The universality of physical law was one of Galileo’s great contributions. Indeed, I would claim it is more fundamental than the discovery of Jupiter’s moons or the phases of Venus. In many ways, he was the first to stake the claim that the science we know and love from our earthly experience extends throughout the entire universe.

The universality of physical law is the real story behind Newton’s “discovery” of gravity. The Moon falls toward Earth in exactly the same way an apple does, governed by the same physical law — gravity. And we have every reason to believe that a galaxy in a distant cluster of galaxies falls towards the center of that cluster according to that same law.

Once we accept the universality of physical law, the possibility of a great interchange between physics and astronomy opens up. For centuries, astronomers have used physical laws to solve astronomical problems, such as computing the mass of stars or the number of photons per centimeter left over from the initial hot Big Bang (the answer is 411, not 409). The debt astronomy owes to physics is huge.

Increasingly, and interestingly, there is a trickle back the other way. A beautiful example is the discovery of the element helium. Its presence was first detected in the Sun 140 years ago (by Lockyer), the evidence being an unknown spectral line. (For a nice historical summary online, search out Leaflet 62 of the ASP, dated 1934.) Later the element was found on Earth, but it still bears the name of the Sun.

A more recent example, close to my heart, is the first firm limit placed on the number of different families of elementary particles. The answer — three families — was established by Dave Schramm and his colleagues on the basis of astronomical observations of the heat left over from the Big Bang and the present abundance of helium in the universe. Only later, and at vastly greater expense, did particle physicists confirm this result. Astronomy is beginning to repay its debt to physics.

A much more important way astronomy influences physics these days is that astronomy offers extremes of physical conditions unavailable in Earthly laboratories. You want a vacuum better than any that can be produced in a lab on Earth? Go to space. You want densities higher than any that can possibly be produced in an Earth-based lab — study the physics of neutron stars. You want to investigate the physics of matter at temperatures of $10^{25}$ K? Go to the early universe. If you can’t afford to build a particle accelerator large enough to give a single proton the energy of a speeding rifle bullet, look for an occasional cosmic ray at that energy.

The 2009 ASP Annual Meeting celebrates, in part, this synergy between sciences. It’s not just physics and astronomy. Chemistry informs biology. Physics assists archaeology. So it was fitting that we heard a review of the progress in all sciences, given by David Grinspoon, as well as a review of 400 years of astronomy by the ASP’s Vice President, Lynne Hillenbrand. Her magnificent summary follows.

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Kevin Partridge is Professor of Astronomy at Haverford College. For more than 40 years he has been measuring properties of the cosmic microwave background radiation and is involved in ESA’s Plank mission. He is also the current President of the ASP.
400 Years of Astronomical Discovery

The story of our accelerating understanding of our place in the universe.

by Lynne A. Hillenbrand

Editor's Note: The following is Lynne's keynote address from the opening of the 2009 ASP meeting in Millbrae. The images in this article are not necessarily those shown by Lynne during her talk.

In order to discuss “400 Years of Astronomical Discovery,” I need to cover about 16 years per minute of speech. However, the scope of relevant material is by no means evenly divided over the years, and so my subtitle is “The Accelerating Understanding of our Place in the Universe.”

We are about three-quarters of the way through the IYA, the International Year of Astronomy. It is thus timely to think about the successes of the year and, as this ASP annual meeting title indicates, forge a path to a future of continued public engagement in astronomy.

Setting the Stage

In this context of public understanding and appreciation of science, it is important to note the world view into which Galileo Galilei was born (1564). The accepted cosmology was that there were two very separate realms: that of the Earth, consisting of soil/earth, air, fire, and water and on which all was transient, and that of the heavens or Heaven, consisting of a perfect regularity — remote from Earth's imperfections, and eternal.

It was Galileo's passion to understand these realms and the connection between them. In pursuing such questions, Galileo blazed the path to modern astronomy — and as we all know, got himself into a bit of trouble along the way. Both scientific and political landscapes play a very important role in the progress of human knowledge.

Some groundwork had already been laid by the time Galileo came of age. Specifically the earlier Copernican revolution (1543) took our cosmology from an Earth-centered to a Sun-centered system of perfect circles. Contemporary Johannes Kepler, while working with Tycho Brahe, determined (1605-09) that planetary orbits are elliptical rather than circular (changing the equation, as it were). The stage was therefore set for Galileo to take humanity from the limited understanding enabled by naked-eye observations of the sky to that revealed by magnified observations through his use of the refracting telescope. He had heard of the 3x magnifier, which he duplicated in 1609 and quickly improved to a 30x version.

By turning a spyglass into a telescope, Galileo taught us (1609-12) that the Moon's surface is not a perfect sphere but rather appears imperfect like Earth, pockmarked with features; the Sun has blemishes and rotates; Venus has phases; and Jupiter has moons. He also saw that there is much more to the universe than the 30 arcseconds of spatial resolution the unaided eye can perceive, such as the non-pointlike or extended nature of the planets, the odd shape of Saturn (later understood as rings), the many faint stars within the Pleiades.
Star Cluster, and that the “Milky Way” is in fact a collection of stars rather than a celestial fluid.

As evidenced from the above, and as we will see as we proceed through this brief history since Galileo, advances in astronomy (and many sciences) are driven by the interactions between three different ways of studying phenomena: invention and experiment; observation and analysis; and hypothesis and theory. I invite you to witness the interleaving as we proceed.

From Newton to Einstein

Although the motions of the planets had been mapped at the time of Galileo, the reason they moved in the manner they did was not yet understood. Isaac Newton, who was born the same year Galileo died (1642), brought explanation and understanding in the form of his universal law of gravitation. But possibly even more important for our story, he improved the telescope in two ways that remain fundamental today. First was his design (1669) of the reflecting telescope (using a mirror instead of a lens as the objective); this weight reduction per magnification factor allowed larger telescopes to be made, which led to new discoveries in the solar system and beyond with each increase in aperture. Second was Newton’s use of a prism that dispersed received light in a spectograph.

It is the spectograph that has given us our greatest understanding of the nature of astronomical objects. Joseph Fraunhofer improved such a “spectroscope” (1814) both optically and through his novel design of a diffraction grating to supplant the prism. With the increase in spectral resolution, he found a forest of almost 600 dark lines interrupting the continuous emission spectrum from the Sun (lower left).

He also found that the lines from several of the brightest nighttime stars were different from one another. Once these lines were explained, several decades later by Gustav Kirchhoff and Robert Bunsen, as sequences formed by the interaction of light with particular atoms, we had a tool to measure what a very distant object is made of. However, it took developments some 100 years later to get this story right, as we will see shortly.

The brother and sister observing team of William and Caroline Herschel built huge telescopes and used them (1780-1834) to conduct a systematic survey of the sky. They identified stars, clusters, nebulae, what we now know as galaxies, etc. They were trying to understand the shape of the universe, really just the Milky Way at that time, through star counts. They also meticulously cataloged the nebulae (eventually resulting in the New General Catalog or NGC — the name by which many famous astronomical objects are still referred). Caroline found numerous comets, while William discovered the planet Uranus, the first planet found with a telescope and also the first addition to the solar system since antiquity.

William expanded our horizons in another important way: by experimenting with the temperature of different colors of light and discovering that there is heat/light outside of the visible spectrum. He is considered the father of infrared astronomy. Today, we have not only full-sky infrared imaging surveys such as 2MASS, SDSS, and the forthcoming WISE and LSST projects, but there are now infrared space observatories located where the background noise is
much lower than here on Earth — Spitzer, Herschel, and Planck — all carrying on the legacy of the Herschels.

Jacobus Kapteyn took advantage of new techniques involving photographic astronomy, which had been developed by Henry Draper, to collect information (1896-1922) concerning star counts, brightness, proper motion, parallax, spectral types, and radial velocities. He estimated average distances for stars of different brightness, and developed the idea of the Galaxy as a flat disk of stars with a radius of roughly 10 kiloparsecs (about 32,600 light-years) and a half-width of some two kpc (6,500 light-years, not too far off given that Kapteyn didn’t appreciate interstellar extinction, as later pointed out by Robert Trumpler). He thought the sun was located only 650 parsecs (2,100 light-years) from the center (pretty far off). This was known as “Kapteyn’s Universe.” He also measured, but did not quite deduce from the two stellar proper-motion streams he observed, that our galaxy is rotating. Bertil Linblad and Jan Oort in the mid-1900s clarified this situation for us.

By the late 1800s, the Newtonian view of gravitation began to hit some limits, particularly with respect to the orbit of the planet Mercury. It precesses at its closest approach to the Sun (perihelion) by 43 arcseconds/century faster than predicted by Newton — even accounting for the effects of other planets, the geometrical deformation of the Sun, and Earth’s frame of reference. Albert Einstein followed up on his 1905 theory of special relativity to develop (1915-19) general relativity, which posited that mass warps both space and time. This rectified the issue with Mercury’s orbit and also predicted that large masses such as stars could noticeably bend light. Arthur Eddington’s famous eclipse observations (1919), which found offsets in the positions of background stars relative to their location when the Sun was situated in another part of the sky, made Einstein a man of international public intrigue. Today, our understanding of these general relativistic effects enables us to study dark matter and the faintest, furthest objects in the universe through gravitational lensing (magnification) effects. Also, LIGO is poised to detect “gravity waves.”

Secrets of Stars
By 1910 Ejnar Hertzsprung and Henry Norris Russell had independently determined the relationship between absolute magnitude and color (spectral type) of stars. This drove consideration of their evolution — a big change in thinking from the days of Galileo when the heavens were considered static but perfect. They initially thought that stellar evolution, occurring in what we now call the “HR diagram” (illustrated on the next page), started with the red giants collapsing to become the early main sequence stars, which gradually moved back towards the red dwarfs during their lifetimes. This is entirely wrong, but I would claim that the philosophical advance of astronomical objects evolving is far more important than the details.

Eddington, a theorist, provided important context for our understanding of HR diagrams based on thermodynamics and radiative transport considerations and concluded that stars were in fact static
for most of their lives and their evolution was short lived — consistent with our current understanding. Robert Emden, William Kelvin, Hermann von Helmholtz, James Jeans, Arthur Schuster, and Karl Schwarzschild all made important contributions.

Building on the significant spectroscopic work of William Huggins in the late 1800s and the increasingly large stellar classification catalogs assembled by Annie Canon, Williamina Fleming, Antonia Maury, and Edward Pickering, Cecilia Payne Gaposchkin determined in the early 1920s that the stellar spectral classes (now OBAFGKMLTY) did not reflect the composition of the stars, but rather their temperatures. Through application of what are now known as the Saha (ionization states) and Boltzmann (electron-level populations) equations, she showed that hydrogen and helium are the dominant elements — even though they have very few lines and are typically weak. Her cracking of the stellar code is considered one of the greatest achievements in astrophysics.

The Universe Expands

Meanwhile, technology was not waiting for the universe to be physically understood. George Ellery Hale had been busy building, in sequence, the largest telescopes of the day. He performed this feat four different times — from the Yerkes 40-inch completed in 1895 to the 60-inch and 100-inch Mt. Wilson scopes and the Mt. Palomar 200-inch, dedicated in 1948 after his death. (A side note here. The recent fires in the Angeles National Forest were a serious threat to the historical Mt. Wilson site, but the valiant efforts of the fire-fighting crews saved this still-working, and state-of-the-art [in some respects] observatory complex from destruction.) Hale was a solar observer and is also responsible for our physical understanding of sunspots and their 22-year cycle as driven by solar magnetic reversals.

Albert Michelson (having already gained prominence for measuring the speed of light) was working on Hale’s 100-inch at Mt. Wilson and developed (1919) with Francis Pease the interferometer, which was soon used to measure the diameters of Betelgeuse and several other stars. By the 1940s, the technique of astronomical interferometry was routinely used at radio wavelengths. It was not until the 1970s that it became extendable to well-separated telescopes at optical wavelengths and is still being perfected today, including usage at Keck, VLT, and many smaller-aperture arrays.

Henrietta Leavitt, much like Cecelia Payne-Gaposchkin, found patterns in observational data that led to a fundamental alteration of our understanding of the physics of the universe. She discovered (1912) that Cepheids, a specific type of variable star, pulsate more slowly if they are more luminous (the so-called period-luminosity relation that has recently been re-named the Leavitt law). Because luminosity can be related through apparent brightness to distance squared, Leavitt’s realization was critical for establishing the distance scale of the Milky Way, the Magellanic Clouds, and later of the larger universe.
Harlow Shapley, who was hired by Hale, was interested in using globular clusters to set the distance scale. He studied RR Lyrae stars as standard candles, calibrating a period-luminosity law for these fainter variables following Leavitt. He plotted the spatial distribution of globulars in three dimensions and found (1918) its center towards Sagittarius — at a distance of 13 kpc (much better than Kapteyn's 0.65-kpc estimate, but still not quite right). He also revised the scale of the Milky Way overall, increasing its radial size from Kapteyn's 10 to 50 kpc and estimated a distance to the Large Magellanic Cloud.

Meanwhile Edwin Hubble (also hired by Hale) and Milton Humason were detecting (1924-29) individual Cepheids in nearby galaxies, again using the Mt. Wilson 100-inch. The 300-kpc value they derived using the same period-luminosity techniques put the spiral nebulae in which the Cepheids were located beyond the scale of the Milky Way. Further, when combined with Vesto Slipher's earlier discovery of redshifted galaxy spectra, Hubble was able to determine a correlation between distance and recession velocity. The so-called "island universes" were not only just that (very distinct collections of stars apart from our own Milky Way), but they were moving apart from us and from one another. The universe was expanding, consistent with the Big Bang theory of origin.

In 1943 Walter Baade was able to make unprecedented clear observations of the nearby Andromeda galaxy to define two types of stellar populations: one in the spiral arms that was blue and young (Pop I) and another in the central bulge that was red and old (Pop II). The implication that there were also two types of Cepheids then led to recalculation of the size of the known universe and a more than doubling of Hubble's distance estimates (which were based on a calibration developed for one type of Cepheid but applied to the other type). There were also implications for the estimated age of the universe, bringing it up and into better alignment with the geologically determined age of five billion years for the Earth.

A New Field in Astronomy

If Galileo is to be credited for advancing optical astronomy through instrumentation, Karl Jansky is our similar hero in radio astronomy. While both built on the insights and advances of those who came before, Jansky invented a new field whereas Galileo (and for that matter Herschel) merely improved the field, albeit by revolutionizing it.

Jansky was studying static and interference in ship-to-shore communications at long wavelengths (14.6 meters) and had built a directional antenna (photo on the next page), a "receiving apparatus," and data-recording equipment. He identified local radio noise due to thunderstorms and from the ionosphere, and he also postulated radio emission from the Sun. But his "Electrical Disturbances Apparently of Extraterrestrial Origin" (1933) introduced us to a new window on the universe that (it was later learned) included not only stars and galaxies but also new exotica such as the galactic center, pulsars, radio galaxies, and more.

Radio astronomy was further advanced by Grote Reber who designed (1937) a radio telescope to improve on the antenna and mapped the Galaxy. Harold Ewen and Edward Purcell were the first to observe (1951) neutral hydrogen, which had been predicted earlier. This soon led to doppler measurements and velocity distances for the "stuff between the stars," thus tracing out the spiral structure of the Milky Way.

Returning to the optical, Fritz Zwicky, who is a well-known...
character in astronomy, suggested many things, including cosmic rays and the connections between the supernovae he cataloged and neutron stars (which were yet to be discovered). He also speculated in the 1930s that there was “invisible matter,” based on studies of the Coma Cluster of galaxies (below) and a consideration of mass-to-light ratios. Later in the 1970s the existence of what we now call dark matter was incontrovertibly confirmed by the careful observations of galaxy-rotation curves by Vera Rubin.

Picking up our stellar story, it took until the late 1950s for us to completely understand how stars are powered and the nucleosynthesis that occurs in their cores. The major players were theorists Hans Bethe, Fred Hoyle, Edwin Salpeter, Geoffrey Burbidge, Margaret Burbidge, William Fowler, and A.G.W. Cameron, who worked out various pieces of the thermonuclear processes. Although many details were (and still are) to be determined, our rudimentary understanding of the basic physics of stars was essentially complete at this time.

Now going not only extragalactic but toward the origin of the universe, Arno Penzias and Robert Wilson, continuing the serendipity of Jansky, were planning to use a radio antenna (the Horn reflector, above) to look for interstellar molecular material (they later found the first interstellar carbon monoxide). But first they decided to test their equipment at a frequency where no cosmic radiation was expected. They found an extra 3° to 4° of unexplained “noise” in their experiment (1964), which turned out to be the relic radiation from the early universe — the cosmic microwave background, the afterglow of the Big Bang. The emission is caused by scattering of photons through a sea of electrons and nuclei (protons and neutrons), the only matter that existed before galaxies formed.

This observation settled the Big-Bang-plus-expansion vs. the Steady-State universe debate. More recently, COBE and WMAP have mapped the cosmic microwave background in great detail, particularly its 1:105 deviations from complete uniformity, with the results interpreted as detection of the earliest structural formation in the universe. The Planck spacecraft has recently launched and will tell us even more.

The 1960s also saw the discovery of several classes of “extreme” objects, which continue to challenge our understanding even today. Maarten Schmidt used Hale’s Palomar 200-inch to discover (1963) quasars, very luminous distant objects that are now appreciated as the accretion of material onto supermassive black holes. This discovery brought our attention to astronomical objects in which relativistic physics is important, including black holes, neutron stars, and pulsars.

Pulsars — rotating neutron stars exhibiting pulses of radio and X-ray light as their beamed photons cross our line of sight — were discovered (1967) by Jocelyn Bell and Anthony Hewish. Joseph Taylor and Russell Hulse identified (1973) the first binary pulsar, which displays behavior that verifies predictions of general relativity such as the bending of radio waves.
Scouring the Invisible

While the well-developed fields of optical and radio astronomy were maturing and producing many discoveries, our eyes on the universe were not entirely open. The 1960s and 70s saw the first exploration of the infrared and the X-ray windows, which required significant technology development including ground-based, jet, balloon, rocket, and satellite work. Pioneering work by Bob Leighton and Gerry Neugebauer, and Frank Low and Harold Johnson, enabled infrared discoveries about the formation of stars, the content and structure of our galaxy, and the enormous infrared luminosities of many distant galaxies.

Riccardo Giacconi developed X-ray astronomy, discovering (1966) the first X-ray source outside the solar system in sco-X1. Subsequent X-ray facilities (including the Einstein, XMM-Newton, and Chandra spacebased X-ray observatories) have probed the physics of stellar coronae, accretion processes around young stars, various galactic exotica, and extragalactic black holes, as well as the intergalactic hot gas that surrounds many clusters of galaxies.

Satellites launched to detect gamma rays from nuclear explosions in the USSR discovered (1967) gamma-ray bursts, occurring at a rate of about one per day. This led to the astronomically oriented BeppoSAX satellite, which found that the bursts are uniformly distributed. The first measured redshift of a gamma-ray burster by Keck (1997) demonstrated the extragalactic nature of the gamma rays bursts and therefore their enormous luminosities. They are now connected with explosive events such as supernovae. Today, the Swift satellite plus an armada of ground-based telescopes are better characterizing these objects and the puzzling physics they exhibit.

Further exploration across the electromagnetic spectrum has included rapidly paced developments in detectors and digitization. CCDs were developed in the late 1970s and 80s, and flown in space on the Hubble Space Telescope. In the infrared, detectors were developed at near-infrared wavelengths for Hubble but were utilized extensively on the ground beginning in the 1990s. At longer mid-infrared wavelengths the detectors developed and flown on the Spitzer Space Telescope at the start of the 21st century have revolutionized discovery. Far infrared and sub-millimeter detector arrays will finally mature in SOFIA and CCAT. Many technologists have contributed to these efforts.

In the quest for ever more photons, efficient instrumentation is not enough. Pioneers in optical mirror design such as Roger Angel, with the weight-reducing honeycomb design, and Jerry Nelson, with his segmented mirror approach, have resulted in the existence of, and the scientific productivity at, the world's largest telescopes: GCTC, Keck, SALT, HET, LBT, Subaru, VLT, Gemini, MMT, and Magellan. We are now at a factor of a million-fold increase in sensitivity over Galileo’s equipment because of novel engineering designs.
Another factor of 100 is coming in the next generation of large telescopes, including the TMT at 30 meters (to consist of 492 small mirror segments compared to Keck’s 36) and the GMT at 20 meters (which will consist of eight 8-meter mirrors operating in sync).

For all we know about the distant universe, we are still — 400 years after Galileo — somewhat ignorant about our own backyard. It was only in 1992 that the first Kuiper Belt Object (since the 1930 discovery of Pluto) was found, following the postulation of such small bodies in the 1950s. Further mapping of the outer solar system led us to realize the extent of the population and to re-think some of the implications for the inner solar system. Wide-field mapping, both in the recent past (2MASS, UKIDSS) and near future (WISE, Pan-STARRS), catalogs the solar neighborhood for the first time in certain low-luminosity regions of the HR diagram (white dwarfs on the blue side and brown dwarfs on the red side). Many observers are contributing to these efforts.

Planet Quest

The most profound and awe-inspiring discovery — probably since the identification of the spiral nebulae as other galaxies and maybe even since the Copernican revolution itself — was the confirmation (1996) of the existence of planets around other Sun-like stars. As with other significant findings, there had been much groundwork laid, including the previous announcement of planetary mass objects around pulsars and the discovery of low-mass brown dwarfs.

However, it was again a technological breakthrough that allowed the precise radial velocities needed to find planets — at first Jupiter-mass and recently close to Earth-mass — via the reflex motion of their central stars as the planets progress about their orbits. Various planet-search teams, including Geoff Marcy et al. and Michel Mayor et al., have found planets where we didn’t expect them to be in many different phase spaces, starting from the very first discoveries. There are now hundreds of exoplanets; so many that popular culture has intervened to establish “top ten” lists.

As the statistics accumulate, it seems clear that there are more smaller planets than larger ones, and there are more at Jupiter-like distances and beyond from their star than closer to their star. There are multiple planet systems of extreme diversity. And the question of the possibility of life somewhere other than on our Earth is closer to mainstream science than ever before. Very recently, some of the first direct images of objects that fall into the planetary mass regime have been taken, though we are still technologically quite far from imaging an Earth analog.

Cosmology

The discovery of a supermassive (five-million solar mass) black hole in the center of our own galaxy (1996) was another important step in our understanding of the relationship between the universe and us. While a black hole in the center of the Milky Way was predicted in the 1960s, it took until the 1990s before sensitive-enough instrumentation (with enough spatial resolution) was available for the Andrea Ghez et al. and Reinhard Genzel et al. teams to peer (in the infrared) through the intervening gas and dust to map the orbits of the stars around the Milky Way’s center black hole (see the illustration on the following page) and establish its mass.

Turning back to cosmology, the expansion of the universe should be slowing down due to the attractive force of gravity. But it was demonstrated (1998) from observations of Type Ia supernovae — first suggested by Baade as possible “standard candles” — that instead of deceleration, there is actually acceleration of the expansion. Again, there were large teams involved in the discovery. An unknown force, dubbed dark energy, drives the acceleration, and we have a major undertaking before us to understand what it is.

At the fore of technology development during this past decade has been adaptive optics (correcting for atmospheric blurring using either natural or artificial guide stars) and interferometry (interfering light collected by widely separated telescopes to achieve extremely high spatial resolution). Both techniques have been around for decades but are only now achieving mainstream utility. More standard observational methods such as imaging and spectroscopy have become massively multiplexed over this same
time period and have launched us into an era of large surveys.

Computing and databases are increasingly important to observers, and time-domain science ranging from transiting planets to variable stars to high redshift transients is now routine. We are contemplating building new and ever-more capable observing machines. By historical precedent these will lead to innumerable discoveries which cannot now be anticipated and for which these instruments were not even intended.

400 Years of the Telescope

We’ve come a long way in 400 years! But we are still building an understanding of our solar system, our galactic neighborhood, the Milky Way, the nearby universe, large-scale structure, the epoch of galaxy formation, and our cosmology.

Any such review is necessarily incomplete. However, I hope to have hit many of the transformative highlights of the field since Galileo. I assert that the pace of discovery — as alluded to in my title — continues to accelerate. However, there are some common themes over the centuries that are worth pointing out. These include first and foremost the inspiration of other scientific discoveries and advances. We have returned again and again through the astronomical generations to cataloging the sky, deciphering the physical nature of astronomical objects, establishing empirical relations and patterns, discovering our place in the universe, and utilizing our cleverness in the pursuit of the unknown.

From Galileo to today and on into the foreseeable future, it is clear that advancement in astronomy is driven by the interaction between technology, observation, and interpretation. But there is another very important element.

Public appreciation of astronomy is currently on the rise. Galileo serves as a role model here as well. Remember that he wrote his Starry Messenger in 1610 in Italian, rather than the Latin preferred by academics of the day. His messages made it literally around the world as a consequence — because they could be understood. We are here to continue this legacy of public understanding and appreciation of astronomy. Astronomy is widely recognized as a gateway science, drawing the interest of those young people inclined to pursue science. So we should all be doing what we can to exploit this fact — for the good of all scientific inquiry.

LYNNE HILLENBRAND is an Associate Professor of astronomy at the California Institute of Technology, Pasadena, and the Vice-President of the ASP. She would like to thank the ASP conference organizers for the opportunity to learn a little astronomical history.
MESSENGER's Third Flyby

NASA / JHUAPL

MESSENGER successfully flew by Mercury on September 29, 2009, gaining a critical gravity assist that will enable it to enter orbit about Mercury in 2011 and capturing images of five percent of the planet never before seen. With more than 90 percent of the planet's surface already imaged, MESSENGER's science team had drafted an ambitious observation campaign designed to tease out additional details from features uncovered during the first two flybys. But an unexpected signal loss prior to closest approach hampered those plans.

A portion of the complicated encounter was executed in eclipse, when the spacecraft is in Mercury's shadow and the spacecraft — absent solar power — was to operate on its internal batteries for 18 minutes. Ten minutes after entering eclipse and four minutes prior to the closest approach point, the carrier signal from the spacecraft was lost, earlier than expected.

According to MESSENGER Mission Systems Engineer Eric Finnegan of the Johns Hopkins University, the spacecraft autonomously transitioned to a safe operating mode, which pauses the execution of the command load and "safes the instruments," while maintaining knowledge of its operational state and preserving all data on the solid-state recorder.

"Although the events did not transpire as planned, the primary purpose of the flyby, the gravity assist, appears to be completely successful," Finnegan adds. "Furthermore, all approach observing sequences have been captured, filling in additional area of previously unexplored terrain and further exploring the exosphere of Mercury."

More information

New Map Hints at Venus' Wet, Volcanic Past

European Space Agency

Venus Express has charted the first map of Venus' southern hemisphere at infrared wavelengths. The new map hints that our neighboring world may once have been more Earth-like, with a plate tectonics system and an ocean of water.

The map comprises over a thousand individual images, recorded between May 2006 and December 2007. Because Venus is covered in clouds, normal cameras cannot see the surface, but Venus Express used a particular infrared wavelength that can see through them.

Although radar systems have been used in the past to provide high-resolution maps of Venus' surface, Venus Express is the first orbiting spacecraft to produce a map that hints at the chemical composition of the rocks. The new data are consistent with suspicions that the highland plateaus of Venus are ancient continents, once surrounded by ocean and produced by past volcanic activity.

"This is not proof, but it is consistent. All we can really say at the moment is that the plateau rocks look different from elsewhere," says Nils Müller at the Joint Planetary Interior Physics Research Group of the University Münster and DLR Berlin, who headed the mapping efforts.

The rocks look different because of the amount of infrared light they radiate into space, similar to the way a brick wall heats up during the day and gives off its heat at night. Besides, different surfaces radiate different amounts of heat at infrared wavelengths owing to a material characteristic known as emissivity.

More information
Phoenix Results Point To Martian Climate Cycles

Favorable chemistry and episodes with thin films of liquid water during ongoing, long-term climate cycles may sometimes make the area where NASA’s Phoenix Mars mission landed last year a favorable environment for microbes. Phoenix ended communications in November 2008 as the approach of Martian winter depleted energy from the lander’s solar panels.

“Not only did we find water ice, as expected, but the soil chemistry and minerals we observed lead us to believe this site had a wetter and warmer climate in the recent past — the last few million years — and could again in the future,” said Phoenix Principal Investigator Peter Smith of the University of Arizona, Tucson.

A paper about Phoenix water studies, for which Smith is the lead author with 36 coauthors from six nations, cites clues supporting an interpretation that the soil has had films of liquid water in the recent past. The evidence for water and potential nutrients “implies that this region could have previously met the criteria for habitability” during portions of continuing climate cycles, these authors conclude.

The mission’s biggest surprise was finding a multi-talented chemical named perchlorate in the Martian soil. This Phoenix finding caps a growing emphasis on the planet’s chemistry, said Michael Hecht of NASA’s Jet Propulsion Laboratory.

“The study of Mars is in transition from a follow-the-water stage to a follow-the-chemistry stage,” Hecht said. “With perchlorate, for example, we see links to atmospheric humidity, soil moisture, a possible energy source for microbes, even a possible resource for humans.”

Opportunity Explores Meteorite on Mars

NASA’s Mars Rover Opportunity has investigated a metallic meteorite the size of a large watermelon that is providing researchers more details about the Red Planet’s environmental history.

The rock, dubbed “Block Island,” is larger than any other known meteorite on Mars. Scientists calculate it is too massive to have hit the ground without disintegrating unless Mars had a much thicker atmosphere when the rock fell than it has now. An atmosphere slows the descent of meteorites. Additional studies also may provide clues about how weathering has affected the rock since it fell.

In late July 2009, Opportunity had driven approximately 180 meters (600 feet) past the rock in a Mars region called Meridiani Planum. An image the rover had taken a few days earlier and stored was then transmitted back to Earth. The image showed the rock is approximately 60 centimeters (two feet) in length, half that in height, and has a bluish tint that distinguishes it from other rocks in the area. The rover team decided to have Opportunity backtrack for a closer look, eventually touching Block Island with its robotic arm.

“There’s no question that it is an iron-nickel meteorite,” said Ralf Gellert of the University of Guelph in Ontario, Canada. Gellert is the lead scientist for the rover’s alpha particle X-ray spectrometer, an instrument on the arm used for identifying key elements in an object. “We already investigated several spots that showed elemental variations on the surface. This might tell us if and how the metal was altered since it landed on Mars.”
Cassini Observes Seasonal Change on Titan

**NASA / JPL / Space Science Institute**

Characterizing seasonal variations in Titan’s volatile system is a primary goal of the Cassini spacecraft’s Equinox and Solstice missions. Two related studies report new observations by the Cassini radar instrument peering through Titan’s thick atmosphere with repeat coverage. Images of the surface at different times show lakes shrinking and disappearing over the course of one to several Earth years. The observations are of interest because they represent Cassini’s initial glimpses into Titan’s active hydrocarbon-based hydrologic cycle and can be used to test models of Titan’s climate.

Synthetic Aperture Radar (SAR) data show that a collection of small features, previously identified as lakes, exhibit more than an order of magnitude increase in radar return and have disappearing borders between observations, suggesting surface change. Radiometrically, these changes cannot be explained without invoking temporal variability. The disappearance of these dark features likely represents volatile transport in Titan’s methane cycle. Two-layer models of radar return suggest transport fluxes are about one meter of liquid per Earth year.

Evaporation is the most likely scenario for observed changes on Titan’s surface. Alternative explanations include freezing, cryovolcanism, and subsurface infiltration. Freezing is thermodynamically discouraged during the summer season in Titan’s south pole, and there are no clearly observable cryovolcanic features in the study areas. If evaporation is responsible, model results suggest rates are about 1m/yr.

More information

Large Ring Around Saturn

**NASA / JPL-Caltech**

NASA’s Spitzer Space Telescope has discovered an enormous ring around Saturn — by far the largest of the giant planet’s many rings.

The new belt lies at the far reaches of the Saturnian system, with an orbit tilted 27° from the main ring plane. The bulk of its material starts about 3.7 million miles away from the planet and extends outward roughly another 7.4 million miles. One of Saturn’s farthest moons, Phoebe, circles within the newfound ring, and is likely the source of its material. Saturn’s newest halo is thick, too — its vertical height is about 20 times the diameter of the planet.

“This is one supersized ring,” said Anne Verbiscer, an astronomer at the University of Virginia, Charlottesville. “If you could see the ring, it would span the width of two full moons’ worth of sky, one on either side of Saturn.” The ring itself is tenuous, made up of a thin array of ice and dust particles.

The discovery may help solve an age-old riddle of one of Saturn’s moons. Iapetus has a strange appearance — one side is bright and the other is really dark, in a pattern that resembles the yin-yang symbol. The ring is circling in the same direction as Phoebe, while Iapetus, the other rings and most of Saturn’s moons are all going the opposite way.

According to the scientists, some of the dark and dusty material from the outer ring moves inward toward Iapetus, slamming the icy moon like bugs on a windshield.

More information

This diagram illustrates the extent of the largest ring around Saturn, discovered by the Spitzer Space Telescope. The pictures of Saturn, Phoebe, and Iapetus were taken by NASA’s Cassini spacecraft; the ring is an artist’s illustration. The size of Phoebe relative to Iapetus has been enlarged to better show Phoebe.
**First Discovery of Life’s Building Block in Comet**  
*NASA Goddard Space Flight Center*

NASA scientists have discovered glycine, a fundamental building block of life, in samples of Comet Wild 2 returned by NASA’s Stardust spacecraft.

“Glycine is an amino acid used by living organisms to make proteins, and this is the first time an amino acid has been found in a comet,” said Dr. Jamie Elsila of NASA’s Goddard Space Flight Center in Greenbelt, Md. “Our discovery supports the theory that some of life’s ingredients formed in space and were delivered to Earth long ago by meteorite and comet impacts.”

“The discovery of glycine in a comet supports the idea that the fundamental building blocks of life are prevalent in space, and strengthens the argument that life in the universe may be common rather than rare,” said Dr. Carl Pilcher, Director of the NASA Astrobiology Institute that co-funded the research.

Proteins are the workhorse molecules of life, used in everything from structures like hair to enzymes, the catalysts that speed up or regulate chemical reactions. Just as the 26 letters of the alphabet are arranged in limitless combinations to make words, life uses 20 different amino acids in a huge variety of arrangements to build millions of different proteins.

Stardust passed through dense gas and dust surrounding the icy nucleus of Wild 2 on January 2, 2004. As the spacecraft flew through this material, a special collection grid filled with aerogel—a novel sponge-like material that’s more than 99 percent empty space—gently captured samples of the comet’s gas and dust.

**Spitzer Spots Clump of Planetary Material**  
*NASA / JPL*

Astronomers have witnessed odd behavior around a young star. Something, perhaps another star or a planet, appears to be pushing a clump of planet-forming material around. The observations, made with NASA’s Spitzer Space Telescope, offer a rare look into the early stages of planet formation.

Planets form out of swirling disks of gas and dust. Spitzer observed infrared light coming from one such disk around a young star, called LRLL 31, over a period of five months. To the astronomers’ surprise, the light varied in unexpected ways, and in as little time as one week. Planets take millions of years to form, so it’s rare to see anything change on time scales we humans can perceive.

One possible explanation is that a close companion to the star — either a star or a developing planet — could be shoving planet-forming material together, causing its thickness to vary as it spins around the star. “We don’t know if planets have formed, or will form, but we are gaining a better understanding of the properties and dynamics of the fine dust that could either become, or indirectly shape, a planet,” said James Muzerolle of the Space Telescope Science Institute, Baltimore, Md. “This is a unique, real-time glimpse into the lengthy process of building planets.”

The observations showed that light from the inner region of the star’s disk changes every few weeks, and, in one instance, in only one week. “Transition disks are rare enough, so to see one with this type of variability is really exciting,” said co-author Kevin Flaherty of the University of Arizona, Tucson.
A new study provides fresh insight into how some stars are born, along with a beautiful new image of a stellar nursery in our Milky Way galaxy. The research shows that radiation from massive stars may trigger the formation of many more stars than previously thought.

While astronomers have long understood that stars and planets form from the collapse of a cloud of gas, the question of the main causes of this process has remained open.

One option is that the cloud cools, gravity gets the upper hand, and the cloud falls in on itself. The other possibility is that a “trigger” from some external source — like radiation from a massive star or a shock from a supernova — initiates the collapse. Some previous studies have noted a combination of triggering mechanisms in effect.

By combining observations of the star-forming cloud Cepheus B from the Chandra X-ray Observatory and the Spitzer Space Telescope, researchers have taken an important step in addressing this question. Cepheus B is a cloud of mainly cool molecular hydrogen located about 2,400 light-years from Earth. There are hundreds of very young stars inside and around the cloud — ranging from a few million years old outside the cloud to less than a million in the interior — making it an important testing ground for star formation.

“Astronomers have generally believed that it’s somewhat rare for stars and planets to be triggered into formation by radiation from massive stars,” said Konstantin Getman of Penn State University, University Park, Pa. “Our new result shows this belief is likely to be wrong.”

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ESA’s XMM-Newton orbiting X-ray telescope has uncovered a celestial Rosetta stone: the first close-up of a white dwarf star, circling a companion star, that could explode into a particular kind of supernova in a few million years. These supernovae are used as beacons to measure cosmic distances and ultimately understand the expansion of our universe.

Astronomers have been on the trail of this mysterious object since 1997 when they discovered that something was giving off X-rays near the bright star HD 49798. Now, thanks to XMM-Newton’s superior sensitivity, the mysterious object has been tracked along its orbit. The observation has shown it to be a white dwarf, the dead heart of a star, shining X-rays into space.

Sandro Mereghetti, INAF–IASF Milan, Italy, and collaborators also discovered that this is no ordinary white dwarf. They measured its mass and found it to be more than twice what they were expecting. Most white dwarfs pack 0.6 solar masses into an object the size of Earth. This particular white dwarf contains at least double that mass but has a diameter just half that of Earth.

The mass determination is reliable because the XMM–Newton tracking data allowed the astronomers to use the most robust method for ‘weighing’ a star, one that uses the gravitational physics devised by Isaac Newton. Most likely, the white dwarf has grown to its unusual mass by stealing gas from its companion star. At 1.3 solar masses, the white dwarf is now close to a dangerous limit.

When it grows larger than 1.4 solar masses, a white dwarf is thought to either explode, or collapse to form an even more compact object called a neutron star. The explosion of a white dwarf is the leading explanation for Type Ia supernovae.
Portrait of a Nearby Galaxy
Goddard Space Flight Center

In a break from its usual task of searching for distant cosmic explosions, NASA's Swift satellite has acquired the highest-resolution view of a neighboring spiral galaxy ever attained in the ultraviolet. The galaxy, known as M31 in the constellation Andromeda, is the largest and closest spiral galaxy to our own.

"Swift reveals about 20,000 ultraviolet sources in M31, especially hot, young stars and dense star clusters," said Stefan Immler, a research scientist on the Swift team at NASA's Goddard Space Flight Center in Greenbelt, Md. "Of particular importance is that we have covered the galaxy in three ultraviolet filters. That will let us study M31's star-formation processes in much greater detail than previously possible."

Several features are immediately apparent in the new mosaic. The first is the striking difference between the galaxy's central bulge and its spiral arms. "The bulge is smoother and redder because it's full of older and cooler stars," Immler explained. "Very few new stars form here because most of the materials needed to make them have been depleted."

Dense clusters of hot, young, blue stars sparkle beyond the central bulge. As in our own galaxy, M31's disk and spiral arms contain most of the gas and dust needed to produce new generations of stars. Star clusters are especially plentiful in an enormous ring about 150,000 light-years across.

More information

Hyperactive Galaxies in the Young Universe
Gemini Observatory / STScI

Looking almost 11 billion years into the past, astronomers have measured the motions of stars for the first time in a very distant galaxy and clocked speeds upwards of one million miles per hour, about twice the speed of our Sun through the Milky Way. The fast-moving stars shed new light on how these distant galaxies, which are a fraction the size of our Milky Way, may have evolved into the full-grown galaxies seen around us today.

"This galaxy is very small, but the stars are whizzing around as if they were in a giant galaxy that we would find closer to us and not so far back in time," says Pieter van Dokkum, professor of astronomy and physics at Yale University in New Haven, Conn., who led the study.

The work by the international team combined data collected using the 8-meter Gemini South telescope in Chile with observations taken by NASA's Hubble Space Telescope. According to van Dokkum, "The Hubble data confirmed that this galaxy was a fraction the size of most galaxies we see today in the more evolved, older universe. The giant 8-meter mirror of the Gemini telescope then allowed us to collect enough light to determine the overall motions of the stars using a technique not very different from the way police use laser light to catch speeding cars."

"By looking at this galaxy we are able to look back in time and see what galaxies looked like in the distant past when the universe was very young," says team member Mariska Kriek of Princeton University in Princeton, NJ.
Meet Your New Board Members

Daniel R. Altschuler was born in Montevideo, Uruguay. In 1975 he received his PhD in physics from Brandeis University. After a post-doctoral position at the University of Maryland he joined the faculty of the Physics Department at the University of Puerto Rico at Río Piedras. In 1985 he spent two years as a Visiting Scientist at the Max-Planck Institut für Radioastronomie, in Bonn, Germany. Between 1991 and 2003 he held the position of Director and Senior Research Associate at the Arecibo Observatory, and became founding director of its Office for the Public Understanding of Science.

While serving as Director of the Arecibo Observatory, Daniel worked to transform the site from a relatively obscure (to the public) research center to an open place where visitors can learn about the many facets of the science done at Arecibo. Under his guidance, and after eight years of fund-raising, the Observatory opened the Angel Ramos Foundation Visitor Center in 1997. It has been a great success, being visited by about 125,000 visitors every year and spawning a series of outreach programs including a unique series of workshops for science teachers. In 2005 he returned to his faculty position at the University of Puerto Rico.

His books: Children of the Stars (Cambridge University Press, 2002), Hijos de las Estrellas (Madrid, Cambridge University Press, 2001, and AKAL 2004) and L'Universo e l'origine della vita (Milano, Mondadori, 2005) have been very well reviewed. Natalie Angier in the New York Times Book Review wrote: "...a slim, elegant and richly illustrated book for the general reader that somehow manages to convey the most important concepts of virtually all the scientific disciplines — astronomy, physics, chemistry, biology, evolutionary theory, geology." Over the years, Daniel has given of his time to lecture to audiences in the US, Latin America, Europe, and in particular Puerto Rico.

He has published a large number of articles in the Puerto Rican press, mostly on topics at the frontier between science and society. He is a founding member and technical advisor of the "Sociedad de Astronomía de Puerto Rico" (Astronomical Society of Puerto Rico), and in 2006 was named president of the Science Section and member of the board of directors of the Ateneo Puertorriqueño, the oldest cultural institution in Puerto Rico. In 2008 the American Association for the Advancement of Science (AAAS), Caribbean Section, recognized him for "Public Understanding of Science and Technology."

Doug Brown is President and Chairman of the Fremont Peak Observatory Association (FPOA), which built and operates an all-volunteer observatory providing interpretive programs to 2,000 students and other members of the public annually, and serves on the Board of Directors of the Astronomical Association of Northern California, an association of amateur astronomy organizations in the San Francisco Bay Area. Doug taught high school science and math in local languages as a Peace Corps volunteer in Malaysia and Nepal, and continues to inspire students at schools around the area through astronomical presentations.

He is an executive with Applied Materials, a global leader in nanomanufacturing technology solutions, where he has made extensive contributions in program management, operations, new product development, and product management. He earned his MBA from the University of Chicago, a BS in Physics (and Philosophy) from Beloit College, and did MSEE graduate studies at Stanford University.

A long-time FPOA member, Doug joined its board of directors to successfully resolve a contractual impasse between the Association and the State Department of Parks. Subsequently he has worked with the board and members to initiate and develop FPOA's first strategic plan, which resulted in a re-write of the organization's bylaws, and led FPOA's collaboration with Hartnell College to develop and expand an award-winning summer internship program for at-risk science and engineering students. He chaired the organizing committee for AANC-CON 2007, and recently briefed a Bay area conference of Math and Science teachers on using local resources to incorporate astronomy teaching into their curriculum.

Although he has designed and built two telescopes and gained pleasure using them, Doug is more of a theorist than an observer, who enjoys understanding and elucidating astronomical concepts at least as much as spending time at the eyepiece.

Don McCarthy is a research Astronomer and Lecturer with Steward Observatory at The University of Arizona. He specializes in infrared astronomy and engineering and has been passionately doing STEM education at all age levels throughout his life. He received an undergraduate degree in physics at Princeton in 1970 and a PhD in astronomy from U. Arizona in 1976. He was a finalist in the initial NASA Shuttle astronaut selection and served in the US Army after college ROTC. He has led the Astronomy Camp
programs at Mt. Lemmon Observatory since 1989, involving thousands of teenagers, educators, adults, and school groups in authentic observatory experiences.

As E/PO lead for NASA's NIRCam project with JWST, he leads a partnership in science education with the Girl Scouts of the USA, involving adult trainers around the US along with graduate students and postdocs. Each semester he teaches a large enrollment, undergraduate course in astronomy or cosmology to non-science majors, and involves students in hands-on learning with unusual projects such as dissecting and reusing so-called One-Time Use Cameras, building crystal radios, barn door trackers, etc.

He has served with Project ASTRO, NOAO's Research-Based Science Education program, Women in Science and Engineering, Spacegrant, helped design the Galileoscope, and teaches in numerous K-12 schools every year. His research emphasizes techniques for high spatial and spectral resolution via interferometry and adaptive optics with applications to the solar system, evolution of stars and galaxies, and our galaxy's black hole. After his senior thesis work, he still avidly follows new developments with the cosmic microwave background. Most recently he led a research team that discovered widespread wave-phenomena in Pluto's atmosphere.

Sandra Preston has spent 30-years building the education and outreach programs of the McDonald Observatory at the University of Texas at Austin where she is currently the Assistant Director for Education and Outreach. In this role, she is responsible for a $2.1 million operating budget, derived from sales income, gifts, and grants, and for a staff of 30. At the inception of the daily two-minute StarDate astronomy radio program in 1978, she launched a campaign that resulted in the fledgling radio series airing on 1,000 radio stations.

She was the project director for the NSF-funded Spanish-language radio program, Universo, which was the most widely syndicated Spanish-language radio program at its inception. She is executive producer for both programs, which continue to air today to a daily audience of more than two million listeners. She has raised millions of dollars for the education and outreach programs at McDonald Observatory, including partial funding for the Frank N. Bash Visitors Center in Fort Davis, Texas, and as PI for the NSF-funded "Decoding Starlight" exhibit that resides there.

In Texas she is PI for a project funded by NASA and private foundations, which partners with the Texas Regional Collaborative for Excellence in Science and Mathematics, the 20 Education Service Centers in Texas, and Connect2Texas, to carry out teacher professional development via videoconference. She has worked with the observatories in the Southwest, in particular, to support the goals and objectives of the Southwestern Consortium of Observatories for Public Education, a group that provides educational information for teachers and astronomy tourism for the public. She is on the EPO advisory committee for the National Solar Observatory.

Additionally, she has worked on a number of international projects, including Sternzeit (1991-2008), the German version of StarDate, and as PI on an NSF-funded meeting in South Africa of international observatories with 8-meter or larger telescopes, called the State of the Art Telescope Education Collaboration (2001-05). She has a Bachelor's in Business Administration from the University of Texas at Austin.

Peter deVroede is co-founder and Chief Technology Officer at Stitcher, Inc., a leading mobile audio company that provides a groundbreaking new media service which allows audio content to be easily aggregated, organized, and shared on mobile devices. He comes to the ASP board with more than 25 years of experience in technology development and management, with a specific focus on the development of technology for creative/artistic applications.

He has developed products for Adobe and Macromedia, and at Xerox's storied Palo Alto Research Center. He has also managed the development of creative production tools for video game development at Electronic Arts and for feature film production at Walt Disney's feature animation division. His experience is rounded out by the several years he spent as a hedge fund manager and as a board member on several other non-profit boards.

Peter is a second-generation amateur astronomer having, at a very early age, inherited a deep interest in the subject from his mother. He has vivid memories of his first planetarium show at the age of five. Two years later he received his first telescope as a gift and successfully modified it for solar observation by the age of 12. Some of his fondest childhood memories revolve around the observational pursuit of meteor showers, solar eclipses, and Halley's Comet (and lamenting the narrow field of view from within the Yosemite Valley where his family spent many summer vacations).

Peter received his Bachelor of Arts in Physics from the University of California at Berkeley, where he spent his work/study time running shows at the planetarium of the Lawrence Hall of Science and doing research in the classification of atmospheric aerosols at the Lawrence Berkeley National Laboratory. He also holds a Masters of Business Administration from the University's Haas School of Business. Peter lives in Piedmont, California with his wife Baener Lucas and his grade school-age twins, Claire and Hunter, with whom he shares a passion for science and sports.

The ASP's New Education Director

The ASP is pleased to welcome Greg Schultz, our new Director of Education. He comes to us from UC Berkeley's Center for Science Education at the Space Sciences Lab, which he joined in 1999 immediately after finishing his PhD in the UCLA Astronomy and Astrophysics program. He arrived at Berkeley after being selected for an NSF science education postdoctoral fellowship. Following three years of the NSF fellowship, Greg was promoted to a staff position as an Education/Outreach Scientist and Teacher Educator.
and continued his science education efforts with the group. His work has been primarily focused on pre-service teacher education, in-service teacher professional development, and science curriculum development. Within these areas, Greg’s research and development activities in science education have involved effectively integrating or utilizing astronomy and space science, and have been grounded in constructivist and inquiry-oriented design and pedagogy. He developed, coordinated, and implemented projects primarily for the Sun-Earth Connection Education Forum, part of the NASA Science Mission Directorate’s national Education and Public Outreach (EPO) support network. He has most recently served in leadership/management capacities for six NASA EPO grants, including two as Principal Investigator at UC Berkeley.

Greg has taught courses in astronomy, physics, astrobiology, planetary science, and science education at five colleges/universities, including UCB, UCLA, and Purdue (where he received an MS degree in physics). He has also been a Project ASTRO astronomer in three Bay Area schools and co-presented dozens of workshops for K-12 teachers nationwide. Greg was elected in 2006 to the California Science Teachers Association (CSTA) Board of Directors and was re-elected for a 2008-2010 term.

**Nominations for 2010 ASP Awards Now Open**

The Astronomical Society of the Pacific is now accepting nominations for the Society’s 2010 awards honoring special accomplishments in astronomy research, technology, education, and public outreach. Recipients receive a cash award and engraved plaque, as well as travel and lodging to accept the award at the Society’s 122nd annual meeting, to be held at the University of Colorado at Boulder from July 31 to August 4, 2010.

See page 41 for a list of the awards, while descriptions of the awards and links to the nomination pages are available on the ASP's Awards webpage. Submission deadlines are either December 15, 2009 or January 1, 2010; check the Awards webpage for details.

If you have questions or need additional information, please contact Albert Silva at (415) 337-1100 x 100, or asilva@astrosociety.org.
i'm a planet-hunter by trade, and like most astronomers, my stock-in-trade is light. it's in the light of stars, spread into a spectrum of wavelengths, where i find the tiny, periodic variations in spectral lines that betray the presence of orbiting planets gravitationally tugging on their stellar parents. by studying the light, we astronomers shed light on what the universe is like and how it got there — and we're up to about 400 extrasolar planets and counting!

the astronomical society of the pacific, with which i've been associated both as a former member of its board of directors and as an enthusiastic supporter, also specializes in shedding light — but on the entire universe. for 120 years, the society's work has paralleled some of the most significant advances in our understanding of the cosmos — communicating, teaching, guiding, and inspiring.

i recognize that this is a challenging year in which to give. but it makes your contribution more important than ever, to keep the society moving forward in its worthy mission. i ask for your support with a financial gift during the society's fall fund drive — an investment in the next 120 years of the astronomical society of the pacific's good work to advance astronomy, science education, science literacy, and to inspire the planet-hunters of the future.

our stock-in-trade is light. i thank you for your vital contribution to support the asp's enlightening work to benefit the future of us all, on the one planet in the universe we still call home.

geoff marcy
professor of astronomy
university of california, berkeley
Annual Report Now Online
The ASP is pleased to provide a summary of our mission-based activities and events through the 2008 Annual Report. We take this opportunity to acknowledge and thank our many benefactors, members, and friends for the support they provided during the year that enabled the Society to carry out its work.

The PDF version of the report is available for downloading, in a screen or print version, at the Annual Reports page on our website. There you’ll also find annual reports from 2005 to 2007 inclusive.

Do You Tweet?
Social networking is all the rage, but it comes with its own set of issues. For example, schools often block Facebook and YouTube because of inappropriate content accessible through those sites. That's too bad, because there is good stuff available.

For example, NASA- and JPL-managed missions are using social-networking websites like Twitter, YouTube, and Facebook to inform the public about their missions. JPL also has its own blog, with posts from scientists and engineers. Here's JPL's website where you can find all the links. (If you're really paranoid, join JPL's Asteroid Watch on Twitter and be the first to learn about any incoming space rocks!)

Not to be outdone, NASA also Tweets and blogs — you can find out more at this webpage. This page also lets you put NASA on your desktop and offers a number of links to various activities.

The Return of Cosmos In the Classroom
Even as folks in the ASP’s head office are finally catching their breath after the successful 2009 annual meeting, thoughts are already turning to next year — especially with the return of “Cosmos in the Classroom: A Hands-on Symposium on Teaching Introductory Astronomy.”

We’ll gather for three days (August 2 to 4) in Boulder, Colorado, to consider how we can do a better job with the introductory astronomy course and to learn from some of the outstanding astronomy professors and instructors in the country. Much of the symposium will be in the format of small-group sessions. Participants will include community and small college instructors, university professors, graduate students and postdocs, advanced high school teachers, and anyone who may be facing a group of non-science majors in the future.

This tri-annual symposium will take place at the University of Colorado at Boulder, July 31 to August 4, 2010. It’ll be held in conjunction with the ASP’s 122nd annual conference (which will include a set of weekend workshops for K-12 and informal educators).

So mark the date in your electronic daytimers; more information will be available in the not-too-distant future. 

ASP 2009 Award winners (from left): Kevin Bundy (Trumpler Award), Carol Lee Lutsinger (Las Cumbres), Isabel Hawkins (Klumpke-Roberts), Frank Shu (Bruce Gold Medal), Ardis Herrold (Brennan), Michael Richmond (Amateur Achievement; accepting on behalf of Thomas Droge's family), and Edward Fenimore (Muhlmann; for the Swift Mission Team).
The Astronomical Society of the Pacific invites nominations for the Society’s 2010 Awards

AMATEUR ACHIEVEMENT AWARD
significant observational or technological contributions to astronomy by an amateur astronomer

THOMAS J. BRENNAN AWARD
dedication to teaching astronomy at the high school level

RICHARD H. EMMONS AWARD
dedication to teaching introductory astronomy at the college level

KLUMPKE-ROBERTS AWARD
contributions to the public understanding and appreciation of astronomy

LAS CUMBRES AMATEUR OUTREACH AWARD
educational outreach by an amateur astronomer

MARIA & ERIC MUHLMANN AWARD
innovative advances in astronomical instrumentation, software or observational infrastructure

ROBERT J. TRUMPLER AWARD
PhD research considered unusually important to astronomy

Further details, submission information, and past recipients can be found on our website:
http://www.astrosociety.org/membership/awards/awards.html
The Skies of November

Slowly sliding into the west as the night progresses is **Pegasus, the Flying Horse**, and its four brightest stars that form the **Great Square** of Pegasus. These four stars aren’t all that bright, but the square-shape is unmistakable. The chart below includes four faint stars within the square; how many can you see with just your naked eye? From the city, you’ll likely see only two or three. But from a dark-sky site, you might glimpse up to 30.

At the end of a string of stars that starts with the southwest corner star of the Square is **M15**, a small glowing ball of suns known as a globular cluster. It’s a pretty sight in binoculars or telescopes. **Jupiter** is perfectly placed for viewing this month. It sits due south as the sky darkens and sets by midnight. On the 23rd, you’ll find the nearly first-quarter Moon hanging above the planet.

**Mercury** is lost in the solar glare this month, but two other planets stand out in the dawn sky. Around mid-month **Saturn** rises about four hours before the Sun. Have a look through a telescope — the ring system is beginning to open up again. The crescent Moon is to the right of the planet on the 12th.

Two mornings later, a thin crescent Moon stands well above and to the right of brilliant **Venus**, and just below the bright star Spica. The following morning (the 15th), the Moon lurks to the right of Venus, but both are very low in the southeast.

Every 30 years or so, the **Leonid meteor shower** peaks in a great storm of “shooting stars.” The last storm occurred between 1998 and 2001; the rest of the time this meteor shower is pretty quiet. But some meteor forecasters are predicting a decent show this year — anywhere from 100 to 500 meteors per hour — but only for a short period of time on the 17th. For more details, check out this NASA Science News story.

The Skies of December

This month’s IYA feature sky sight is **M42**, the **Orion Nebula**. It’s easy to find, even in a city (though you’ll need to use binoculars if that’s your observing location). The seven bright stars of **Orion, the Hunter**, are rising out of the southeast these December evenings. Aim your binoculars at **Orion’s Belt**, the three bright, close-together stars in the middle of this great shape. Slowly scan down (south); as the three stars slip out of your field of view, a greenish haze near a fainter star will slide into view. That haze is M42 (see the star chart on the next page).

**Jupiter** is gradually slipping lower and lower into the southwest after each December sunset. It’s still nicely placed for viewing, but sets around 10:00 pm. The crescent Moon will make a pretty sight to the planet’s lower right on the 20th and upper left on the 21st.

**Mercury** will join Jupiter in the sunset skies, but it’s poorly placed. Around mid-month it sets only 80 minutes after the Sun. Still, look for it just below the 2-day-old Moon on the 18th.

By 10:00 pm **Mars** is rising in the east. The red planet brightens rapidly as the month passes; its fiery red appearance makes it an easy-to-spot object. On the 6th, the waning gibbous Moon rises just below the red planet.

Last up is **Saturn**, climbing above the horizon around 1:00 am. The Moon, just past last quarter, rises beside the ringed planet on the 10th. Venus is now lost in the Sun’s glare and won’t emerge until mid-February.

This year’s **Geminid Meteor Shower** should be a good one. It peaks during the night of December 13/14, and the sky will
be moonlight-free (new Moon falls on the 16th). From a light-pollution-free location, you should be able to spot several dozen meteors per hour.

On a slightly different lunar note, December contains two full Moons: on the 2nd and the 31st. The second full Moon in a month is often known as a \textit{Blue Moon}.

**The Skies of January**

- Go to Sky & Telescope’s January 2010 Sky Chart
- How to use S&T’s Interactive Sky Chart

Nearly overhead these January evenings is the brilliant star \textit{Capella}, the brightest light in \textit{Auriga, the Charioteer}, and the sixth brightest star in the night sky. Auriga’s four other not-quite-as-bright stars combine with Capella to give this constellation the shape of a pentagon.

Inside the southern portion of the pentagon are two open star clusters: M36 and M38. Nearby is M37 (all appear on the chart at upper right). You won’t see them as naked-eye sights in a city sky, but binoculars will let you easily find, compare, and contrast these three tiny stellar cities. M36 appears compact and is the brightest of the three, while M38 is a larger, diffuse glow. The appearance of M37 seems to fall between the other two.

\textit{Jupiter} emerges low in the west-southwest as twilight fades. But hurry if you want to explore this giant planet with a telescope — it’ll be lost in the solar glare come March. A thin crescent Moon passes near on the 17th and 18th.

Although not as interesting a sight in small scopes as Jupiter, ruddy \textit{Mars} is well up in the east as darkness falls. At month’s end, it rises at sunset and is in \textit{opposition} (opposite the Sun in Earth’s sky) on the 29th. The Moon rises with Mars on the 2nd, and does so again on the 29th.

\textit{Saturn} appears low in the east before midnight and is well placed for viewing (high in the south) during the pre-dawn hours. The nearly last-quarter Moon stands on Saturn’s right during the morning hours of the 6th.

Finally, \textit{Mercury} puts in a dawn-sky appearance during the last half of the month, rising roughly 80 minutes before the Sun and standing low in the southeast before sunrise. But \textit{Venus} is still too close to the Sun to be seen; watch for its reappearance in the west next month.

**IYA Feature Sky Sights: Crab and Orion Nebulas**

During each month of the International Year of Astronomy, one particular celestial object is highlighted. The ASP provides more information about each object, as well as downloadable lesson plans, on our Discovery Guides site.

- November — Crab Nebula. Discover the life and death of stars.
- December — Orion Nebula. Learn about the birth of stars and planets.

2010 — Repeat as appropriate. The topics and activities are timeless, but a few of the date-specific observing activities — Venus (January), Earth’s Moon (February), Saturn (March), and Jupiter (September) — won’t necessarily be appropriate in 2010 during the 2009 month they are listed in.

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2010 — Repeat as appropriate. The topics and activities are timeless, but a few of the date-specific observing activities — Venus (January), Earth’s Moon (February), Saturn (March), and Jupiter (September) — won’t necessarily be appropriate in 2010 during the 2009 month they are listed in.
Thanks to *Sky & Telescope* magazine, *Mercury* readers have direct access to *S&T*’s online Interactive Sky Chart. While anyone can go to Sky’s website, registration is required to load and use the charts. Registration is free and has some advantages, but it’s not necessary for ASP members who just want to retrieve the monthly star chart.

*Sky & Telescope*’s Interactive Sky Chart is a Java applet that simulates a naked-eye view of the sky from any location on Earth at any time of night. Charted stars and planets are the ones typically visible without optical aid under clear suburban skies. Some deep-sky objects that can be seen in binoculars are plotted too.

**Using the Chart: The Basics**

When you launch *Sky & Telescope*’s Interactive Sky Chart applet in your Web browser, you should get a rectangular, naked-eye view of the sky on the upper left and a circular all-sky chart on the right. If the chart does not appear, see the “Tech Talk” section at the end of this article.

For instance, when you click on the link for the November Sky Chart, you should see, in a new window, a screen that looks like the image above. Each of the monthly links in Sky Sights will take you to a chart set for 40° north latitude and 100° west longitude (so it’s useful throughout the continental US) at 10 pm local time at mid-month in November, December, and January. The chart can be used one hour later at the start of each month and one hour earlier at month-end.

If all you want is a copy of the circular All-Sky Chart to take outside, press the “Create PDF” button, and then print the result. You’ll find the easy-to-use instructions included on the chart.

But Sky’s Interactive Chart offers much more. Click on any area of the circular All-Sky Chart that you’d like to see in more detail. The green frame will jump to where your cursor is pointing, and the scene in the Selected View window will now show this area.

Or click and hold down your mouse button within the green frame on the All-Sky Chart, then drag the frame around the sky. The scene in the Selected View window will change as the location of the green rectangle on the All-Sky Chart changes.

Finally, click and hold down your mouse button in the Selected View window, then drag the cursor to move to another part of the sky. The green frame in the All-Sky Chart will follow your movements.

**Changing the Chart**

Below the Selected View window you’ll find the latitude and longitude the chart is set for, as well as the date and time. These can all be changed.

To alter the date and time, click on the month, day, year, hour, or minute in the display at lower left, which will become highlighted. (You can change only one parameter at a time.) Then use the + or – button to increase or decrease the value you’ve selected. Each time you change a quantity, both the Selected View and All-Sky Chart will be updated instantly.

If you’d rather do a wholesale change, click the large “Change” button in the Date & Time display area. A pop-up window will appear. Here you can choose any date between January 1, 1600, and December 31, 2400, using the day and month pull-down lists and the year text-entry box.

To alter the location (and time zone), you’ll need to click the large “Change” button in the Location display area. A pop-up window will appear that will let you select a new location (be sure to enter data in just one of the three sections of this page). A follow-up page will let you select a time zone. But note that unless you register, the system will not remember your new location.

You’ll find more detailed instructions and hints for using the chart on the Help page. To really become familiar with this program, see the article: Fun with *S&T*’s Interactive Sky Chart.

**Tech Talk**

The applet should work properly in most Java-enabled Web browsers. For best results on a PC, use Internet Explorer 6 or Netscape 7; on a Mac, use OS X 10.3 (or higher) with Safari. If you’ve installed a “pop-up stopper” to block advertisements that automatically open in new browser windows, you’ll probably have to turn it off, as the Interactive Sky Chart needs to open in a new browser window.

If you have trouble getting the Sky Chart to open on your computer, please review Sky’s detailed system requirements to check whether you’re using a supported operating system. And don’t forget to also review the Help page.
Sky-Skan was invited to be at the White House Star party with our portable Definiti PD II system about two weeks ahead of the event. One dome was already planned — the GeoDome owned by NASA's Goddard Space Flight Center. But with more than 120 school children at the event, and less than two hours for them to experience all the activities NASA had planned, two domes were needed to get them through in time. Carter Emmart from the American Museum of Natural History presented in the GeoDome, and Suzanne (an AMNH educator) and I presented in the Sky-Skan dome.

It was intended to have the inflatable Starlab dome under a NASA tent if there were strong winds. The day turned out to be perfect, except for strong gusts, which caused set-up problems for the dome. After an interesting afternoon on the South Lawn of the White House manhandling a wayward Starlab dome, I finally got what I needed and set up under one of the NASA tents. As you may know, it's a struggle climbing inside one of these domes, so I had little expectation of the First Family crawling inside.

I began the first show following President Obama's remarks, with 25 middle school kids seated around the perimeter of the dome. A few minutes into the program I heard activity at the entrance, turned around in my seated position, and there was President Obama entering the tent, meeting me at eye level, and saying: "Don't worry about us." Now I've done a lot of planetarium shows in my time, but I have to say this was the most interesting turn of events ever to happen! "Thanks for coming, Sir," I said, and Suzanne and I continue with the show.

The only space to sit was right next to the Definiti PD II star projector. So...imagine me seated in a semi-crouched position next to a small laptop and the star projector, with some grassy space beside it. The President and youngest daughter sat three feet in front of me next to the projector, Malia sat next to me at the console, and Michelle Obama was just behind me. So what did the First Family experience in the dome?

We had already taken off from Earth and were orbiting, when the President asked a question that had come up during their dinner that evening about the cause of seasons. Suzanne gave a great explanation, while I controlled the visuals and starfield in real-time. I then added a short demo that showed the changing solar illumination at the north pole of the Earth over a six-month period.

Happy with that, I backed away from the solar system, showed recent images from the previous week's flyby of Mercury by the Messenger spacecraft, and discussed light-speed travel time from the Earth to the Moon and across the solar system. Meanwhile, Orion hung in the sky. I told a personal story of teaching my own youngest daughter (a little older than Sasha) about Orion by using glow stars on her ceiling for a month before taking her outside to see if she recognized anything. She immediately found the familiar pattern, which she now calls "my Orion." Perhaps there will be glow stars on the ceiling of the White House bedroom before long!

After 10 minutes, the First Family got up to leave. The President thanked me as they quietly departed, and I continued the show for the kids. Normal White House events have the President staying no more than 30 minutes — the Obama's had requested 45 minutes for the star party, and ended up staying more than an hour. Everyone recognized their real interest in astronomy.

Of course no cameras are allowed in a planetarium, so no photos were taken inside the dome. But I have a strong visual memory of that scene — of two young girls and their parents staring up at a starry sky, the Earth hanging there as a beautiful jewel, and a planetarium projector giving a fine performance.

I've represented the planetarium community at a lot of events, particularly during my tenure with the International Planetarium Society, but never imagined being in that place, at that time, on the White House lawn. I can tell you that I feel incredibly honored and privileged to have been there.

Martin Ratcliffe is the Director of Professional Development at Sky-Skan, a company that manufactures digital planetariums and control systems.