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Posters From Boulder

VARIOUS AUTHORS (introduction by PAUL DEANS)

At the ASP’s 2010 conference in Boulder, there was an excellent assortment of poster papers — 120, in fact, in the two meeting streams (Education and Public Outreach and Cosmos in the Classroom). In this issue, in alphabetical order by lead author, are 11 poster papers from that meeting.

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Rosetta triumphs at asteroid Lutetia, the first potentially habitable exoplanet, and a rare eclipsing pulsar — these are some of the discoveries that recently made news in the astronomical community.

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New Ideas

I very much like the ASP’s annual conferences, even though I’m not a professional educator. There is lots of enthusiasm, plenty of good ideas, and there’s always something useful I can take home that’s applicable to the informal astronomy talks I sometimes give.

I really enjoyed the Boulder meeting this past August, because it brought together the Education and Public Outreach component with the tri-annual gathering of Cosmos in the Classroom. The ideas and enthusiasm were overflowing, particularly when these two groups interacted. Way back in the previous century, one of the Cosmos workbooks assembled by Andy Fraknoi helped me immensely as I prepared and presented teacher workshops as part of my duties in a planetarium. So it was delightful to be able to attend the Cosmos gathering itself.

On the other hand, I found the Boulder meeting somewhat frustrating — precisely because it brought together the regular EPO folks with the tri-annual gathering of Cosmos! There was just too much to see and take in. We really needed six days and multiple repeat sessions to do the conference justice — and I know I’m not alone with this thought. Still, better too much than too little, and I’m confident everyone went home with a plethora of new ideas.

The new ideas extend to how participants “work” the conference. No more pencils, pens, and pads of paper. Instead, laptops rule the sessions, video-capturable DSLRs record presentations, and several iPads put in an appearance. Even reviewing posters is much simpler than in bygone days — a shot or two with a digital camera records the poster’s details (or at least the presenter’s name and e-mail).

Of course, not every ASP member can attend these conferences. That’s why we publish a Conference Proceedings book, and why Andy Fraknoi will, once again, assemble the Cosmos in the Classroom information into a book or CD-ROM.

And to provide everyone with a sample of the work presented in Boulder, this issue of Mercury features reprints of 11 posters from both the EPO and Cosmos streams. Enjoy.

Paul Deans
Editor, Mercury
I'm currently a member of NASA's Astrophysics Subcommittee, a group of scientists, academics, and others that advises the NASA Science Mission Directorate (SMD) Astrophysics Division on matters of importance to NASA and the field. We meet periodically, and met most recently this past September in Washington, D.C., to offer our perspectives on issues related to the recently completed astrophysics "decadal survey," commissioned by the National Research Council.

The decadal survey is the result of a different group of scientists, academics, and others collecting the observations, opinions, white papers, and proposals of many, many others and distilling them into recommendations about what the SMD Astrophysics Divisions' budget and mission priorities should be for the next decade — as well as recommendations for NSF's astronomy effort (the survey is available online). It's an important process and worth taking a look at. It will give you a sense of the thinking that goes into the decisions about what missions and operations get funded as NASA and NSF lead the government-supported effort to explore and understand the universe in space and from the ground, respectively.

I should mention that former ASP Board member Lynne Hillenbrand and former ASP Advisory Council member, the late John Huchra, had key roles in the process. I'm also pleased to say that the report includes a chapter on the value and importance of education and outreach — and I'm further pleased to say that the ASP is mentioned by name.

When my subcommittee meeting was done and I had a few moments of my own, I wandered over to the nearby Air & Space Museum to take in the IMAX movie, Hubble 3-D — the production chronicling the Hubble Space Telescope's wildly successful final servicing mission, which seemed to replace or repair nearly every instrument and major system it had. There was a good crowd for a Saturday (as there always is at Air & Space), and we all thrilled to the big-screen, 3-D exploits of the intrepid crew of astronauts — from the tummy-rattling launch of the shuttle, through the nail-biting difficulties and eventual success of every operation, to the satisfying release of Hubble to go forth and discover once again, and the 3-D tours of some of its latest images of the universe.

As I watched, I was reminded that Hubble was a high priority of a previous decadal survey (as was the James Webb Space Telescope for the decade just past). And that setting strategic priorities really does matter. The process clarifies, focuses, gets spacecraft built and flown, and gets things done.

The same is generally true of strategic planning — of just the sort that your Society has recently embarked upon. About every half-decade, we engage in strategic planning to do much the same thing as the astrophysics decadal survey: to clarify, focus, prioritize, and provide strategic direction in the coming years.

It's a collaborative process, and we welcome our members to give us their thoughts about where they think the Society should be heading in the future and what things should matter most. White papers would probably constitute overkill, but if you have comments, observations, perspectives, ideas, or suggestions, please share them with us at strategic@astrosociety.org. We look forward to your thoughts as we do our “half-decadal” with plans to finalize a new five-year strategic plan around the time of next year’s annual ASP meeting.

We're not trying to build and launch a Hubble or a JWST. But we are looking at how we can, as a Society, best support and serve the cause of astronomy as a vehicle for improving science education, communication, literacy, and an understanding of the fantastic universe that the likes of Hubble (and in a few years, JWST) reveal to us regularly. It's a worthy effort; let's think of how we can accomplish it together! ☑

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JAMES G. MANNING is the Executive Director of the Astronomical Society of the Pacific.
These days it's common knowledge that there are planets around other stars; several hundred have now been found. But 30 years ago none had yet been discovered, and there was much discussion about whether other planetary systems did exist. In *Mercury* for Sept/Oct 1980, David C. Black wrote about this issue, and how it might be approached.

A major question for astronomers was how the solar system formed. Black wrote that: “if we are ever to understand the origin of our own planetary system, we must look for other planetary systems in the hope of establishing, for example, whether planetary systems are a common or a rare occurrence, whether planetary systems are found around single stars or also found around binary and multiple stars, and whether the structure of planetary systems in general is similar to that of the solar system.” Today we have some answers to these questions.

Theories of the solar system’s origin were of two main types. First came the nebular hypotheses, in which the planets condensed out of the same cloud that the Sun was born from. This was followed by the catastrophe concepts, in which the Sun had a near collision with another star. This pulled material out of the Sun, which then condensed into planets.

An important difference between the two hypotheses concerned “the frequency of occurrence of planetary systems. If the [catastrophic] hypotheses are correct, planetary systems are the exception rather than the rule simply because they only form when a very rare event occurs, such as a near collision between two stars. If the [nebular] hypotheses are correct, planetary systems are the rule.” Hence if we could find other such systems, this would support the nebular ideas. But in 1980, “there is currently no unequivocal observational evidence for the existence of other planetary systems.”

Black described two techniques that could be used in such a search. Indirect techniques involved inferring the existence of planets by the observable effects they have on their star. These effects could be either very slight fluctuations in the position of the star, or Doppler effect changes in the star’s speed toward or away from us. As of 1980, observing methods lacked sufficient precision to be able to detect either.

Direct techniques meant looking for radiation from planets around other stars, but the challenge is the difference in relative brightnesses combined with the distance of a planet from its star. A star like the Sun would appear two billion times brighter than a Jupiter-like planet orbiting it, and at 33 light-years away, the planet and its star would lie only 0.5 arcseconds apart. In 1980, this pair of circumstances meant detection of such a planet was not possible.

Future prospects relied on improved instrumentation, both with Earth-based telescopes and with the planned Space Telescope. Black noted that: “The accuracy of the ST’s astrometric systems will be around a milli-arcsecond,” a significant improvement over Earth-based observations. This would make possible the detection of minute changes in a star’s position. (This has turned out not to be the most productive way to find planets.)

Black concluded that, “if we invest even a modest amount of time, thought, and funding into a search for other planetary systems we will be able within a decade to answer one of the most far-reaching questions posed by mankind,” and he looked forward to “the certainty that our discoveries will far surpass our expectations.”

The first definitive detection of a planet outside the solar system occurred in 1992, around a pulsar; in 1995 the first planet around an ordinary star was found. Since then, many more have been identified, and as of October 2010, some 494 such planets were known. Most of these are large, hot Jupiter-like planets, very close to their stars, and 55 are in systems that contain more than one planet. The largest such system, found in 2010, contains seven planets, including one that may be only 1.4 times bigger than Earth.

The most useful method for detecting extrasolar planets has turned out to be the Doppler shift fluctuations in the star’s velocity, caused by the planet and star orbiting a common center of mass. These studies have been conducted with large Earth-based telescopes around the world. In some cases, a planet passing in front of its star (a transit) reduces the incoming starlight by a tiny but measurable amount. The Kepler spacecraft, launched in 2009, utilizes this technique and has identified some 10 planets so far.

Clearly planetary systems are not exceedingly rare, so the catastrophic theories of their formation seem unlikely. New planets are found almost daily. But we are still waiting for the discovery of a truly Earth-like planet.

**KATHERINE BRACHER** 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.
THE YEAR 2009 MARKED THE 400TH ANNIVERSARY OF THE TELESCOPE, and this year we can mark the 300th birthday of a man whose expertise brought the telescope to a new level of refinement. During his lifetime, James Short (1710-68) produced more than 1,300 telescopes — including the world’s largest.

Short began life with a major disadvantage: his parents both died by the time he was 10. In an age of few professional opportunities, his pious grandmother determined he should embark upon a religious career. His studies at the University of Edinburgh fortuitously led him to a mathematical class by Colin Maclaurin (1698-1746), an 18th-century intellectual giant.

By 1732, Maclaurin’s influence had Short engaged in telescope making in the college rooms. Maclaurin neatly summed up Short’s future promise in a letter of 1734. “Mr. Short, who had begun with making glass specula, is now employing himself to improve the metallic. By taking care of the [parabolic] figure, he is enabled to give them larger apertures than others have done; and, upon the whole, they surpass in perfection all that I have seen of other workmen.”

This letter highlights one of the great engineering problems of the age. A glass speculum (mirror) had to be mounted with such care that, despite its weight, it must not bend by more than one ten-thousandth of an inch. When a telescope has a metallic speculum, this matter becomes simplified for it can be cast with grooves and projections in its back to aid in support. A glass speculum was cast flat and usually rested on a metal plate.

Short took advantage of the metallic speculum to build the world’s largest telescope in 1734. Even though the mirror was only 38 centimeters (15 inches) in diameter, this was 10 times larger than Galileo’s telescope, and more than double the previous record-holder, a 15-centimeter (6-inch) telescope made by Edmund Halley in 1721. The fame of this achievement was recognized at the highest level.

Short was lucky to live in an age of enlightenment, when royal patronage could quickly advance a career. Queen Caroline, wife of George II, was keen to have her son William learn mathematics, and she employed Short for this purpose in 1736. It was the profits from this job that launched Short on his future business of telescope making.

By 1740 he had established his business in London, but another decade would pass before he broke his own size record. In 1750 he completed a 0.5-meter telescope. It would remain the world’s largest until 1761.

Another event in 1761 would further immortalize the name of James Short. A transit of Venus occurred just as serious scientific instruments were being created for the first time, and astronomers all over Europe took advantage of this extremely rare event. Short used his mathematical skills to study the data derived from the transit, from which he determined the Sun’s parallax to be 8.666, close to the currently accepted value of 8.794. An accurate value of the parallax made possible the first reliable determination of the size of the solar system.

James Short died a wealthy man in 1768, at the relatively young age of 58, but he was not the only member of the Short family to have a major impact on astronomy. After the death of James, his younger brother Thomas ran the telescope manufacturing business in London. Thomas returned to his hometown of Edinburgh in 1776, where he founded Edinburgh Observatory. This consisted of Observatory House on Calton Hill, with the observatory itself nearby (it was demolished in 1850).

Grand plans for a 48-foot octagonal tower never materialized due to lack of funds, but the scaled-down version of Observatory House became home to the resident astronomer. It was closed to the public in 1820 when a new observatory was built, but the building got a new lease on life in 2010. After a $600,000 makeover, it is now available for holiday rentals.

“The Old Observatory House is probably the finest surviving building by the architect James Craig,” said Edinburgh city councilor Deidre Brock. “The proposal to lease the property will ensure that the newly restored and historically significant house is inhabited again.” Any readers of Mercury who would like to stay there should check out the rental opportunities.

CLIFFORD J. CUNNINGHAM was recently seen on the Battleship Missouri at Pearl Harbor, at a ceremony marking the 65th anniversary of the formal ending of World War II.
Searching for Solar Siblings

By Jennifer Birriel

Evidence indicates that the Sun was born in a cluster, so what happened to its siblings?

For nearly two decades, astronomers have amassed observational evidence supporting the idea that most stars in our galaxy are not born in isolation. Rather, the majority of stars are born as members of a cluster. These clusters have masses ranging from just a few tens of solar masses to as much as 100,000 solar masses. In addition, the mass distribution of stars born within a cluster (the so-called “initial mass function”) appears to be almost universal.

It is likely that the Sun and its planets were born in a star cluster some 4.6 billion years ago. Although long gone, the properties of the Sun’s parent cluster can be inferred using the current physical properties of our solar system. For example, the fact that the planets orbit the Sun in the same direction and nearly the same plane makes it reasonable to assume that the parent cluster could not have been too densely packed, otherwise the planetary orbits would have been disrupted by the passage of a nearby star.

In a 2009 paper, Simon Portegies Zwart used both chemical and dynamical traits of the solar system to constrain the initial mass and size of the Sun’s parental cluster. He determined that the Sun was likely born in a cluster containing between 500 and 3000 solar masses of material with a radius of one to three parsecs. This means that the Sun probably formed in a bound open cluster with a few thousand other stellar companions.

Portegies Zwart calculated the Sun’s orbit backward in time by using its known velocity and the galactic gravitational potential. From this, he determined the birth location of the Sun in the Milky Way. He also calculated the possible locations of the Sun’s lost siblings using a model star cluster with the same properties as the Sun’s birth cluster. Assuming that the parent cluster dissipated along the solar galactic trajectory, he found that one percent of the Sun’s siblings should lie within 100 parsecs of our current location. This number increases to as much as 10% within 1,000 parsecs of the Sun. So, can we find any of the Sun’s stellar siblings? Portegies Zwart expects that solar siblings can be identified, since these stars should remain along the Galactic trajectory of the Sun. Solar siblings, he argues, should have similar orbital properties to the Sun and their chemical compositions should be similar as well.

Recently, Portegies Zwart and colleagues Anthony Brown and Jennifer Bean reported on their first attempt to identify solar siblings using the Hipparcos Catalogue. Based on Portegies Zwart’s earlier work, the group expects that between 100 and 1000 of the Sun’s siblings should be located within 1,000 parsecs of the Sun’s current location. These stars should be located in or near the plane of the Galaxy and should have orbits leading and trailing the Sun’s orbital path. However, they will have to be picked out of a total stellar population of about 100 million stars!

Identifying candidate siblings from this vast population of stars presents quite a challenge. Brown and his colleagues narrowed down the list of Hipparcos candidate stars by first simulating the expected proper motion and parallax of solar siblings. They determined that candidate stars should be limited to nearby stars on almost the same orbit as the Sun. This resulted in only 87 possible candidate siblings from the Hipparcos data. After comparing ages, chemical compositions, and radial velocities of these candidates to the Sun, the group eliminated all but one star. The one possible solar sibling is designated HIP 21158; however, its radial velocity is on the high side.

Finding the Sun’s siblings is fundamental to constraining both the solar birth location and environment. The Hipparcos Catalogue is only complete down to about 7th or 8th magnitude, so the stellar sample is biased to stars greater than one solar mass. In a few years the Gaia mission will provide the critical new data needed to search out the Sun’s siblings. However, the search for solar siblings will also require high-resolution spectroscopic analysis of candidate stars, since the Sun’s stellar brothers and sisters are expected to have the same chemical composition.

JENNIFER BIRRIEL, is an Associate Professor of Physics in the Department of Mathematics, Computer Science, & Physics at Morehead State University. She and her siblings are spread across the country much like the Sun’s siblings are spread across the galaxy.
Suborbital Planetary Science

Getting ready to do space science ‘in the field.’

As a professional planetary scientist I spend a great deal of my research time typing at my computer keyboard — coding numerical simulations, plotting up data, and writing papers to present the results. Oh, and writing proposals to fund it all. A LOT of time writing proposals!

But I’m also extremely fortunate to be able to get very ‘hands on’ with my research as well. I’ve conducted a great many hypervelocity impact experiments to better understand the way asteroid materials respond to shattering impacts. I’ve gone into the field in some pretty remote and exotic locales to gather samples or test new exploration technologies. And I’ve flown some amazing aircraft for observational projects and reduced-gravity research.

Up to now, though, just about every space science researcher like me has done their ‘field work’ here at home — not very far afield, really, in the grand scheme of things. A few highly trained payload specialists have flown in low-Earth orbit, and one very fortunate geologist traveled to the Moon in 1972. But for the most part, those of us in the space sciences haven’t had direct personal access to the focus of our studies the same way that botanists or oceanographers have enjoyed all along.

That’s going to change very soon.

We’re on the heels of a revolution in access to space. This revolution, fueled by billionaire investors such as Richard Branson and Jeff Bezos, is fielding a whole new generation of commercial reusable suborbital vehicles (Virgin Galactic’s SpaceShipTwo, Blue Origin’s New Shepard, and XCOR Aerospace’s Lynx), developed initially with a primary focus on the space-tourism industry. But these vehicles are also now poised to offer researchers and educators frequent (weekly, even daily) and comparatively low-cost (up to an order of magnitude cheaper than conventional sounding rockets) access to near-Earth space.

With routine, gentle rides to space, very ‘clean’, turbulence-free periods of microgravity lasting minutes (rather than the seconds available on parabolic aircraft flights), and the ability of the scientist or educator to actually fly along for crucial hands-on operations of their experiment payloads, these new vehicles are going to provide wonderful complements to the fleet of conventional sounding rockets and reduced-gravity research aircraft that researchers have relied on until now to conduct their experiments. What a great set of ‘training wheels’ for payloads destined for valuable time on the International Space Station.

You can probably pretty quickly think of lots of good opportunities this will offer for life sciences, microgravity physics, upper atmosphere studies, and for testing and maturing new aeronautics and aerospace technologies. But there are great applications to planetary science as well!

I’m an asteroid guy, very much interested in better understanding the unique geological processes that go on in the microgravity environments on the surfaces of small asteroids. Short of actually going to asteroids and conducting in-situ observations and experiments, the next best chance we have to gain the important new knowledge that will better allow us to plan for future human missions to near-Earth asteroids is to simulate those environments right here at home. Some planetary scientists and astronomers are interested in the earliest stages of the accretion of protoplanetary material under similar microgravity conditions. Still others see the opportunity for off-the-shelf telescopes and cameras to observe near the Sun where other space telescopes cannot, and do so at infrared and ultraviolet wavelengths not accessible by ground-based telescopes.

I’m chomping at the bit to get onto these new suborbital vehicles to do my experiments, and I know I’m not alone. Last February, more than 350 people attended our Next-Generation Suborbital Researchers Conference here in Boulder. The meeting was such a success that we’ve planned another for next spring, February 28 to March 2, at the University of Central Florida in Orlando, and we’re expecting even greater attendance.

Imagine a world of pervasive personal spaceflight. What would you do with your time in space? Get ready, because that future starts in just a couple of years.

Daniel D. Durda

Daniel D. Durda is a Principal Scientist in the Department of Space Studies at the Southwest Research Institute in Boulder, Colorado and a member of the Suborbital Applications Research Group, an advisory committee of the Commercial Spaceflight Federation.
Pick up any basic astronomy book, and you’ll read how stars 20 times more massive than the Sun are destined to become black holes. This has been astrophysical dogma for more than 50 years, based on general relativity and subsequent work by the likes of Karl Schwarzschild, Subrahmanyan Chandrasekhar, and Robert Oppenheimer. But determining precisely which massive stars form black holes has just gotten a bit more complicated.

A team led by Simon Clark and Ben Ritchie (The Open University, UK) has determined that a magnetar, a type of ultra-highly-magnetized neutron star, originated from a 40-solar-mass star. This mass is even well beyond the typical wishy-washy astronomy error bars that place black hole progenitors between 10 and 25 solar masses.

The finding raises a multitude of enticing questions: For example, are we vastly overestimating the number of black holes in the universe if we base that number entirely on solar mass? And, does the creation of a magnetar require the presence of an extremely massive star that uniquely sheds its mass shortly before it goes supernova?

Let’s review some basics. Black holes can form from massive stars that have depleted their fuel. These stars burn brightly, thousands of times brighter than our Sun, and quickly, gone in a few million years. Without fuel for nuclear fusion, these stars have no energy to support their mass. The core collapses upon itself, while the rest of the star, through a series of shock waves originating from the collapsing core, explodes outward. This is the supernova event.

If the star’s remaining core mass is more than about two or three solar masses, there’s no stopping the collapse. Gravity takes over, and all the matter collapses onto a point of infinite density, a black hole. Models predict that 20-solar-mass stars blow away much of their mass but still maintain a core exceeding five solar masses and thus collapse into a black hole.

Stars smaller than about 20 solar masses yet a few times more massive than our Sun usually become neutron stars. The core collapse is halted by what is called degeneracy pressure from dense matter resisting further squeezing, in this case neutrons. Neutron stars have strong magnetic fields, in the range of 1012 gauss, millions of times greater than the most powerful human-made magnets.

The magnetar, which admittedly sounds like one of Superman’s foes, is ultramagnetic for reasons unknown, peaking at 1015 gauss. It is rather exotic, too. Scientists have identified only 15 or so.

Clark and Ritchie’s team studied a magnetar in Westerlund 1, a star cluster 16,000 light years away. Well, actually they studied a binary star system called W13 near the magnetar.

The gist is that all stars in this remarkable cluster formed at the same time, about five million years ago. Using the European Southern Observatory’s Very Large Telescope, the astronomers determined that the W13 stars are about 25 and 35 solar masses.

The more massive of the two likely shed five solar masses during the course of its lifetime. Using the logic that bigger stars burn faster, this implies that the magnetar, now past its supernova stage, must have been even larger than 40 masses.

This Westerlund 1 magnetar needed to shed plenty of mass quickly to become a neutron star instead of a black hole, but it did so nonetheless, Clark said. This implies that other massive stars can do the same and that we cannot assume all massive stars ultimately collapse into a black hole.

Less is clear, however, about the conditions needed to create a magnetar as opposed to an ordinary neutron star. As for the environment, “There is gathering evidence that magnetars are somehow associated with massive star clusters in several cases now,” said Kevin Hurley, a magnetar expert at Space Sciences Laboratory at University of Berkeley, California, who was not a part of this latest analysis.

And yet contradictions abound. The rapid mass loss should carry angular momentum away from the star, leaving a more slowly spinning proto-neutron star, which could act against a star becoming a magnetar, Hurley said. “Theoreticians are still divided as to whether the magnetar field is a fossil field, present in the pre-supernova star...or is somehow amplified in a dynamo during collapse.”

“They can also form from much lower mass stars,” said Clark. “The bottom line is that we’re not at all sure what ingredients are required to form a magnetar.”

Hurley agrees. “It’s still pretty mysterious.”

Baltimore-based science writer CHRISTOPHER WANJÉK doesn’t fear that venturing near a magnetar would strip data from his credit card, stating he has nothing to lose.
How do you know if learning is occurring in your classroom? Most of us depend on anecdotal evidence: we perceive students to be engaged or hear comments from students that a class was especially “good.” Eventually, exam scores will tell us how well students mastered certain topics, but that information is too late to affect learning, and grades offer incomplete descriptors of learning.

To really know whether learning occurs, we need to invest in classroom assessment. I choose the word “invest” because assessment is a commitment not only of class time but also in the way we view our interactions with students. All of us will need to embrace assessment as general education committees and accreditation agencies increasingly demand evidence of learning.

Assessment, at first glance, may seem to be another fad in education (e.g., recent metastudies have demonstrated that learning styles are not fruitful constructs for classroom engagement). Not all of us are prepared to spend the energy required to learn how to assess or to give up class time for non-content instruction. And assessment sounds hard: How do I really find out what my students think, short of intensive interviews?

If we’ve had experience with assessment, it usually comes from departmental or program reviews. These self-studies require proof of student achievement, typically summative assessment such as Praxis testing, professional entrance exam scores, qualifier exam scores, end-of-course exam scores, or course grades. For best use, any assessment tool must be studied rigorously to understand its validity and reliability. Interpreting whether student learning occurred using summative assessments is a multivariate analysis that most of us do not have the skills to perform or interpret. And it closes the barn door after the horses have fled — it tells us about past learning but not current learning.

It’s more important to assess the learning of individual students as it occurs. This is the path of formative assessment. Formative assessment is intended to demonstrate to the student (not the instructor) whether he or she has mastered a topic and where difficulties may lie. It is useful to the instructor because timely intervention can occur when students hit bottlenecks.

A key ingredient for successful assessment is to first write educational outcomes. Instead of saying “I want my students to understand stellar spectra,” outcomes are specific items or tasks that can be measured, such as “I want students to demonstrate how to use stellar spectra to determine the temperature of a star.” Clicker Questions are one example of formative assessment tools, but others exist such as a one-minute paper at the end of class, focused listing, preconception checks, and listing the “muddiest point” from a lecture.

Angelo and Cross have produced 50 classroom assessment techniques (CATS) that work in a variety of disciplines and settings. Pick three or four CATS and use them consistently and frequently, so students learn how to use them to shape their learning. Other assessment examples may be found at FLAG, the Field-tested Learning Assessment Guide.

A typical college class period of 50 to 75 minutes may have three to six assessments of various types per session, depending upon the tools used. Do not mix many different types of assessment together in one class. Changing tools frequently creates an undue cognitive load for students. Encourage students to use “writing as thinking” — bullet points, single-word answers, and loose writing structures do not force students to evaluate their thinking.

If you haven’t integrated assessment into your class yet, try a simple experiment for four or five class periods. Hand out index cards at the end of class and ask students to define one concept from the day’s lecture. Alternatively, ask them to describe two take-away points from the lecture. The answers will be illuminating. And may it lead you to assessment as a means to actively shape your course.

DAVID BRUNING is a Distinguished Lecturer at the University of Wisconsin-Parkside. He likes cats of many types.
Instead of stars, of course, the Roman poet Virgil sang of “arms and the man” as he set out in The Aeneid to tell the tale of Aeneas, a Trojan who fled Troy and ultimately founded Rome.

But astronomy has stories of stars — and of men and women.

Greek and Roman mythology give us stories of the men, women, and beasts that they pictured in the constellations. Cultures from all around the world do the same thing. In addition to honoring their heroes, these tales teach ethical values or explain what the teller sees.

Many years ago I was a storyteller, and I became fascinated with the idea of utilizing fictional stories as opportunities to teach astronomy. My friend Tim Livengood, a planetary scientist and storyteller, set out to do this in a more systematic and studied way, bringing both traditional and his own original stories to the classroom. He found mostly acceptance, but some resistance, from teachers in using this approach. While some teachers thought his fictional tales inappropriate learning tools, most accepted the approach.

The advantage is that it provides a “verbal model” in which to organize facts about our surroundings. Scientists are used to mathematical models, or graphical models, or manipulative models. But verbal models, through stories, are one of our oldest forms of trying to understand our world. As Carol Birch and Melissa Heckler write in the introduction to their book, Who Says? Essays on Pivotal Issues in Contemporary Storytelling, “Perhaps stories are a mental opposable thumb, allowing humans to grasp something in their minds — to turn it around, to view it from many angles, to reshape it, and to hurl it even into the far reaches of unconscious.”

In addition to these fictional tales, there are the factually true historical stories behind how we have come to know what we know. At one of the very first story-swaps I went to, one of tellers told a story about the composer Claude Debussy and how he took inspiration from events in his life to compose one of his famous works. I could have learned that in other ways, but the narrative, as an oral talk, brought it to life. The act of telling makes a further connection between the teller, the story, and the listener. It becomes an experience for all three.

Here we can really sing of stars and men and women. Astronomy is filled with tales of men and women struggling to understand the universe. At the ASP meeting in Boulder this past summer, Marcia Bartusiak shared the contorted story of how we came to know that the universe is expanding. Based on her book, The Day We Found the Universe, it is a story complete with twists and turns. It’s about the people who almost make the big discovery but don’t recognize it, and the ones who change jobs (or die prematurely) and so never follow the path of their work to its completion. There also are the profound influences of one scientist on another — either positively or negatively.

As educators, we like to use these stories to teach about the process of science. But when done well, these stories not only say something about science, but something about us.

A good story will literally get to the heart of the matter. When the characters, or the narrator, reflect on the meaning of the actions, the story makes an emotional connection. This meaning may focus on the big question (“What is our place in the universe?”) or an insight into character and motivation, or interactions with another person. It is through this emotional connection that the right story at the right time can change a person’s life.

Finally, there is the personal narrative. Over the years I have collected stories from my colleagues about how they came into this profession. People come by different routes, from those who knew at the outset that this is what they wanted, to those who start as artists. By telling those stories, we help people understand who we are and what we do. And they let people realize (especially young people): “I can do that!”

It’s too clichéd to end this with “Everyone has a story. What’s yours?” But considering the ability that story has to change someone’s life, I just have to say it: Everyone has a story. What’s yours?

JIM LOCHNER is the E/PO lead for the Astrophysics Science Division at NASA/GSFC. He has a few story collections, including his own translation of The Aeneid, in his library.
An Approach to Universal Scale in Observational Astronomy

Our observational astronomy course takes students through a history-laden workout with modern equipment.

Working at Phillips Exeter Academy provides a special opportunity to offer programs unlike many others around the globe. The Academy is a New England preparatory school with slightly more than 1,000 students, 20% of whom are day students, commuting to campus each day and living at home with family. The rest of the student body rooms on campus in one of many dorms and houses, with the faculty and staff acting as their parents, teachers, advisors, and mentors. The school programs encompass all living activities from sports to classes, hobbies and recreation. The astronomy program at Phillips Exeter Academy is strong, with three course offerings available throughout the three-term school year. All courses are taught using the school’s overarching pedagogy, the Harkness Method.

The Harkness Method

More than 75 years ago, Edward S. Harkness made a revolutionary gift to the academy — a new pedagogy. Classrooms no longer have row after row of desks with the teacher at the head of the class behind a lectern. Classes now have a single oval table around which the students and teacher sit, all at the same level, with no head or foot to the table. Rather than use lecture methods, the typical class involves discussion and problem solving to better understand the material assigned previously. A class would unfold as follows:

- Students enter the classroom, sit and chat briefly until all have arrived and the class time begins.
- Attendance is taken concurrently.
- The teacher asks about the prior night’s assignment looking for any issues for clarification.
- Student-led discussion ensues with the teacher acting as a guide, asking key questions, and insuring that understanding is met before moving on to the next problem.

Classes are dynamic, active, and fluid in their direction. The teacher spends a lot of time maintaining a record of the material covered. Often the direction of a class can bounce from topic to topic, learning topics that are essential to the course but not in any pre-determined order. Miraculously, the topics often do come in an order that is well established or even predictable. Sometimes the teacher must put a halt to certain lines of research, as the time is not ripe. More material must be learned to better make use of any new lines of such activity.

An interesting outcome of the Harkness Method is a seemingly backwards method of education. Typical school pedagogy would have a lecture followed by a lab to demonstrate what had just been told to the students, followed by an assessment. The Harkness method strives to teach by experience. Data are collected, and students are asked to determine relationships through their observations. Depth is great.

Astronomy at the Academy

The astronomy content consists of three courses: Astronomy-I, Astronomy-II, and Observational Astronomy. Astronomy-I is offered as a typical Astro 101 course in each of the three terms — fall, winter, and spring. The requirement is a full year of either chemistry or physics. The course covers typical astronomy material in 10 weeks, along with a strong lab component involving the use and operation of telescopes to make visual observations.

Astronomy-II covers the topics of CCD imagers, photometry, astrometry, and an introduction to variable star astronomy. Astronomy-II and Observational Astronomy both require that a student has taken Astronomy-I. These two courses are project based.
The instructor takes a week or two for various classroom topics, and data are collected electronically (CCDs, spectrographs, etc) for later evaluation and processing in class. Observational Astronomy is the capstone course in many ways and the one I wish to share with you in greater detail. Here students learn about the cosmic distance ladder in a very personal manner.

The Observational Astronomy course takes students through a history-laden workout with modern equipment. The goal is to teach students about how astronomers make the observations they do, and how conclusions are reached from years of evidence and data. The course begins with a refresher discussion about CCDs, filters, and telescopes. The opening lab activities include imaging the season’s available open clusters, nebulae, and asteroids. Discussion then heads towards the first basic of the cosmic distance ladder, the Astronomical Unit, and how we can use the small-angle formula to make measurements to various nearby astronomical objects. While we cannot use radar to measure our distance to Venus, we can image asteroids, and that turns into an activity in which orbits are calculated and the distance to the asteroid also calculated.

By now students have an understanding of parallax, and it is time to bring in the inverse square law of apparent brightness and use this to determine distances to open clusters within our galaxy. Students use B and V photometric filters to image the clusters, then plot a color-magnitude diagram, which in turn allows them to calculate a distance to the cluster by taking into account the shift of the cluster’s main sequence due to distance and interstellar reddening. This process takes time! It is not uncommon for a solid week to go by before all the images are taken (weather concerns) and discussions conclude with a process.

Along the way, students begin to wonder how astronomers find the distances to unresolvable objects, namely galaxies outside of our own. Teams of students work at the observatory honing their skills at photometry. Little do they know that throughout the term, they have been imaging Cepheid variables. Given enough clear nights and data, light curves can be created, and students can use the period-luminosity relationship to find the distances to these stars. The physical processes involved are also taught, key among them the Eddington Valve process. Granted, we do not have telescopes of sufficient diameter to resolve Cepheids in galaxies other than our own, but the technique is the same.

The course’s end takes us through the last remaining dependent methods: Tully-Fischer and Faber-Jackson Relationships and the use of Type Ia supernovae as standard candles. Once again, we are limited by equipment and time, but data from external sites can be used to demonstrate the methods and allow students the opportunity to get buried in mounds of information.

While students are learning the principles of astronomy and the scale of the universe, they are also learning skills as science researchers. Students learn about data collection and handling with modern equipment used in today’s observatories. Granted, we’re not a large-aperture facility on a mountaintop, but the methods are similar. Students learn to work in teams in a fast-paced environment with constantly changing goals, a situation that they will undoubtedly run into throughout their lives in many professions. Perhaps that is the real key!

Not many students will go on to become astronomers, physicists, or even scientists, but they leave with an appreciation of the processes and dedication that scientists have for their field. I cannot think of a better way to promote science — show its importance, and know that future generations appreciate it.

JOHN A. BLACKWELL is the Director of the Grainger Observatory and Instructor in Science, Phillips Exeter Academy. He is also the winner of the ASP’s Thomas Brennan Award for 2010.
Posters From Boulder

by Paul Deans

One of my particular pleasures at conferences is browsing the poster papers. Unlike the workshops and the oral presentations that come and go (often with the most interesting sessions running concurrently), the posters are available for perusal for the entire day; sometimes for the entire conference.

I’ll often slide into the poster-paper site early in the morning, quickly browse through them, note the ones of particular interest, and then go back later to examine them in detail and talk to the author. It’s a great opportunity to talk one-on-one with scientists and researchers — some well established, others just beginning their careers.

In the issue of Mercury that immediately follows each annual meeting of the ASP, I like to include material from the conference. My goals are to bring back good memories for those who attended, provide a small sample of what went on for those who didn’t, and shamelessly plug the Proceedings from the conference and, in this case, promote the proceedings from the Cosmos gathering, both of which will be appearing next year.

At the 2010 ASP conference in Boulder, I was delighted with the assortment and quality of the posters, which is why you’ll find on the following pages (in alphabetical order by lead author) 11 poster papers from that meeting. There were 120 posters in the two meeting streams (Education and Public Outreach and Cosmos in the Classroom), so the contents of this issue is merely a small sample of what was available at the conference.

Finally, a couple of brief editorial notes. A few of the posters have been edited for length. Also, some of the images that originally appeared in several of the poster papers were excluded (also due to length), while a few images that were not included in the original posters have been added.

At the end of each poster article you’ll see “RETURN” as a hotlink. Click on it to come back to this page and the Table of Contents for the posters.

I hope you enjoy this snippet from the Boulder conference. And don’t forget to keep an eye on the ASP’s website for the publication of both the E/PO Conference Proceedings book and the Cosmos in the Classroom papers (as either a book or a CD-ROM), though neither item will be available until sometime in early 2011.

With 120 poster papers, the poster and exhibit hall at the ASP’s annual meeting in Boulder, Colorado, was always a busy place.
“Extreme” Inquiry-Based Learning: Engaging Non-Science Students with the WOW Factor and Science Portfolios

by David Baker, Physics Department, Austin College, Sherman, TX

Introduction

One of the greatest challenges we face today as science educators is to engage non-science majors in the scientific process. Unfortunately for many students, science can be dry and boring.

Austin College offers a freshman seminar course in which the instructor serves as the students’ academic mentor for the next four years. Each 20-student section has a different academic topic from the humanities, social sciences, or natural sciences — our section explores “The Most Extreme Places in Our Solar System.” We present two unique, inquiry-based approaches that stimulate non-science undergraduate students to overcome their fear of science:

1) an engaging, nontraditional course topic with a WOW factor,

2) Science Portfolios that encourage students to do their own science.

Extreme WOW Factor

Surprisingly, the majority of students in this science class are non-science majors — the WOW factor draws them in. Rather than a standard tour of the solar system, this course explores the most extreme places, including cool stuff like “The Incredible Shrinking Planet,” “Best Vacuum Cleaners,” “Stinkiest Place,” “Shocking Superbolts,” and “Life in the Dark.” We use a recent popular science book appropriately titled The 50 Most Extreme Places on Our Solar System (D. Baker and T. Ratcliff, 2010, Harvard University Press, Boston, Mass., 304pp) as the “textbook.”

Each student investigates a specific phenomenon (e.g., climate) and writes a research paper on extreme examples (for instance, the runaway greenhouse of Venus, the climate extremes of Mercury, and the bizarre seasons of Uranus). Each student essentially becomes an extreme expert. Then, working with other students, these “extreme scientists” try to convince a mock NASA panel where to focus its next spacecraft mission.

Extreme Science Portfolios

The extreme learning doesn’t stop there. Science Portfolios utilize a true inquiry-based learning approach. Students document their own observations, ask their own scientific questions, develop their own hypotheses, design their own experiments, and evaluate their scientific growth. It is an open-ended exercise with few constraints. Talk about extreme: students are answering their own questions, not questions deemed important by the instructor.

Each student portfolio must contain examples in each of the following four categories:

• Observations of Science in Everyday Life
• Scientific Questions and Hypotheses
• Use of the Scientific Method in Everyday Life
• Personal Scientific Growth

The effectiveness of Science Portfolios has been assessed with pre-/post-surveys, focus groups, and the portfolios themselves. The results are impressive. At first, students are hesitant to take scientific risks — their confidence is low. But as the semester progresses, they develop as scientists and obtain ownership of their learning. As one student remarked, “After starting this portfolio, I realized that it is fun to try to figure out things myself...it feels like I am following the ways of great scientists.”

Implementation in Larger Courses

These techniques can be implemented in courses with enrollments larger than 20 students, with some modifications. Extreme subject matter can still be the topic of the course, but the scope of research papers and presentations to a mock NASA panel would need to be reconsidered.

Similarly, Science Portfolios could possibly be scaled back to include examples in only the first two categories (Observations of Science in Everyday Life and Scientific Questions/Hypotheses). Nevertheless, these approaches — even in modified form — would likely resonate with non-science students and help make science more exciting and meaningful.
Teaching Astronomy a New Way: Cultural Astronomy

by David Bruning, University of Wisconsin-Parkside, Kenosha, WI

Cultural astronomy is an interdisciplinary approach to teaching astronomy that presents astronomy in its cultural context. As a general education course, this approach appeals to a broad range of students who perceive traditional Astro 101 courses as too scientific, too mathematical, and not relevant to their everyday lives. While one can argue that it is our job to help students see the relevance of modern science to the world around them, Cultural Astronomy hasn't needed such marketing. Even its first semester, the course filled during pre-registration and has remained over-subscribed ever since.

What is Cultural Astronomy?

This is not archaeoastronomy. While Cultural Astronomy looks at building alignments, pictographs (early writing forms), petroglyphs (rock art), and other archaeological evidence, the focus is the culture of the people and how astronomy helps define that culture. It is this holistic view of a people that engages students in the course, even when discussing the purely astronomical parts of the course.

Showing students how people use astronomy in a cultural context becomes a transforming moment and allows non-science students to engage science in a different way.

My university regulations require that I focus primarily on Native North Americans, but this is not a restriction as there is great variety among the astronomies of the Absaroka, Diné, Hopi, Hopewell, Inuit, Iroquois, Lakota, N'deh, Native Hawaiians, Ojibwe, and Tski’ki (I have a bibliography of references for Native American astronomy). Even with this cultural subset, one can quickly get bogged down in the course trying to treat culture, history, migrations of people, economies, rise of civilization, emergence stories, the role of religion in society, the development of astronomy, sky motions, navigation, and the myriad other topics necessary to link cultures and astronomy.

Bringing it All Together

A course such as this needs a “story line” or an organizing principle to make sense of the disparate topics. While there may be several different themes that one could pick, I chose “the production of food” as the unifying topic. Tracing the development of food crops allows one to follow the growth of astronomy from the stellar astronomy of hunter-gatherers through the solar astronomy of fixed villages (fixed agriculture) to the complex astronomy of city-states (organized agriculture). Writing develops as trade increases in the city-states, enabling astronomers to record complex planetary motions and eventually develop models.

Class activities include cultural activities, such as learning tribal names for themselves, sky motions, the use of starfinders, the development of calendars, and navigation. One math activity uses Mayan mathematics to introduce the invention of “zero” by the Maya and to demonstrate the Long Count used in the Mayan...
calendar. The most successful assignment I have used in this class requires groups to create a local Wiki page about the astronomy of a Native culture. Students often remark that having to immerse themselves in one culture and its astronomy was the most meaningful part of the course.

Teaching a Cultural Astronomy course, like many things, has pros and cons. Cultural Astronomy pushes your skills because the interdisciplinary nature of the course requires that you teach anthropology, astronomy, sociology, the history of science, and perhaps diversity topics, all rolled into one. Mastering many different aspects requires considerable preparation and a willingness to explore the ideas of culture, diversity, Native religions, Native viewpoints, historicity, and many other topics far from the HR diagram and the inflationary universe. One must learn many new cultural rules, such as not mentioning the names of the dead, not mentioning constellations or stars when they are not visible, and learning what knowledge may be shared, to name a few. To be honest, if they were just rules, students would lose patience, but explaining the cultural reasons for the rules helps them understand and encourages them to explore their own culture more deeply. The same respect applied to creation stories has won greater exploration of Genesis and scientific origins by students than seemingly more straightforward discussions of creationism.

Why Teach It?
Despite the additional burdens in teaching cultural astronomy versus Astro 101, the rewards are many. Students engage this course more easily than Astro 101, student demand is high, and students appreciate the interdisciplinary nature of the course. Several students each term mention that this is the most inspiring class they have ever taken (a comment I have rarely heard in my Astro 101 course). Students interact with you in entirely different ways than you have experienced with traditional astronomy classes.

For those of us who believe that Liberal Education is a vital part of training our next generation of leaders, cultural astronomy provides a marvelous avenue to introduce the interdisciplinary work that students wish to experience.

The Use of Archived Astronomical Images as a Vehicle for Introducing Scientific Methodology to Non-Scientists

by Benjamin F. Griego Jr. (Colorado State University), Roger B. Culver (CSU & GNAT), Eric R. Craine (CSU, GNAT, Western Research Co.), and Roy A. Tucker (Goodricke-Pigott Observatory)

While Americans have become voracious consumers of technology, their younger generations have increasingly withdrawn from technology-based careers. Technology is more important to our culture than ever before, but our ability to produce it is being usurped by other countries. Indeed, the average growth rate of patented technology has stagnated at 3%/yr in the United States (1996-2005), while rapidly growing over the same period in Asian countries such as South Korea (40%), China (33%), and India (26%).

Further, enrollments in science, technology, engineering, and mathematics (STEM) university degree programs are encompassing increasing numbers of foreign students. Unlike years past, when these students aspired to remain in the United States and be absorbed into the domestic job market, more are now returning to their native countries, where their American technical educations are employed in competition with American productivity, a source of major concern for domestic industry.

In addition, standardized testing indicates that science and technology literacy in the United States is well below that of other developed countries, and even below that of some emerging third world countries. The recent result from the 2006 Programme for International Student Assessment showed K-12 students from the United States ranked 22nd of the 40 participating countries in scientific literacy and in understanding how science itself operates.

Equally frustrating is the state of science and technology literacy among adults. Myriad public opinion polls taken over the past decade indicate a disturbing lack of scientific literacy on the part of the American public. An NSF survey of 1,574 adults conducted in 2001 indicated that only 48% of those surveyed believe that the dinosaurs predated humans in Earth’s geological history, and 30% believed that the Sun orbits Earth. A Gallup poll conducted in 2007 found that 44% of the respondents did not accept the concepts of evolution. A Yankelovich Partners poll conducted in 1997 indicated a significant increase in paranormal beliefs in the years 1976-97. This upward trend seems to be continuing in the years since. Fully 48% of the respondents to a 2002 Roper poll believed that “UFO’s have visited the Earth in some form over the years.”
It is thus clear that there exists a need for providing meaningful and productive STEM educational outreach to teachers, students, and the adult community at large. The protocols described below provide one approach to this end.

The GNAT Archive
The Global Network of Astronomical Telescopes (GNAT) has, for the past 10 years, worked with the Moving Object and Transient Event Search System (MOTESS) to undertake a large-scale digital sky survey directed primarily at discovering and characterizing variable stars.

The Present Project
Described below is a protocol designed to acquaint any individual with many of the important aspects and techniques involved in the scientific process, again using the MG1 database as a resource. Many objects listed in the Washington Double Star Catalogue (WDS) have been captured by the MG1 observations. We have developed procedures designed to take an individual through a start-to-finish procedure in which WDS systems captured in the MG1 catalogue are identified, and finder charts are prepared for each of the identified systems. Follow-up data are then either directly obtained by the individual or, more likely, presented to the individual in the form of raw image data. The individual is then shown how these raw images are calibrated before final position angles and separations are measured for each system. Having completed these reductions, the individual then proceeds to the final steps necessary prior to the submission of his or her results for publication.

Narrowing the Database; Constructing a Finder Chart
One of the important aspects of scientific data reduction is the management of large amounts of data. In our procedure, the individual is able to gain experience in this regard by sifting through the WDS Catalogue, which contains more than 100,000 objects and is available online. Matching an MG1 image to a known WDS entry is accomplished by having the individual first narrow the WDS data set to those objects which are located in the aforementioned MG1 strip of sky centered on DEC = +03° 18’. Next, a faintest-magnitude limit is placed on the remaining objects as a final condition for selection or rejection. The result of this data-handling procedure is to generate a list of WDS objects that should have been captured on the MG1 image set.

The next step in the procedure is the construction of a finder chart for one or more of the WDS objects from the preceding list. This is accomplished by using the online resource Simbad, allowing the object to be sought out from the WDS coordinates. In this pro-
cess the individual becomes acquainted with the subtleties of producing an astronomical finder chart, such as the image scale and orientation. Such finder charts are necessary for any follow-up observations that may be attempted.

**Calibration of Images**

An important factor in the reduction of a scientific data set is the recognition and correction of a variety of instrumental and other factors that may corrupt the final data output. Numerous GNAT follow-up observations of WDS objects located in the MG1 data base have been made, or conversely could be made by a given individual. In the former instance, MG1 images can be provided to the individual for analysis. For more sophisticated individuals with access to appropriate instrumentation, follow-up observations can be made and images generated by that individual.

Once the images are in hand, corrections must be made to remove the factors caused by the camera that corrupt the camera image. These include different zero points (bias), dark currents, and sensitivities among camera pixels. There are a number of commercially available software packages that can deal with these calibrations. The package used in this project is *MaxIm DL 5*, which offers relatively straightforward procedures for correcting images for the effects of bias using a zero dark-exposure frame or bias frame; dark currents using a finite length dark-exposure frame or dark frame; and variable pixel sensitivity using a uniformly illuminated frame or flat frame. These three basic image corrections provide an excellent illustration of the sorts of corrections that must often be performed on raw scientific data.

**Double Star Measurements**

The final measurements of the position angle and separation of a given double star can be done using a relatively inexpensive online software package called *MPO Canopus*. Once the calibrated image(s) from above are loaded into *Canopus*, the target object can be readily located using the finder chart(s) previously prepared, and the measurements of position angle and separation can be easily made for each image of each object (see the image at the bottom of the previous page).

The final result of this step is the generation of a series of separation and position angle values for a given star or set of stars which provide the opportunity to illustrate another important aspect of data reduction process in science-error analysis. By going through such an error analysis, the individual comes to have an “up close and personal” feeling for the accuracy of the data that has been reduced.

**Preparation of a Manuscript for Publication**

The capstone in the process of the analysis of scientific data is the preparation and organization of the data into a manuscript suitable for publication. The GNAT double-star data are once again well suited for this aspect of the process. Many of the objects listed in the WDS have not been observed in decades, and thus our data set from the MG1, plus our follow-up observations, provide an opportunity to publish useful observed data on these neglected double stars. Moreover, the time interval between the first MG1 images and the most recent follow-up observations of these objects spans nearly a decade, thus making the data set even more valuable from the standpoint of possible orbital analysis. As the final step in this program, the individual, under the guidance of a mentor, will be expected to prepare a summary of their work suitable for publication in an appropriate journal such as the *Journal of Double Star Observations*.

**Acknowledgements**

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**The Ultimate Astronomical Field Trip: Observing Experiences for Teachers**

*by Mary Kay Hemenway (University of Texas at Austin) and John Lacy (UT at Austin)*

**Abstract**

Since January 1998, a group of Texas grade 6–12 science and math teachers have met several times per year to learn first-hand about scientific instrumentation and its use. They followed the development of the SOFIA Echelon Cross Echelle Spectrograph (EXES) and its prototype ground-based instrument TEXES.

In addition to learning about the technology of astronomical instrumentation, they explored scheduling and preparation for observing runs, as well as a wide range of astronomical topics. Participating in observing runs with TEXES at Gemini North and the NASA IRTF in Hawaii provide the ultimate field trip. The participants report their increased knowledge of astronomical concepts and
of the culture of professional astronomy. The participants have shared their experiences with each other, other teachers, and their students.

Support from the National Science Foundation AST-0607312 is gratefully acknowledged. All images in this article are courtesy the University of Texas at Austin.

Topics and Evaluation
The topics that teachers reported they use in their classrooms included:

- wavelength of light
- atomic theory and quantum mechanics in chemistry
- atmospheric hydrocarbons
- spectrograph resolution
- telescope and optics.

Use in secondary school classrooms included:

- designing an activity on active optics
- designing an activity on multi-wavelength astronomy
- designing an activity on analyzing infrared spectra from line tracings
- designing an activity comparing telescopes of different sizes.

Eight of the ten teachers completed evaluation instruments. They reported moderate to great agreement with the following statements:

- It increased my confidence in myself as a teacher.
- It elevated my enthusiasm for teaching.
- It increased my interest in research and the ways that science, mathematics, or technology can be applied.
- It stimulated me to think about ways I can improve my teaching.
- It increased my interest and ability in networking with teachers and other professionals.

Sample Teacher Comment:
"The main points I took away from my trip to the IRTF were the collaborative nature of research and a greater appreciation for the applications for spectroscopy. On our first night, we had a researcher from Paris using data from TEXES to determine the velocity of winds in the middle atmosphere of Saturn. Matt Richter from UC Davis had the job of managing the TEXES instrument to collect the needed data. The IRTF telescope operator managed the operation of the telescope itself. The second night we started looking at emission spectra from Titan’s atmosphere with an astronomer visiting from Korea. The image of the lone scientist quietly working at the telescope was definitely changed. Seeing the actual uses for spectroscopy will also enrich my explanations for my classes."

Participating Teachers

- Sherrie Boothman — high school/Austin
- Natascha Cox — middle school/Friendswood
- Quentin Donnellan — high school/Keller
- Karen Green — high school/Lago Vista
- Wade Green — high school/Round Rock
- Jody Harkrider — high school/San Antonio
- Kelley Janes — high school/Austin
- Dee Dee Senglemann — high school/Shiner
- Hepsy Singh — high school/San Antonio
- M. J. Tykoski — middle school/Wylie

TEXES, the Texas Echelon Cross Echelle Spectrograph is a high-resolution (~100,000) mid-infrared (5-25 micron) spectrometer. The detector is a Raytheon 256-by-256 pixel Si:As array, the same type of detector that is used in Spitzer Space Telescope. TEXES is shown in the lowest cage on Gemini North telescope in Hawaii.

M. J. Tykoski, middle school teacher, is above the clouds.

Astronomer Matt Richter (UC Davis) describes his research to Wade Green and Kelley Janes.
Astronomy EPO and the 2012 Hysteria: Your Personal Guide to Joining the Battle

by Kristine Larsen, Central Connecticut State University, New Britain, CT

Introduction
By now everyone in the astronomy EPO community has come face to face with the 2012 phenomenon: the widespread belief that the Maya calendar forecast something cataclysmic occurring on December 21, 2012. As educators and ambassadors for astronomy to the general public, it is our duty to combat the ignorance and misinformation head-on, bringing to bear our years of experience in working with the public and debunking pseudoscience.

Make no mistake: the war symbolism in this poster is intentional. We are in a battle for the hearts and minds of the general public, and if the 1910 apparition of Halley’s Comet and the 1997 Heaven’s Gate cult mass suicide demonstrate, real lives may be on the line. This poster seeks to educate EPO specialists on what they can do to join the fight.

Gather the Troops
All of us in the astronomy EPO community have a role to play. From teachers and professors to planetarium and museum staff, graduate students and researchers to professional organizations, there are still far more potential victims of the 2012 hysteria than there are of us. Regardless of our specialties and resources, we can all join in the campaign to replace ignorance with enlightenment. All it takes is time and effort.

Work With Our Allies
Astronomy is not the only target of the 2012 pseudoscience proponents. In their effort to sell books, movies, and generally garner attention, they also misuse, misinterpret, and mutilate geology, anthropology, archaeology, statistics, and history. Therefore, working with colleagues in these areas will not only add to our numbers but will increase our own education on the truth behind the rumors. 2012 is an interdisciplinary fraud: combating it effectively will take an interdisciplinary approach.

Know the Enemy
In addition to the literally hundreds of books and thousands of websites making extraordinary claims about what will supposedly occur in 2012 (and offering to share their secret knowledge of how to survive the cataclysm for a mere $19.99), movies such as 2012, 2012: Supernova, and 2012 Doomsday entertain while propagating a variety of pseudosciences (and in some cases extreme religious viewpoints). Cable channels such as the SyFy Channel and National Geographic Channel have broadcast “documentaries” on 2012 of varying quality (the accuracy of the facts usually being inversely proportional to the amount of hype used to sell the program).

While all of these have played a significant role in promulgating the misinformation that is central to the 2012 phenomenon, by far the greatest source of misinformation and hype is The History Channel.

Programs such as “Doomsday 2012,” “Nostradamus 2012,” “Mayan Doomsday Prophecy,” and “Apocalypse Island” have spread the 2012 disease to countless viewers, reinforcing the misinformation peddled by the Internet and vanity presses.

As part of our preparation to take on the 2012 hoax community, we should not only familiarize ourselves with the variety of erroneous materials out there, but also actually bite the bullet and read and view some of this dreck. In this way, you can debunk in good faith and when someone asks if you’ve actually read/viewed some of it, you can confidently answer in the affirmative.

Arm Yourself With the Facts
In order to effectively debunk a pseudoscience, you must know its claims and why those claims are false. In the case of the 2012
hysteria, it seems there are new claims being made every day. Some of the most common (all of which are false) are:

- The Maya calendar will end on December 21, 2012.
- The Maya calendar predicts the end of the world on December 21, 2012.
- The Bible and/or Nostradamus predict the end of the world on December 21, 2012.
- On December 21, 2012 we will be aligned with the center of the Milky Way. Such an alignment will have a harmful effect on Earth.
- The polarity of the Earth’s magnetic field will suddenly shift in 2012. This will cause a shift of the Earth’s rotational poles (or stop the rotation of the Earth altogether).
- Alternate claim: the outer layers of the Earth will slide over the core, causing penguins and polar bears to switch geography without migrating (as portrayed in the film
- Scientists have evidence that a supernova will fry Earth in 2012.
- Yellowstone will have a massive eruption in 2012, plunging the world into a nuclear winter.
- Scientists have evidence of a “missing” planet named Nibiru which was known to the ancient Sumerians and which will either hit Earth in 2012 or affect its tilt/rotation.
- There will be a solar maximum on December 21, 2012, which will be the greatest on record and will fry the Earth.

For a crash course on these and other 2012 claims, visit 2012hoax.org, the granddaddy of all 2012 debunking sites. Inherent in most of these claims is a grand conspiracy theory involving the government and scientists (who, after all, always keep vital information from the general public). This leads us to the next point …

Avoid Civilian Casualties

Remember, our goal here is to educate the general public and, equally importantly, assuage their fears concerning 2012. In the process, we do not want to turn them off to science, or even worse, deepen their belief in the 2012 hysteria by unintentionally convincing them that we are a part of the very same conspiracy the enemy is warning them of. In order to do this, our tactics must include the following important philosophies (all attempts at humor will be avoided for the moment):

Be honest. You cannot promise someone that the world won’t end. What you can do is explain that there is no evidence to support the claims of the 2012 proponents. For example, you can explain why scientists are convinced that Nibiru does not exist as claimed, and that even if it did, there is no way within the laws of physics that such a huge, undetected object could make it to Earth’s orbit from the outer solar system in two years.

Be understandable. When communicating with the general public, it is vital to be clear, concise, and comprehensible. Avoid jargon at all cost and concentrate on the heart of the matter.

Be patient and empathetic. Treat all questions with respect and seriousness, no matter how absolutely ludicrous you know them to be. If it matters enough to John Q Public to ask you, it matters enough for you to provide a serious answer. Remember — part of successful debunking is learning what misinformation is circulating in the public consciousness, and what better way to collect this information than to collect questions? Finally …

Stick to the Science. A great deal of New Age philosophy has been interwoven with the pseudoscience of 2012. You gain nothing by trying to debunk claims such as “the collective consciousness is moving towards a harmonic convergence,” but will gain a great deal of trust, good will, and “street cred” with the general public by openly refusing to fall into this trap. By admitting that such claims are out of the realm of science, and hence you can’t make any statements about them, you avoid becoming the annoying stereotype of the “uber skeptic” who feels the need to attack religion and spirituality. Channel your inner Stephen Jay Gould and resist the urge to comment on nonscientific claims.

Finally, we come to the most important part of the battle …

Choose the Weapon That Suits You Best

The astronomy EPO community is filled with individuals of varying experiences, talents, and resources. Therefore no one activity suits each EPO practitioner. Conversely, there are so many ways that one can become involved in this battle that it is unrealistic to expect a
single individual to do everything. Below is a sample of concrete ways you can help stamp out the 2012 hysteria:

1) Include a 2012 FAQ on your personal, institutional, or facility website. Alternately, set up a page of 2012 weblinks for interested patrons and students.

2) Write and produce blogs, podcasts, and newsletter articles for the general public about 2012.

3) Develop planetarium shows, public library talks, and press releases debunking the 2012 hoax. Work with colleagues in other affected disciplines wherever possible.

4) Approach the local media (TV, newspaper, and radio) about doing a story on the 2012 phenomenon.

5) Educate your colleagues about this problem, through professional organizations and meetings, as well as local gatherings (including other affected disciplines).

6) Contact your local school district and offer to give teachers a crash course in 2012. They have questions, and you want to make sure they are passing along the right information to their students when they ask questions.

7) Answer every phone call and e-mail about 2012 that you receive from the general public. If you are deluged, have a standard referral to your website.

8) Join 2012hoax.org

The 2012 hysteria is not going to diminish until at least December 22, 2012. Each of us has a part to play in combating this threat to the public's relationship with the cosmos. NASA astrobiologist David Morrison put it bluntly: “This cosmophobia could be one of the worst long-term consequences of the 2012 doomsday hoax — to make people fearful of astronomy and the universe.”

As astronomy EPO specialists, we must become involved. If not us, who? If not now, when? ■ [RETURN]
What They’ve Always Wondered: Questions Students Ask on the First Day of Astro 101

by Kristen A. Larson, Western Washington University, Bellingham, WA

Abstract
Tapping into students’ native curiosity is one of the most effective ways to motivate students in an introductory astronomy course. I present the results of a multi-year campaign to collect one question about astronomy from each student at the first lecture of a large, college-level astronomy course for non-science majors. I show how the questions that students submit not only identify which topics interest them, but provide insight into their concepts of what astronomy is and their understanding of the nature of science itself.

The Questions
“Astro 101” courses introduce college students to astronomy. At Western Washington University, a public comprehensive masters-level university, the course is called ASTR 103 and is taken by undergraduates to satisfy part of their general education science requirements. The course is explicitly not intended for science majors, although future elementary science teachers have often taken the course. The course is taught unassisted by an instructor to 150 students in lecture format over a ten-week term.

Starting in Fall 2002, I took roll on the first day of class by asking students to submit a piece of paper with their names and one question they have about astronomy. In this work I compile, categorize, and evaluate more than 800 questions from students asked in six different terms, ending with Winter 2009.

Questions by Topic

80% of the questions were within science. Examples: Can gravity bend light? How can we see objects that no longer exist? Is the universe expanding? How do we know how old the universe is? Why can’t we find a large fraction of the universe? What is a nebula? What is a quasar? What is pulsar? Where does a black hole go? How does a black hole work? What is the farthest galaxy? How are galaxies formed? How is it that we have pictures of our galaxy even though we can’t travel out of it? How are stars formed? Why do stars burn out? How do we know the age of stars? How do we know the makeup of stars? How many stars are there? Why do stars form in clusters? How fast is the Sun burning up? Why is our Sun the color it is? How do we discover other planets? How many solar systems are there? What keeps the planets spinning? Why can’t Pluto be a planet? What effect does the Moon have on the Earth? Why do stars twinkle? Why do stars fall? What causes the aurora borealis? Why is the sky black?

20% of the questions were beyond science. Examples: Why is the 13th zodiac constellation ignored? Who names constellations? Do all constellations have mythical meaning? Are we alone in the universe? What are the chances of intelligent life elsewhere? Is astronomy an extremely difficult subject to learn? What is the most important thing in astronomy? What is the largest telescope in the world? Who came up with the Big Bang theory? How can we comprehend the size of the universe? Why do stars exist? How is it possible for scientists to be so sure of things? Could evidence for dark matter be proof that there is a God? What could a graduate of this class say to a creationist? Did the US really make it to the moon in 1969? What is the future of the Hubble telescope? What is the purpose of deep space exploration when we can’t get there or change it? What careers are in astronomy? Are the planets in the Star Wars movie based on real planets? How long can someone survive in space? Will humans live on Mars soon?
Observed Patterns

Within Science vs. Beyond Science:

The full range of topics within the science of astronomy is well spanned by student questions (see the sidebar Questions by Topic on the previous page). Many of the questions that students ask, however, are not about science. Questions on topics such as history, culture, and philosophy are important questions, worthy of study and discussion, but are not within the bounds of science.

Many students misunderstand what science is and what the boundaries of science are. In our classes, how do we teach students what astronomy is and what it is not? Furthermore, how do we honor the questions that are beyond science and use them to engage students?

Understanding vs. Facts:

Students still often see science as stamp collecting. Questions that ask for a tally or a location or a name have one-word answers and do not get at the heart of the most interesting parts of astronomy. The most common questions were “How many ____ are there?” I separate these kinds of questions, the fact questions, from the questions such as “How does ____ work?”, the understanding questions (see the sidebar Questions by Type at right).

It is encouraging to see not only how many of the questions students ask are about how the universe works, but that the questions on topics within the boundaries of science are more likely to seek understanding that the questions beyond science. This is our opportunity as instructors, to tap into that native curiosity. In our courses, how do we minimize astronomical fact acquisition and emphasize gains in understanding? How do we move from “What is the nearest star?” to “How do we know how far away stars are?”

Future Work

Prior Knowledge and the Media:

Some students who have some knowledge about astronomy seek to fill the holes. The media can spark interest in astronomy but can also breed misunderstanding and resentment. How do we convince this generation that astronomy matters?

Syllabus Evolution:

Students are anxious about physics but still want to know about it. Astronomy is still, and will be for some time to come, about stars. Cosmology will always be important for asking the big questions, but exoplanets are becoming the new black holes. How do we keep our astronomy courses flexible enough to change with the times?

Conclusions

We must find a way to address the questions that students wonder about to keep them engaged, but we must draw a firm box around science to differentiate it from all that is beyond science. We must resist the temptation to let students collect facts, and must demonstrate with our coursework that astronomy is about asking how and how we know.

In this work, I show that 80% of my students are asking science questions about the range of topics typically included in “Astro 101,” and 60% of those are seeking understanding about physical processes and methods of discovery. Their questions continue to teach me about my own values, too. Try it for yourself! □ [RETURN]
The history of astronomy can enhance students’ understanding of science and the nature of science by highlighting not only the science but also the story of how we know what we know. We have embodied the past 100 years of discovery about the nature of the universe, from Einstein’s formulation of gravity to the discovery of dark energy, into Cosmic Times, a suite of curriculum-support materials.

The materials can be used with existing Astro 101 topics to provide historical context or to solidify specific scientific concepts. Or the materials can be combined to trace one of the dominant Cosmic Times themes. Or, taken as a whole, Cosmic Times provides a modern cosmology framework around which an Astro 101 course might be taught. This framework combines history, science, and science readings to give students a firmer grounding in the science and the process of science.

What is Cosmic Times?

Cosmic Times is a suite of curriculum materials that examines cosmology during the past 100 years. The centerpiece of Cosmic Times is a series of front-page newspapers tied to key moments in this history, with articles written to trace three themes: our evolving understanding of the expansion of the universe, the changing cosmic distance scales (and how we measure them), and the nature of supernovae. Each issue of Cosmic Times is accompanied by four to five lessons, which reinforce key science concepts, highlight the process of science, and underline social aspects surrounding the scientific events. This suite of materials was designed to be modular, allowing instructors to use some or all of the articles and lessons in the classroom.

Each issue of Cosmic Times coincides with a significant milestone in how we have come to our current understanding of the universe. The 1919 issue centers on the eclipse results that confirm Einstein’s General Relativity. In the 1929 issue, Edwin Hubble determines that the Andromeda Nebula lies outside our Milky Way Galaxy and that the universe is expanding. Einstein dies in 1955, at a time when the debate between the steady state and Big Bang theories rages. In 1965, the Big Bang theory claims victory when Arno Penzias and Robert Wilson discover the remnant radiation from a young, hot universe — the cosmic microwave background (CMB). Scientists continue to study the CMB to produce a picture of the very early universe in 1993, using data from the COSmic Background Explorer (COBE). Finally, in the 2006 issue of Cosmic Times, cosmologists struggle to understand the nature of dark energy, a major component of our universe first discovered in 1997. There are one or two articles in each issue of Cosmic Times that relate to the year’s milestone events; supplementary articles cover other developments relevant to the Cosmic Times themes.

Here we illustrate just two examples of Astro 101 topics that could be enhanced through the Cosmic Times materials.

Astro 101 Topic: Hubble’s Law

It was not just another day in science when Hubble determined the distance to the Andromeda Nebula nor was his subsequent discovery of the correlation of galaxy redshifts with their distances. Both discoveries were universe-changing events. Overnight our universe went from being merely the Milky Way to consisting of countless galaxies, and it went from being static and unchanging to expanding and evolving. Cosmic Times looks at Hubble’s law twice in the last 100 years: its first discovery in 1929 and its hidden surprise that continues to be studied in 2006.

The 1929 issue of Cosmic Times tells about both of Hubble’s landmark discoveries. The article titled “Andromeda Nebula Lies Outside Milky Way Galaxy” describes Hubble’s work with Cepheid variables and how he drew on Henrietta Leavitt’s early discovery of a relationship between their period and intrinsic brightness. Hubble’s discovery of the expanding universe is discussed in “Universe is Expanding,” Students are invited to reproduce a modern version of Hubble’s Law in the “Determining the Universe” lesson plan (based on a lesson developed by Harvard-Smithsonian Center for Astrophysics).

The 1929 issue also includes an article titled “Minds Atop Mount Wilson,” which introduces the students to Edwin Hubble and his assistant Milton Humason. Students can then investigate the lives of lesser-known scientists such as Humason and Leavitt through the “Unsung Heroes of Science” lesson.

Cosmic Times revisits Hubble’s Law in 2006 after the discovery of dark energy. Hubble’s Law should break down for galaxies of a sufficient distance, due to a slow-down in the expansion of the universe; at least, that’s what cosmologist thought before 1997. In 1997 cosmologists saw Hubble’s Law break down, but not in the way they expected — the expansion was speeding up rather than slowing down. We have attributed this speeding expansion to dark energy, a mysterious component of our universe. The Cosmic Times 2006 articles “Faster Walk on the Dark Side” and “Biggest Mystery: What is Dark Energy?” discuss this discovery and the search for the nature of dark energy. With the “Measuring Dark Energy” lesson, students plot modern data on a Hubble diagram to reproduce the discovery of dark energy.
Astro 101 Topic: Evidence for the Big Bang

The evidence for the Big Bang builds throughout each issue of *Cosmic Times*, showing the ongoing process of how scientific theories are made. Today we treat the steady state theory as an archaic (and maybe embarrassing) theory, but it motivated the observations that ultimately confirmed the Big Bang. Since then, nuances in the nature of the microwave background have furthered the theory.

Three key *Cosmic Times* issues that deal with the Big Bang are: 1955, when it was still in competition with the steady state theory; 1965, when the debate is put to rest; and 1993, when we get our first picture of the young, hot universe.

The 1955 issue of *Cosmic Times* introduces the debate between the Big Bang and steady state theories in the articles titled “Origin of Everything: Hot Bang or Ageless Universe?” and “Hoyle Scoffs at ‘Big Bang’ Universe Theory.” Students then explore the nature of scientific debate by examining observations and inferences supporting either the steady state and/or Big Bang in “The Evidence is Clear” lesson.

In the 1965 *Cosmic Times* issue the debate has been resolved when Penzias and Wilson discover the cosmic microwave background (CMB) as described in “Murmur of a Bang.” The CMB is the signature of a hot, early universe that was predicted by Big Bang theory — the steady state theory had no good answer for the presence of the CMB permeating the universe. The article “Big Hiss Missed by Others” shows a few scientific near-misses of researchers who had the data to prove the CMB existed but did not quite connect the data with the theory. In the “Cosmic Microwave Background” lesson students use an expanding balloon to explore why the CMB permeates the universe and why we find it in the microwave portion of the electromagnetic spectrum.

*Cosmic Times* picks up the CMB again in the 1993 issue when the Cosmic Background Explorer (COBE) publishes the first map showing tiny temperature differences in the CMB, which lead to the universe we live in today. This discovery is discussed in the article titled “Baby Universe’s First Picture.” Refinements to the Big Bang theory are presented in the 1993 issue in “Inflation in the Universe,” which shows students how a scientific theory changes with new data and observations. In the “What’s the Problem with Isotropy” lesson, students explore the CMB to understand how an object that appears smooth can also be lumpy, and why scientists needed those lumps.

Your Next Steps

We have presented just two examples of Astro 101 topics that could be enhanced using a historic perspective. Other topics included in the *Cosmic Times* materials are supernovae and the distinction between the different types of supernovae; the various distance indicators which have been used in astronomy; and the cultural and scientific settings in which the discoveries took place.

The *Cosmic Times* website provides the *Cosmic Times* lessons, teacher guide, and downloadable editions of the posters. Hardcopies of the posters available by request via the *Cosmic Times* website.
The James Webb Space Telescope’s Near-Infrared Camera: Making Models, Building Understanding

by Don McCarthy (University of Arizona), Larry Lebofsky (UAz & Planetary Science Institute), Michelle Higgins (Sahuaroo Girl Scout Council), and N. R. Lebofsky (UAz, Retired)

The Astronomy Camp for Girl Scout Leaders is a science education program offered by the near-infrared camera (NIRCam) team for NASA’s next large space telescope: the 6.5-meter James Webb Space Telescope (JWST). Since 2003, our team has hosted “Train the Trainer” workshops with adult leaders from all Councils of the Girl Scouts of the USA (GSUSA). These workshops directly benefit thousands of young girls of all ages, not only in general science education but also specifically in astronomical and technological concepts relating to JWST. Training includes topics in basic astronomy (night sky, phases of the Moon, the scale of the solar system and beyond, stars, galaxies, telescopes, etc.) as well as JWST-specific research areas in extra-solar planetary systems and cosmology, to pave the way for girls and women to understand the first images from JWST.

A New E/PO approach

In its proposal to NASA to build the near-infrared camera for JWST, the science team adopted an unusual approach for education and public outreach (E/PO). Instead of waiting until JWST’s launch, we decided to begin spending our resources immediately to impact the education and attitudes of girls and young women towards subjects involving science, technology, engineering, and math (STEM). Our project, led by a prominent woman astronomer (Dr. Marcia Rieke), especially targets K-14 girls to combat the misconceptions that women can’t do or enjoy physical science.

We began partnering with the Sahuaroo Girl Scout Council (Tucson, Arizona) to train and equip adult Girl Scout leaders so they could, in turn, host astronomy-related activities at the troop level and teach young women essential concepts in astronomy, i.e., the night sky environment. To date, our E/PO team of faculty, post-docs, and graduate students has trained more than 100 leaders from 24 states, Washington D.C., Guam, and Japan. A byproduct of our workshops is the revision of the “Sky Search” badge material that impacts many thousands of junior girls (ages 8-11). Together, all of us form a growing team that works to promote the excitement of JWST. Through the GSUSA’s extensive infrastructure, we will help explain the exciting scientific results from JWST when it launches in 2014.

Understanding Images of the First Stars Ever Formed

The primary scientific goal for JWST is to discover, image, and study the first material objects that ever formed. These so-called “First Light” objects are predicted to be unusually massive stars that may have led to the formation of supermassive black holes at the centers of today’s galaxies. Although these images will be profound because they represent our origins, they may be mere smudges, and explaining them to the public is a challenge requiring several levels of abstraction including concepts such as infrared light, redshift, expanding universe, Big Bang, stars, black holes, etc.

Unfortunately, many of our GSUSA trainers have a difficult time visualizing basic astronomical concepts that are normally taught in elementary and middle school — rotation and revolution, the yearly motions of the planets, the scale of the solar system, and phases of the Moon, for example. In order to foster girls’ interest and creativity in STEM subjects, it is crucial that all of us create an environment that not only encourages their interests early in their lives, but also creates a safe place for girls to try and fail, and then try again and succeed. Therefore, a major part of our effort is to allow participants to discover the night sky by making observations via both the naked eye and with a variety of portable telescopes. The Camp culminates with a night on the Kuiper 61-inch telescope on nearby Mt. Bigelow.

Overall, we model what astronomers do by engaging people in hands-on processes of scientific inquiry, and we equip leaders to...
host astronomy-related activities at the troop level. In other words, we merge the separate STEM letters into a single thought process.

While many of the Camp's activities relate to the "First Light" theme, others relate to additional science themes of JWST and NIRCam — "Birth of Stars and Protoplanetary Systems" and "Planetary Systems and the Origin of Life." The latter includes our own solar system.

The series of images in this poster paper (all courtesy of the University of Arizona NIRCam Team) highlight several of the activities we conduct during a typical three-day long workshop.

Galaxy Classification and Hubble Deep Field Images. Through the use of colored images of prominent galaxies and interacting pairs, teams of leaders first develop their own classification system. Then we progress to learn about galaxy evolution, the scale of the universe, the Hubble Deep Field images, and so on.

Relative Sizes, Planetary Diameters. The relative sizes of the planets are modeled using clay, beads, and Styrofoam balls.

Categorizing Planets. Participants are shown how people, as well as scientists, group or categorize things such as plants and animals, cats and dogs, etc. In small groups, the participants group and categorize 10 spheres based on their properties and characteristics (color, size, etc.). Similarly, astronomers categorize objects in the solar system, and there may be more than one “right” answer!

Lunar Phases. The Earth-Moon system can be modeled by combining a tennis ball and penny separated by ten Earth circumferences. This combination can also be used in daylight to understand the concept of phases.

Acknowledgements

NIRCam's E/PO program for JWST is funded by GSFC under Contact NASS-02105. Information concerning the NIRCam E/PO can be found here.
Macramé Solar System Distance Model. The relative distances of the planets from the Sun are modeled to scale, and in the correct relative orientation, using macramé.

Human Orrery. This model is based on the Human Orrery at the Armagh Observatory in Northern Ireland. Participants can model day and night, the motion of the planets in their orbits around the Sun, and the positions of the planets in the sky from the perspective of the Earth. There are also plates to show the positions of the 13 zodiacal constellations. A more detailed description of the orrery's construction, as well as its use for STEM education, will be available (in 2011) in the ASP's Boulder meeting Conference Series book.

Comparing JWST/NIRCam With a Disposable Kodak Camera. The optomechanical and electrical components of a used, Kodak disposable camera provide an excellent analogue for experiencing the design of the NIRCam instrument. Girl Scout leaders dissect a disposable camera in order to discover the various subsystems and how they work together.

My! What Big Eyes You Have, JWST. Using counting disks and circles of various sizes, the Girl Scout leaders visualize the arithmetic associated with lightcollecting area and are able to “see” how much more light JWST will gather relative to the human eye and why bigger is better.
Constellation and Planet-Sorting Cards. Leaders participate in two separate activities — classification of stars, and the classification of the objects in our solar system (and extra-solar planets). Constellation Sorting Cards enable participants to sort according to various stellar parameters such as luminosity, temperature, apparent brightness, diameter, distance, etc. A more advanced set includes absolute magnitudes, types, and spectral classes. Planet Sorting Cards show information about the planets, dwarf planets, asteroids, comets, and satellites. Their orbits are also shown. There are two card sets with grade-appropriate information. The more advanced set includes several extra-solar planets.

Lookback Time in Our Daily Lives. JWST and NIRCam will provide the longest lookback time yet achieved for stars and galaxies in the universe. To convey this fundamental concept, we use familiar phenomena such as thunder, lightning, and fireworks to introduce the concept of the finite speed of light. We then extend this concept beyond Earth to discuss communication with the rovers on Mars and other distant spacecraft. Finally, we use the “Photon Conveyor Belt” activity created by former graduate student, Dr. Jennifer Donley, to involve our leaders in concepts relating to galaxy formation versus redshift.

Hubble’s Law. To the general public the expansion of the universe is often a confusing, and potentially threatening, concept. However, this concept is essential to understanding the mission and science from JWST. To teach this concept, we engage our leaders in measuring motions of familiar objects like cars and Slinkys, as well as simulated galaxies in an overlapping set of overhead transparencies produced at different levels of enlargement.
Learning by Teaching: Implementation of a Multimedia Project in ASTRO 101

by Delphine Perrodin (Franklin & Marshall College, Lancaster, PA) and Andrea Lommen (F&M College)

Introduction
ASTRO 101 students hold deep-seated preconceptions regarding topics such as the cause of Moon phases. We present a project designed to address and correct these preconceptions, which was implemented in two sections of “AST 170 — Survey of Astronomy” at Franklin & Marshall College in the spring of 2010.

After addressing the topics in a learner-centered fashion (with the use of props, online animations, Lecture-Tutorials, and Mastering Astronomy tutorials), we took this a step further. In a conceptually intense course such as astronomy, “learning by teaching” enables students to truly master concepts. But how do we get each of 25 students to practice teaching the cause of Moon phases?

Using classroom time for this did not seem realistic. We therefore created a “multimedia/video project” for the course where students were to film their teaching session, edit the film, and produce a 10-minute video that would demonstrate the highlights of their teaching session. Thanks to this setup, the project did not take time away from covering the course content and was very easy to organize.

Implementation
We asked students to organize into groups of three. Each group of three was to recruit three to five participants among other students on campus (not enrolled in the course). They had full flexibility in finding a time and place to meet with their participants and teach them the lesson on the cause of Moon phases (materials were provided by the instructor; the students had been taught the same topic with the same materials). While teaching, students taped the whole session.

As part of the project, students attended an iMovie workshop provided by Information Technology Services. They were then able to edit their film and produce a 10-minute final movie highlighting their teaching techniques and showing students in the process of learning the concepts. Some of the best movies were shown in class and were critiqued by all of the students using a rubric provided by the instructor.

Outcomes
This “experiment” turned out to be a great success for several reasons.

Learning by Teaching: students gained experience explaining conceptually challenging topics, which they then taught learning the material better and address/correct their own preconceptions about Moon phases.

Teaching experience: students learned to teach for (most likely) the first time, applying learner-centered techniques (using Styrofoam balls, leading tutorial activity, having students vote, etc.). These skills are applicable to all fields.

Engagement with the community: the project provided a connection between the classroom and the rest of the college, making students responsible for sharing their knowledge with their peers. This social aspect made astronomy more relevant to non-science majors and opened their eyes to what other students know or don’t know about astronomy.

Confidence builder: students built confidence with the teaching and the social aspect of this activity.

Video-editing skills: students learned to use iMovie, which helped make the project interesting and taught students useful skills.

Discussion
When we initially asked students to write down what they thought was the cause of Moon phases, the overwhelming majority got it wrong, answering that they were due to the shadow of Earth, a common misconception. Through a plethora of activities, including this project, students were able to correct their preconceptions about the Moon phases.

The interesting aspect of this project was the new role taken on by the students. Not just passive receivers of information, they took the action beyond the classroom and became student-teachers and student-citizens. It was great to see students who had labeled themselves as “not the science type” being fully involved with the project and teaching the Moon phases with enthusiasm.

Students also started to think about the role of astronomy and science in society. Some of the students expressed astonishment at the ignorance of their fellow students or of “their really smart sister who’s in graduate school.” Our hope is that students will keep thinking about the role of science in society and not always trust the opinions of the general public when it comes to science.

We acknowledge that end-of-the-year student feedback on this project was mixed, with some students commenting that the project took too much time for too little credit. Some students also did not understand the pedagogical aspect of this project. Despite these comments, and for the reasons already laid out, we do believe in the value and potential of this type of activity.

We thank “Information Technology Services” at F&M for providing the iMovie workshop. D. Perrodin and A. Lommen are funded by NSF grant AST 0748580.
Lunar Phases Planisphere

by Stephen Shawl (University of Kansas, Pima Community College)

Why a Lunar Planisphere?
Student misconceptions in understanding lunar phases are well documented (Lightman & Sadler 1993; Lindell 2001; Lindell and Olsen 2002; Lindell & Sommer 2004). The topic is often discussed in the AstroLRner Yahoo! Group discussions. A posted question asking if anyone had developed a lunar phases “planisphere” encouraged me to resurrect the device I developed during the 1980’s — this device and its use is the topic of this paper.

The purpose of the device is not, by itself, to teach the cause of the lunar phases but rather to help the student to visualize better, from the point of view of the observer, the angle between the apparent location of the Sun and Moon, and to answer questions such as “if the Sun sets at 6:00 pm, what time would the waxing gibbous Moon set?” The goal is for the student to be able to answer the question without using the planisphere, because practice with it will aid in visualizing and understanding the geometry that causes the phases.

The device consists of a movable “sky” over a fixed local horizon/meridian. Figure 1 (on the following page), marked at the bottom as “movable,” is photocopied to a transparency and placed over a paper or transparency copy of Figure 2 (also on the next page), marked as “fixed.” Figure 2 shows the stationary horizon as viewed by an observer facing south — the general direction an observer must be facing to see the Moon from mid-northern to northern latitudes. Placed on the horizon are the cardinal points such an observer would see: south (straight ahead), east (to the left), and west (to the right). Since the view is that of the observer, north would be behind the back of the observer/user of the planisphere. In addition, times in three-hour intervals for the approximate location of the Sun in the sky above and below the horizon are shown. For simplicity, we assume sunrise is always at 6:00 am and sunset is always at 6:00 pm.

The movable part shows the Sun and the Moon at its various waxing and waning phases. The drawing is not, of course, to scale but is meant to show the relative locations as seen by an observer. However, the Sun and Moon are drawn the same size since their angular sizes are so close. For simplicity, the phases are shown every 45°. Also for simplicity, we neglect the hourly motion of the Moon in relation to the Sun.

The user needs to remember that time is determined by the location of the Sun: noon when on the meridian above the horizon to the south, 3:00 pm when halfway between the meridian and setting, 6:00 pm at setting, midnight when on the meridian below the horizon, and so on.

Assembly
The assembled lunar planisphere will have the movable transparency piece on top of the fixed one. (Two transparency pieces could be used on an overhead projector for teaching students how to use it.) The small circle at the center of each figure is to be carefully cut out so that a brass brad can be inserted to hold the two pieces together and provide a pivot point during use. A thumbtack or pushpin could be used in place of the brass brad if the transparency were placed on a piece of cardboard.

Examples of Use
The use of the planisphere is best described through some specific examples. The stationary piece is always held with the horizon parallel to the ground.

New Moon. Set the movable piece so that the new Moon and the Sun are both setting on the western horizon. One sees that the new Moon sets at sunset, which is 6:00 pm. Rotating the movable piece so that the new Moon is rising shows that it rises at 6:00 am.

Waxing crescent: Set the movable piece so that the waxing crescent Moon is setting. Given the location of the Sun at 9:00 pm on the dial, we see that the waxing crescent Moon sets at 9:00 pm. Moving the waxing crescent to its rising location in the east will show that it rises at 9:00 am. Rotate the top piece so the Moon is traveling across the sky above the horizon; notice that the right side of the waxing Moon as seen by the observer is illuminated by the Sun.

The user should notice that during a given night, as the Moon (and Sun) cross the sky from east to west, the phase remains the same throughout the night. In other words, the angle between the Sun and Moon is constant throughout the night as Earth rotates underneath the distant Sun, Moon, and stars.

Waning gibbous Set the waning gibbous Moon to rising. From the location of the Sun, it is 9:00 pm with a set time of 9:00 am. Rotate the top piece so the waning gibbous Moon is traveling across the sky above the horizon; notice that the left side of the waning Moon as seen by the observer is illuminated by the Sun.

We can turn the question around and ask: Where in the sky is the last-quarter Moon at noon? Turning the top piece to noon (the Sun on the meridian) shows the last-quarter Moon to be setting.

Questions to Answer
- Describe the location of the Sun at 3:00 am and at 9:00 pm.
- What time did the first-quarter Moon rise? Set?
- At what time will the first-quarter Moon be visible on the meridian?
- At what time will the first-quarter Moon be on the meridian below the horizon?
- Will the waning crescent Moon be visible at 2:00 am?
- What is the angle between the waning gibbous Moon and Sun at moonrise? When the Moon is visible on the meridian at moonrise? When the Moon is on the meridian below the horizon?
- Describe the location of the last-quarter Moon at 3:00 pm.
- Set the lunar planisphere to show where the Moon would be at noon during a solar eclipse. Describe your finding.
- Set the lunar planisphere to show where the Moon would be at 9:00 pm during a lunar eclipse. Describe your finding.
References


Dark Skies From the Ground Up: Before, During, and After GLOBE at Night

by Constance E. Walker (NOAO), Stephen M. Pompea (NOAO), and Robert T. Sparks (NOAO)

The GLOBE at Night program before, during, and after the citizen-science sky-brightness monitoring campaign, tries to convey the importance of what has been lost to light pollution as well as how light pollution affects various areas of life beyond astronomical research. It provides foundational resources that build toward participating in the GLOBE at Night campaign, teaches how to take part in the most successful citizen science light pollution monitoring campaign in the last five years, and if participants are interested, provides access to the data to look for changes and trends over time and with respect to other data sets. By offering ways to become more aware of light-pollution issues, the program tries to convince people to take steps to help redress the issues and provides some tools on how to do so.

Introduction
Dark night skies are being lost all over the globe, and hundreds of millions of dollars of energy are being wasted to “achieve” this loss. In the US and Europe, more than half of the population cannot see the Milky Way from where they live.

Because of light pollution, most urban dwellers also experience the effects of poor-quality lighting. Improper lighting is a concern on many fronts: safety, energy conservation and cost, human health, and its effect on animals. Light pollution also robs us of the beauty of viewing the night sky. To address this issue, the National Optical Astronomy Observatory (NOAO) began a partnership in 2005 with GLOBE (Global Learning and Observations to Benefit the Environment) and ESRI (Environmental Systems Research Institute, Inc.) to develop a worldwide light pollution education and measurement campaign called GLOBE at Night.

During GLOBE at Night
GLOBE at Night is an annual citizen-science campaign that encourages people all over the world to record the brightness of their night sky. For two weeks every March, when the Moon is not out during the early evening and the constellation of Orion can be seen by everyone almost everywhere, children and adults match the appearance of Orion with seven star maps of progressively fainter stars found on the website. They then submit their measurements (e.g., which star map they chose) online with their date, time, and location. Many GLOBE at Night citizen scientists use special digital meters to measure the night sky brightness and also post their results online.

The GLOBE at Night website explains how to participate in the campaign, but also offers background information on good and bad lighting. There are interactive games and fun quizzes to check proficiency on the key concepts. Teacher and Family Guides come in 14 different languages. To help publicize the campaign, there are downloadable postcards and flyers in English and Spanish. The reporting page is user-friendly, and the mapping page has data in various formats.

Before GLOBE at Night
The program includes a set of activities (called “Dark Skies Rang- ers”) that can be used to prepare the public (and especially students) to participate in GLOBE at Night. In particular, the activities introduce children and adults to the affects light pollution has on public health, economic issues, ecological consequences, energy conservation, safety and security, and astronomy.

More than 500 teaching kits for GLOBE at Night, developed by the NOAO education group, have been built and distributed at the training workshops for GLOBE at Night. The kit includes materials for a light-shielding demonstration, a digital Sky Quality Meter to measure night-sky brightness, interactive educational activities, resource DVDs, publicity materials (postcards, poster, flyers, etc),

Guided by the Office for the Protection of the Quality of the Sky of the North of Chile, the people of Monte Patria took steps to redress their light pollution problem, replacing their 3500 luminaires with compliant and night-sky friendly technology. Shown is the difference in brightness, before and after lighting changes were implemented.

The light-shielding demonstration (which is part of the Dark Skies kit) illustrates key concepts of glare, sky glow, and light trespass, as well as issues of safety, energy, cost, and the ability to enjoy a dark night sky full of stars.
light pollution trading cards, and a story book for children called There Once was a Sky Full of Stars.

After GLOBE at Night
In addition to the materials and activities provided to support the GLOBE at Night campaign, there are also projects that use the worldwide measurements of light-pollution levels. With more than 50,000 data points from the five annual campaigns, the GLOBE at Night data can be compared over time to look for trends and can be compared to population density maps. The data can also be used to search for dark-sky oases or to monitor lighting ordinance compliance. Most recently, the data has been compared with telemetry of the Lesser Long-Nose Bat near Tucson, Arizona, to examine whether or not the bats are preferentially staying in darker areas while traveling between roosts and foraging areas.

Communities are also using their GLOBE at Night data to implement local lighting changes to save energy and make the sky more visible. For example, students in a school district in Indiana created a three-dimensional model of their GLOBE at Night sky measurements by using layers of 35,000 LEGO® blocks, each layer a different color, to help visualize how much of the night sky was lost to light pollution. The students presented their findings to local leaders and were honored for their efforts.

GLOBE at Night 2010 Results
The GLOBE at Night 2010 campaign (which took place March 3-16) set a record high of more than 17,800 measurements from people in 86 countries. The dots (or points) on the resulting world map (below) represent the contributed measurements of night-sky brightness — the lighter colored the dot, the brighter the sky, and the darker the dot, the darker the sky. The lightest colored dot, Limiting Magnitude 1, represents a night sky you might see from a very large city (e.g., only a handful of stars are visible across the whole sky). The darkest dot, Limiting Magnitude 7, represents a night sky you would see from a national park where no city lights are visible (e.g., so many stars, the constellations would be almost indistinguishable from one another).

In the United States during the GLOBE at Night 2010 campaign,

49 out of 50 states plus the District of Columbia contributed more than 10,900 measurements. The top three states were Arizona (more than 1,800), Michigan (more than 1,200) and West Virginia (more than 1,000). Puerto Rico had more than 1,000 measurements; Poland more than 800; Romania and Chile each more than 600; the Czech Republic more than 400; Argentina more than 300; Hungary close to 300; Canada, the United Kingdom and South Korea slightly more than 200; and China just under 200.

Summary
GLOBE at Night has grown from a prototype project centered in Arizona and Chile to a global cornerstone program of the recently completed International Year of Astronomy 2009 (IYA2009). Thanks to everyone who participated! Through GLOBE at Night, students — alongside teachers, parents, and community members — are amassing a data set with which they can explore the nature of light pollution locally and across the globe.

Join us for GLOBE at Night 2011. For more information, visit www.globeatnight.org or contact Connie Walker.

Acknowledgements
NOAO (the National Optical Astronomy Observatory) is operated by the Association of Universities for Research in Astronomy (AURA), Inc. under cooperative agreement with the National Science Foundation. GLOBE at Night has been supported by a grant from the National Science Foundation. Acknowledgement is also given to Tom Baker (ESRI) for the production of the GLOBE at Night maps; Mike Warner of the Cerro Tololo Inter-American Observatory (CTIO) for production of the GLOBE at Night data files in Google Earth format; Hugo Ochoa (CTIO) and David Orellana of CADIAS (an Astronomy Teaching Support Center in Chile) for their support in training teachers in astronomy, light pollution education, and GLOBE at Night; IDA (the International Dark-Sky Association) for partnering with NOAO on the development of the “School Outdoor Lighting Audit” (an activity in the Dark Skies Rangers Program); and GLOBE for their work on the website, helping to market the campaign worldwide, and assisting in answering questions during the campaign.

This image was the third-place winner in the Beauty of Night Sky category of the TWAN/IYA Dark Skies Awareness “Earth and Sky” photo contest. The photo called “Stargazers” was taken during a public observing on a hill overlooking Targoviste, Romania.

Worldwide GLOBE at Night measurements in 2010: the lighter colored dots indicate brighter skies; the darker dots indicate darker skies. The range in limiting magnitudes is 1 (brighter) to 7 (darker).
Excerpts from press releases that describe an assortment of recent astronomical discoveries.

**ASU Camera Yields Best Mars Map Ever Assembled**
*Arizona State University*

The best Mars map ever made is now available online for planetary scientists and armchair astronauts alike. And citizen scientists are invited to help make it even better.

Websites developed recently at Arizona State University’s Mars Space Flight Facility, in collaboration with NASA, the Jet Propulsion Laboratory and Microsoft, make it easy for anyone to trek the craters, volcanoes and dusty plains of Earth’s small red neighbor world.

“We’ve assembled the best global map of Mars to date,” said Philip Christensen, Regents’ Professor of Geological Sciences in the School of Earth and Space Exploration, part of the College of Liberal Arts and Sciences. “And we made it available via the Internet so everyone can help make it better.”

The map is accessible as an interactive zoomable global map, which is the easiest for most viewers to use. (Advanced users with large bandwidth, powerful computers and sophisticated software capable of handling gigabyte images can download the map in sections at full resolution.)

The maps show Mars as if sliced from a globe, unwrapped and flattened out on a table. Nearly 21,000 individual images have been smoothed, blended, fitted together and cartographically controlled to make a giant mosaic that web viewers can zoom into and scroll around. The few missing pieces show where clouds and poor lighting have thus far prevented map-quality imaging; these places are high on mission planners’ must-image target list. “Portions of Mars have been mapped at higher resolution,” said Christensen, “but this is the most detailed map so far that covers the planet.”

**Mars’s Mysterious Elongated Crater**
*European Space Agency*

Orcus Patera is an enigmatic elliptical depression near Mars’s equator, in the eastern hemisphere of the planet. Located between the volcanoes of Elysium Mons and Olympus Mons, its formation remains a mystery.

Often overlooked, this well-defined depression extends approximately 380 km by 140 km in a NNE–SSW direction. It has a rim that rises up to 1800 m above the surrounding plains, while the floor of the depression lies 400–600 m below the surroundings.

The term ’patera’ is used for deep, complex or irregularly shaped volcanic craters such as the Hadriaca Patera and Tyrrhena Patera at the northeastern margin of the Hellas impact basin. However, despite its name and the fact that it is positioned near volcanoes, the actual origin of Orcus Patera remains unclear.

Aside from volcanism, there are a number of other possible origins. Orcus Patera may be a large and originally round impact crater, subsequently deformed by compressional forces. Alternatively, it could have formed after the erosion of aligned impact craters. However, the most likely explanation is that it was made in an oblique impact, when a small body struck the surface at a very shallow angle, perhaps less than five degrees from the horizontal.

The existence of tectonic forces at Orcus Patera is evident from the presence of the numerous ‘graben,’ rift-valley-like structures that cut across its rim.
Rosetta Triumphs at Asteroid Lutetia

European Space Agency

Asteroid Lutetia has been revealed as a battered world of many craters. ESA's Rosetta mission has returned the first close-up images of the asteroid showing it is most probably a primitive survivor from the violent birth of the Solar System.

The flyby was a spectacular success with Rosetta performing faultlessly. Closest approach took place [on July 10] at 18:10 CEST, at a distance of 3162 km.

The images show that Lutetia is heavily cratered, having suffered many impacts during its 4.5 billion years of existence. As Rosetta drew close, a giant bowl-shaped depression stretching across much of the asteroid rotated into view. The images confirm that Lutetia is an elongated body, with its longest side around 130 km.

At closest approach, details down to a scale of 60 m can be seen over the entire surface of Lutetia. “I think this is a very old object. Tonight we have seen a remnant of the solar system’s creation,” says Holger Sierks, OSIRIS principal investigator, Max Planck Institute for Solar System Research, Lindau, Germany.

The flyby marks the attainment of one of Rosetta’s main scientific objectives. The spacecraft will now continue to a 2014 rendezvous with its primary target, comet Churyumov-Gerasimenko. It will then accompany the comet for months, from near the orbit of Jupiter down to its closest approach to the Sun. In November 2014, Rosetta will release Philae to land on the comet nucleus.

More information

All Stars Are Born the Same Way

Max-Planck-Institut für Radioastronomie

An international research team led by Stefan Kraus with team members from two research groups of the Max Planck Institute for Radio Astronomy in Bonn has been able to obtain the first infrared image of a compact disc closely encircling a massive young star. This provides strong evidence that massive stars form in the same way as their smaller brothers — thereby closing an enduring debate.

The team of astronomers looked at an object, known by the cryptic name of IRAS 13481-6124. About twenty times the mass of our Sun and five times its radius, the young central star, which is still surrounded by a disk, its pre-natal cocoon, is located in the constellation of Centaurus, about 10,000 light-years away. Disks of gas and dust around young stars are the material reservoir from which also planets can form.

“Our observations show a disc surrounding an embryonic young, massive star, which is now fully formed,” says Stefan Kraus, who led the study. “One can say that the baby is about to hatch!”

From archival images obtained by the NASA Spitzer Space Telescope as well as from observations done with the APEX 12-metre submillimetre telescope, astronomers discovered the presence of a jet.

“Such jets ejected from young stars, generally indicate the presence of a circumstellar disc,” says Karl Menten from the team at the Max-Planck Institute for Radioastronomy (MPIfR) in Bonn. “Radio telescopes like the APEX sub-mm telescope allow us, for the first time, to study outflows at short radio wavelengths in the submillimeter range. The present project brings together the expertise of two research groups at MPIfR, infrared interferometry in order to investigate the structure of the disk and submillimeter astronomy showing the structure of the bipolar outflow.”

More information
First Potentially Habitable Exoplanet

University of California Santa Cruz

A team of planet hunters from the University of California (UC) Santa Cruz, and the Carnegie Institution of Washington has announced the discovery of a planet with three times the mass of Earth orbiting a nearby star at a distance that places it squarely in the middle of the star's "habitable zone," where liquid water could exist on the planet's surface. If confirmed, this would be the most Earth-like exoplanet yet discovered and the first strong case for a potentially habitable one.

To astronomers, a "potentially habitable" planet is one that could sustain life, not necessarily one where humans would thrive. Habitability depends on many factors, but having liquid water and an atmosphere are among the most important.

"Our findings offer a very compelling case for a potentially habitable planet," said Steven Vogt, professor of astronomy and astrophysics at UC Santa Cruz. "The fact that we were able to detect this planet so quickly and so nearby tells us that planets like this must be really common."

Their paper reports the discovery of two new planets around Gliese 581. This brings the total number of known planets around this star to six, the most yet discovered in a planetary system outside of our own.

The most interesting of the two new planets is Gliese 581g, with a mass three to four times that of the Earth and an orbital period of just under 37 days. Its mass indicates that it is probably a rocky planet with a definite surface and that it has enough gravity to hold on to an atmosphere, according to Vogt. (You can watch the webcast of this announcement; skip the first 4:30 of dead air.)

Richiest Planetary System Discovered

European Southern Observatory

Astronomers using ESO's world-leading HARPS instrument have discovered a planetary system containing at least five planets, orbiting the Sun-like star HD 10180. The researchers also have tantalizing evidence that two other planets may be present, one of which would have the lowest mass ever found. This would make the system similar to our solar system in terms of the number of planets (seven as compared to the Solar System's eight planets). Furthermore, the team also found evidence that the distances of the planets from their star follow a regular pattern, as also seen in our solar system.

"We have found what is most likely the system with the most planets yet discovered," says Christophe Lovis, lead author of the paper reporting the result. "This remarkable discovery also highlights the fact that we are now entering a new era in exoplanet research: the study of complex planetary systems and not just of individual planets. Studies of planetary motions in the new system reveal complex gravitational interactions between the planets and give us insights into the long-term evolution of the system."

The newly discovered system of planets around HD 10180 is unique in several respects. First of all, with at least five Neptune-like planets lying within a distance equivalent to the orbit of Mars, this system is more populated than our solar system in its inner region, and has many more massive planets there. Furthermore, the system probably has no Jupiter-like gas giant. In addition, all the planets seem to have almost circular orbits.
Eclipsing Pulsar Promises Clues to Crushed Matter  
Goddard Space Flight Center

Astronomers using NASA’s Rossi X-ray Timing Explorer (RXTE) have found the first fast X-ray pulsar to be eclipsed by its companion star. Further studies of this unique stellar system will shed light on some of the most compressed matter in the universe and test a key prediction of Einstein’s relativity theory.

The pulsar is a rapidly spinning neutron star — the crushed core of a massive star that long ago exploded as a supernova. Neutron stars pack more than the sun’s mass into a ball nearly 60,000 times smaller. With estimated sizes between 10 and 15 miles across, a neutron star would just span Manhattan or the District of Columbia.

“It’s difficult to establish precise masses for neutron stars, especially toward the higher end of the mass range theory predicts,” said Craig Markwardt at NASA’s Goddard Space Flight Center in Greenbelt. “As a result, we don’t know their internal structure or sizes as well as we’d like. This system takes us a step closer to narrowing that down.”

Known as Swift J1749.4-2807 — J1749 for short — the system erupted with an X-ray outburst on April 10. During the event, RXTE observed three-minute eclipses of the binary stars twice during the 5.6-hour orbit.

These observations led to the confirmation of an important theory about white dwarf stars. Stars end their lives in many ways. White dwarf stars are the very dense remnants of stars like the sun, with dimensions comparable to the earth. A star becomes a white dwarf when it has exhausted its nuclear fuel and all that remains is the dense inner core, typically made of carbon and oxygen.

In this artist conception of the unique binary star NLTT 11748, the larger but less massive helium white dwarf star is partially eclipsed by the smaller but more massive normal white dwarf, which is about the size of Earth.
Origin of Key Cosmic Explosions Still a Mystery
Harvard-Smithsonian Center for Astrophysics

When a star explodes as a supernova, it shines so brightly that it can be seen from millions of light-years away. One particular supernova variety — Type Ia — brightens and dims so predictably that astronomers use them to measure the universe’s expansion. The resulting discovery of dark energy and the accelerating universe rewrote our understanding of the cosmos. Yet the origin of these supernovae, which have proved so useful, remains unknown.

“The question of what causes a Type Ia supernova is one of the great unsolved mysteries in astronomy,” says Rosanne Di Stefano of the Harvard-Smithsonian Center for Astrophysics (CfA).

Astronomers have very strong evidence that Type Ia supernovae come from exploding stellar remnants called white dwarfs. To detonate, the white dwarf must gain mass until it reaches a tipping point and can no longer support itself.

There are two leading scenarios for the intermediate step from stable white dwarf to supernova, both of which require a companion star. In the first possibility, a white dwarf swallows gas blowing from a neighboring giant star. In the second possibility, two white dwarfs collide and merge. To establish which option is correct (or at least more common), astronomers look for evidence of these binary systems.

Given the average rate of supernovae, scientists can estimate how many pre-supernova white dwarfs should exist in a galaxy. But the search for these progenitors has turned up mostly empty-handed.

Astronomers Discover an Unusual Cosmic Lens
California Institute of Technology

Astronomers at the California Institute of Technology (Caltech) and Ecole Polytechnique Fédérale de Lausanne (EPFL) in Switzerland have discovered the first known case of a distant galaxy being magnified by a quasar acting as a gravitational lens.

Quasars, which are extraordinary luminous objects in the distant universe, are thought to be powered by supermassive black holes in the cores of galaxies. A single quasar could be a thousand times brighter than an entire galaxy of a hundred billion stars, which makes studies of their host galaxies exceedingly difficult. The significance of the discovery, the researchers say, is that it provides a novel way to understand these host galaxies.

“It is a bit like staring into bright car headlights and trying to discern the color of their rims,” says Frédéric Courbin of EPFL, the lead author on the paper. Using gravitational lensing, he says, “we now can measure the masses of these quasar host galaxies and overcome this difficulty.”

The first such gravitational lens was discovered in 1979, and produced an image of a distant quasar that was magnified and split by a foreground galaxy. Hundreds of cases of gravitationally lensed quasars are now known. But, until the current work, the reverse process — a background galaxy being lensed by the massive host galaxy of a foreground quasar — had never been detected.

Astronomers have searched galaxies like this — M101, also known as the Pinwheel Galaxy — in a hunt for the progenitors of Type Ia supernovae, but their search has turned up mostly empty-handed.

More information
Astronomers Step Towards Revealing the Universe’s Biggest Mystery

An international team of astronomers using gravitational lensing observations from the NASA/ESA Hubble Space Telescope has taken an important step forward in the quest to solve the riddle of dark energy, a phenomenon that mysteriously appears to power the universe’s accelerating expansion.

Normal matter like that found in stars, planets and dust clouds only makes up a tiny fraction of the mass-energy content of the Universe. It is dwarfed by the amount of dark matter — which is invisible, but can be detected by its gravitational pull. In turn, the amount of dark matter in the universe is itself overwhelmed by the diffuse dark energy that permeates the entire universe. Scientists believe that the pressure exerted by this dark energy is what pushes the universe to expand at an ever-increasing rate.

Probing the nature of dark energy is, therefore, one of the key challenges in modern cosmology. Since its discovery in 1998, the quest has been to characterize and understand it better. This work presents an entirely new way to do so.

The team measured the properties of the gravitational lensing in the galaxy cluster Abell 1689. Gravitational lensing is a phenomenon predicted by Einstein’s theory of general relativity, and was here used by the team to probe how the cosmological distances (and thus the shape of space-time) are modified by dark energy.

Planck Unveils the Universe — Now and Then

ESA’s Planck mission has delivered its first all-sky image. It not only provides new insight into the way stars and galaxies form but also tells us how the universe itself came to life after the Big Bang.

“This is the moment that Planck was conceived for,” says ESA Director of Science and Robotic Exploration, David Southwood. “We’re not giving the answer. We are opening the door to an Eldorado where scientists can seek the nuggets that will lead to deeper understanding of how our universe came to be and how it works now. The image itself and its remarkable quality is a tribute to the engineers who built and have operated Planck. Now the scientific harvest must begin.”

From the closest portions of the Milky Way to the furthest reaches of space and time, the new all-sky Planck image is an extraordinary treasure chest of new data for astronomers.

The main disc of our Galaxy runs across the centre of the image. Immediately striking are the streamers of cold dust reaching above and below the Milky Way. This galactic web is where new stars are being formed, and Planck has found many locations where individual stars are edging toward birth or just beginning their cycle of development.

Less spectacular but perhaps more intriguing is the mottled backdrop at the top and bottom. This is the ‘cosmic microwave background radiation’ (CMBR). It is the oldest light in the universe, the remains of the fireball out of which our universe sprang into existence 13.7 billion years ago.

While the Milky Way shows us what the local universe looks like now, those microwaves show us what the universe looked like close to its time of creation, before there were stars or galaxies. Here we come to the heart of Planck’s mission to decode what happened in that primordial universe from the pattern of the mottled backdrop.
Board Secretary Retires

Congratulations and best wishes to Dr. Mary Kay Hemenway on her retirement as secretary of the Astronomical Society of the Pacific after 11 years (1999–2010) of sterling service to the Society.

Mary Kay is Senior Lecturer and Research Associate at the University of Texas at Austin, where she teaches astronomy classes and engages in astronomy education research. For many years, she has worked with the University of Texas McDonald Observatory Education and Outreach Office helping to design and implement teacher and student programs for the Observatory’s Visitor Center in Fort Davis. She is also Director of the university’s Educational Services Office for the astronomy department, and has been the principal investigator or co-investigator on numerous NSF- and NASA-funded projects in science education. She has been a member of the International Astronomical Union’s Working Group for the 2009 International Year of Astronomy.

Mary Kay served as the Education Officer of the American Astronomical Society (AAS) from 1991-97, and just this year was awarded the AAS Education Prize “for her leadership and dedication to astronomy education and improvement of K–20 science education at the state and national level throughout her career.” And she has served as our faithful and expert secretary.

The ASP Board of Directors, staff, and membership sincerely thank Mary Kay for more than a decade of minutes-taking, record-keeping, organizing, and exercising her procedural duties — essential functions without which the Society cannot operate effectively — and for her role on the Executive Committee, for being the memory of the Society, and for her sage advice over the years. We will miss her, and wish her well in her future adventures.

IYA’s Cosmic Diary Released as a Free Book

One of the International Year of Astronomy’s Cornerstone Projects was the Cosmic Diary. Now many of these diary entries have been turned into a book, Postcards from the Edge of the Universe. The book features articles from astronomers around the world about the hottest astronomical topics of the moment.

From sunspots to black holes, planets around other stars, supernovae, and dark matter, Postcards from the Edge of the Universe unveils the mysteries of today’s research, looking at cutting-edge astronomy from around the world. Articles by 24 frontline astronomers from all corners of the globe explain their science in accessible language.

This book is based on a handpicked selection of the best posts and science writing from the astronomy blog Cosmic Diary. The contributions have been compiled into an edited anthology that gives an enthralling snapshot of contemporary astronomy. The four-page popular-science articles all have a personal flavor, as each contributor has selected their own research topic, giving the reader a personal insight into work at the forefront of astronomy.

Postcards from the Edge of the Universe is available as an electronic book for free download from www.postcardsfromuniverse.org or can be ordered as a hardcopy book from the ESO’s shop.

Galileoscopes in Stock [by the Galileoscope Team]

With the new academic year beginning, consider purchasing Galileoscopes for your local schools — a great way to impact science education and engage more kids in learning about the natural world. They’re ideal for Boy Scouts, Girl Scouts, and other youth groups too. Galileoscopes are backed by a growing suite of educational and observing aids compiled by the US National Optical Astronomy Observatory’s Teaching With Telescopes program providing helpful resources for science teachers everywhere.

Gone are the days when our tiny band of volunteers couldn’t match the supply of telescopes to the demand from customers. (If you were among the many customers who had to wait an inordinate amount of time for your order to arrive, please accept our sincere apologies.) Our warehouse is now piled high with Galileoscopes, just in time for the start of the new school year and the holiday shopping season. We have a large inventory in stock for quick delivery.
The Astronomical Society of the Pacific Invites Nominations for the Society’s 2011 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**
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Further details, submission information, and past recipients can be found on our website:
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Because of rising costs, we've had to increase our prices, but even at $30 US plus shipping, the Galileoscope still offers the very best value in a small telescope. And discount pricing is now available to everyone who buys by the case — six Galileoscopes for $150 US (only $25 each), plus shipping. Thanks for your support, and enthusiasm.

Year of the Solar System
Did you know it is now the (Martian) Year of the Solar System? It's not an “official” event like the International Year of Astronomy, but NASA has built a very cool YSS site for this celebration. According to their overview page, “Over the next 23 months of the Year of the Solar System, you will be able to explore how the solar system formed, how different objects in the solar system are from each other, how alike they are, and how we know what we know about the solar system.”

Okay, so the concept is a bit of a shameless plug for NASA and all the educational work they do, but there is already a large amount of useful material available on the site — and it's sure to grow as the “year” progresses. For example, in the Educational Resources segment of the website there are four products (images and information), nine solar system related podcasts, and five videos available for downloading. And make sure you visit their multimedia page.

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AstroShop
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NEW MEMBERS — The ASP welcomes new members who joined between June 1 and September 30, 2010.

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Where’s the Big Dipper these evenings? To anyone living above 40° North latitude, that might seem to be an odd question. “Why, it’s over there in the north,” would be the reply.

But if you’re a skywatcher living south of 40° North — in Los Angeles, Phoenix, Dallas, Houston, New Orleans, Atlanta, and Miami, to name but a few US locations — you already know that the Big Dipper isn’t always in the sky. The three charts at the bottom of the page illustrate this by showing the location of the Big Dipper, shortly after sunset in November and December, at three different latitudes.

Indeed, the farther south you go, the less of the Big Dipper you’ll see at this time of year. (And let’s not even talk about Hawaii, where the Big Dipper is low or below the horizon in the evening for several months each year.)

The cause of the Big Dipper’s variable northern location is, of course, latitude. Once you’re higher than 49° North (hello, most of Canada and Alaska), all of the Big Dipper is always above the northern horizon. The farther south you are, the less of the Dipper you see at certain times of the year.

How far south must you be to never see the Big Dipper? Well, if you live at roughly 41° South — in Wellington, New Zealand, or in Tasmania (Australia) — none of the seven stars of the Big Dipper will ever peek above your northern horizon.

November is leap month for Venus, as the planet leaps out of the solar glare at dawn. By mid-month, it rises nearly two hours before the Sun. Rising even earlier is Saturn; Venus chases, but doesn’t catch, the ringed world. A skinny crescent Moon is to Saturn’s right on the 3rd, and sits beside both planets at dawn on December 1st.

Mercury is lost in the glare of the Sun; Mars nearly so. You might glimpse the red planet to the right of a thin crescent Moon after sunset on the 7th if you have a clear, flat, western horizon. Fortunately, Jupiter is nicely placed for observing, rising in the southeast at sunset. On the 15th, the Moon is to the right of this giant world.

The highlight of the month is the total eclipse of the Moon during the night of December 20/21. This is the first total lunar eclipse visible from North America since February 21, 2008. Although the eclipse is not central, the total phase still lasts 72 minutes.

At the instant of greatest eclipse, the Moon is almost directly overhead for observers in southern California. The entire event is visible from North America and western South America. Observers on South America’s east coast miss the late stages of the eclipse because they occur after moonset. Likewise, much of Europe and Africa experience moonset while the eclipse is in progress, though northern Scandinavians can catch the entire event. For observers in eastern Asia, the Moon rises in eclipse. None of the eclipse is visible from south and east Africa, the Middle East, or South Asia.

Listed below are some of the key events, and the times they will occur, during December’s total lunar eclipse. Note that UT is Universal Time (sometimes called Greenwich Mean Time or GMT). Eastern Time is UT – 5 hours; Central is UT – 6; Mountain is UT – 7; and Pacific Time is UT – 8 hours. The eclipse is also visible in its entirety from Alaska (local time is UT – 9 hours) and Hawaii (UT – 10 hours), but be aware that most of the eclipse occurs on the 20th in these two regions. (Also see the diagram on the next page.)

December 21, 2010

<table>
<thead>
<tr>
<th>Event</th>
<th>UT</th>
<th>Eastern</th>
<th>Pacific Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Penumbra Eclipse Begins</td>
<td>05:29</td>
<td>12:29 am</td>
<td>9:29 pm on the 20th</td>
</tr>
<tr>
<td>Partial Eclipse Begins</td>
<td>06:33</td>
<td>1:33 am</td>
<td>10:33 pm on the 20th</td>
</tr>
<tr>
<td>Total Eclipse Begins</td>
<td>07:41</td>
<td>2:41 am</td>
<td>11:41 pm on the 20th</td>
</tr>
<tr>
<td>Greatest Eclipse</td>
<td>08:17</td>
<td>3:17 am</td>
<td>12:17 am</td>
</tr>
<tr>
<td>Total Eclipse Ends</td>
<td>08:53</td>
<td>4:53 am</td>
<td>12:53 am</td>
</tr>
<tr>
<td>Partial Eclipse Ends</td>
<td>10:01</td>
<td>5:01 am</td>
<td>2:01 am</td>
</tr>
<tr>
<td>Penumbral Eclipse Ends</td>
<td>11:04</td>
<td>6:04 am</td>
<td>3:04 am</td>
</tr>
</tbody>
</table>

While the eclipse officially begins when the Moon enters the penumbra (Earth’s faint, outer shadow), it’s an event that’s impossible
to see. Sharp-eyed observers might notice a slight dimming on the Moon's eastern edge about 30 minutes later (see the diagram below).

The real “action” begins when the Moon enters Earth’s dark shadow — the umbra. As the umbra covers the Moon, notice that Luna doesn't become completely dark and invisible. Light bent through Earth's atmosphere still reaches the shadowed Moon and gives it a dull brown or reddish glow. (Since the Moon passes through a large range of umbral depths during totality, its appearance will change dramatically with time.) The color and darkness of the totally eclipsed Moon depends on how murky Earth’s atmosphere is, and that depends on such things as how much cloud cover, storm activity, and human pollution there is around the globe, and even how recently (and vigorously) volcanoes have erupted.

So set your alarm clock (if necessary), and don't miss this lovely spectacle. A lunar eclipse is one celestial event that's leisurely and doesn't require a telescope to observe — your eyes are all you need (though binoculars are a nice addition).

One other December event of note is the Geminid Meteor Shower, which peaks on the night of the 13-14. With up to 100 meteors per hour streaming from its radiant (located slightly west of the bright star Castor in Gemini, the Twins), the Geminids are the year's best shower. But for the best show, you'll need to wait until the Moon sets (after midnight on the 14th). Once its light is gone, the shower's fainter meteors will be visible.

Rising more than 3.5 hours before the Sun, Venus is a brilliant sight high in the southeast at dawn. Dimmer Saturn is to Venus's upper right and continues to climb higher each morning. Look for the crescent Moon beside these two planets on the 1st, to Saturn's right on the 28th, and to Venus's upper right on the 30th (and immediate right on the 31st).

Both Mars and Mercury start the month low in the southwest after sunset; neither sticks around very long. Try for Mercury on the 7th, when it sits to the lower right of a thin crescent Moon. By month's end, Mercury appears in the morning sky far to the lower left of Venus. Jupiter is high in the southeast at dusk and is a fine sight in a small telescope. On the 13th, the first-quarter Moon hangs above it.

The winter constellation is Orion the Hunter. Its seven brightest stars — like those of the Big Dipper in the north — are the dominant sight in the winter night sky. The three Belt stars, plus Bellatrix and Saiph, shine as bright as the Dipper stars, but gold-orange Betelgeuse and blue-white Rigel are even brighter. Our star chart below doesn't do the constellation justice, and keep in mind that the stars are farther apart in the sky than they look on the chart.

Hanging below the Belt stars is a hazy bit of mist; binoculars show it as a small glowing patch of light; and a small telescope reveals it as a pale-green smudge of nebulosity. This is M42, the Orion Nebula. Don't be disappointed by your first view of it through a telescope — forget all those Hubble Space Telescope images. Instead, tease out the delicate details of the nebulosity no matter what instrument you're using, and appreciate it for what it is — the closest region to Earth of massive star formation.

The Quadrantid Meteor Shower has a short, sharp peak of activity during the night of January 3-4. Unfortunately for North American skywatchers, the peak is very short and in 2011, it favors viewers in west Asia and Eastern Europe.

Venus shines like a brilliant beacon in the dawn sky. Mercury joins it early in the month. If you have a clear and low southeast horizon, and feel like planet-spotting on New Year's Day morning, see if you can find Mercury to the left of the very thin crescent Moon.

Rising around 2:00 am, Saturn is well up in the south-southeast as dawn breaks. Look for the Moon to the right of this ringed world on the 24th, and below it on the next night. Meanwhile, in the post-sunset sky, only Jupiter shines. (Mars is hidden in the sunset glare.) On the 9th, the crescent Moon hangs to the right of the giant planet, making the pair a pretty sight — both are high in the south at sunset. And look for Uranus, less than 1° to Jupiter's upper right all month.

Finally, a partial eclipse of the Sun will take place January 4. The local circumstances (for cities in Europe, Africa, and Asia) are available from NASA as a downloadable PDF. The eclipse is not visible from the US.
Thanks to Sky & Telescope magazine, Mercury readers have direct access to S&T’s online Interactive Sky Chart. While anyone can go to it on 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 8:00 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.
Neptune

Reflections on the discovery of a planet, one orbit later.

In the early hours of Saturday morning, July 17, 2010, Mike Conley, a friend since high school, and I paid a visit to the “Hermitage,” a dark-sky site where we operate a small clamshell observatory housing a 10-inch Ritchey-Chretien. We opened the clamshell, turned the telescope to a point in the sky near the border between Aquarius/Capricorn where Neptune was lurking, and at once sighted a small bluish disk, situated among a scattering of unremarkable stars (right).

I had often seen it thus; on such occasions it has rarely merited more than a casual glance. But on this night, my heart began to race, and I recalled the lines of Keats (uttered about another discovery, that of Uranus by William Herschel in 1781), which have been repeated to the point where they have become cliché:

Then felt I like some watcher of the skies When a new planet swims into his ken.

Tonight, I didn’t mind the cliché; the lines were most appropriate. I reveled in the chance to relive the circumstances of a famous discovery.

That discovery took place on the night of September 23, 1846, when a German astronomer, Johann Gottfried Galle, and a Danish student-volunteer, Heinrich-Louis d’Arrest, entered the dome of the 9-inch Fraunhofer refractor at the Berlin Observatory. Galle had just received a letter from Paris, written by a mathematical astronomer, Urbain Jean Joseph Le Verrier. Le Verrier, in investigating the off-track motion of Uranus, had just calculated a position for it near what was then the Aquarius/Capricorn border. (Unbeknownst to any of them, a young English mathematician at St. John’s College, Cambridge, John Couch Adams, had been pursuing the same game, but even at the beginning of that month was still revising his calculations.)

“Right now,” Le Verrier had written to Galle, “I would like to find a persistent observer, who would be willing to devote some time to an examination of a part of the sky in which there may be a planet to discover.” Now what true red-blooded observer would ever pass on a chance like that?

Galle was his man, and he went immediately to his director, Johann Encke, to request permission to do the search. Encke was skeptical but nonetheless acquiesced: “Let us oblige the gentleman in Paris.” D’Arrest, a visiting student, begged to be included. He soon proved his worth as it was he who suggested searching among the Berlin star charts to see if there was one of the area in which Le Verrier had put his planet. On looking through a pile of maps in the vorzimmer (anteroom) of Encke’s office, they found Dr. Bremiker’s map of Hora XXI, published at the beginning of 1846 but not yet distributed to observatories elsewhere. (If only the Reverend James Challis, of Cambridge University Observatory, who had been carrying out a secret search and was slowly checking the positions of stars, one by one, looking for one that had moved, had had such a chart, he might already have captured the planet at the beginning of August.) D’Arrest later recalled:

“We then went back to the dome, where there was a kind of desk, at which I placed myself with the map, while Galle, looking through the refractor, described the configurations of the stars he saw. I followed them on the map one by one, until he said: ‘and then there is a star of the 8th-magnitude in such and such a position,’ whereupon I immediately exclaimed: ‘That star is not on the map!’ Its position was at right ascension 21 hours, 53 minutes, 25.84 seconds, declination -13 degrees 24 minutes.”

The position of the actual planet was located less than a degree from Le Verrier’s calculated position, and about 10 degrees from the latest by Adams. It thus deserves to be remembered as the planet “discovered with the stroke of a pen.”

Ponderously traveling through its huge majestic orbit around the Sun, Neptune in 2010-11 returns, for only the first time, to the same field of stars where Galle, his eye directed to this part of the heavens by Le Verrier’s calculations and Bremiker’s map, saw it that night so long ago. A reminder, if any were needed, that the solar system is a huge place indeed.

WILLIAM SHEEHAN is a historian of astronomy. His latest book is A Passion for the Planets: Envisioning Other Worlds, From the Pleistocene to the Age of the Telescope.