Astronomy compels the soul to look upwards and leads us from this world to another
— Plato

Dear champions of astronomy and science literacy,

As many people know, from time to time it is an excellent idea to review your estate plan and legacy giving options. And please try not to let the word “estate” mislead you. Regardless of income and assets, everyone has an estate, everyone will have final expenses, and everyone is responsible for his or her own financial planning. End of life issues are sensitive and can be scary. They are also incredibly important to address when you have the capacity and capability to do so. Each month, the ASP provides updated information about estate planning and planned giving, as well as examples of what has happened to people who did not pay attention to their financial housekeeping.

For those of you impacted by the end of the Defense of Marriage Act (DOMA) and the increasing number of states that recognize same sex marriage, it is particularly important to keep abreast of rapidly changing regulations and benefits in these areas:

- Powers of attorney (healthcare, financial)
- Living wills
- Advance directives
- Gift/inheritance taxes
- Probate issues
- Hospital visitations/medical decisions
- Funeral decisions

- Child guardianship
- Assumption of debts
- HIPPA
- Social security survivor benefits
- Medicare/Medicaid
- Military and veteran’s benefits

You have worked hard for all that you have accomplished and achieved in life. Your legacy is too important to be left to chance — or to the often painful vagaries of probate court. The best gift you can give to the loved ones you leave behind is an organized, thoughtful, and comprehensive estate plan.

Please visit Give for Tomorrow every month to keep informed about the very latest estate planning news and information, and to learn how your legacy gift can support the ASP for years to come.

Thank you,

Kathryn Harper
kharp@astrosociety.org
415-715-1406
A Sample of ASP Posters from San Jose
Here are five of the 70 posters that were presented at the 2013 ASP Conference in Tucson. All the conference posters, oral presentations, and workshops, will appear in the Conference Proceedings, available by mid-2014.

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ALICE OLMSTEAD, SUSANNA KOHLER

20 Training Young Astronomers in EPO: An Update on the AAS Astronomy Ambassadors Program
ANDREW FRAKNOI, RICHARD TRESPH FIEBERG, SUZANNE GURTON, ANNA HURST SCHMITT, DENNIS SCHATZ, EDWARD E. PRATHER

23 Student Engagement and Success in the Large Astronomy 101 Classroom
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28 Wibbly-Wobbly, Timey-Wimey Stuff: Teaching with a Time Lord
KRISTINE LARSEN

The Story of Comets and Comet ISON
ALEXEI V. FILIPENKO

Is Comet ISON, coming to December’s morning skies, really the “Comet of the Century”?

Astronomy in the News
Voyager 1 enters interstellar space, colliding dead stars may be responsible for Earth’s gold, and a bizarre alignment of planetary nebulae — these are some of the discoveries that recently made news in the astronomical community.
Last month I spent an hour with Canadian astronaut Chris “Good morning Earth” Hadfield. Well, okay…me and perhaps 600 others. Chris gave the keynote address at a conference I attended, and it was the highlight of the gathering (see him if you get the opportunity). In the Q&A, Chris was asked about chronicling life aboard the space station via Twitter and how the Space Oddity video came to be. He said:

“When I went into space, I wasn’t sure if the technology would let me tweet from orbit. So I made a deal with our middle son, Evan. I said: ‘If I can’t tweet, I’ll send you an e-mail; please re-tweet it for me.’ He said: ‘Okay.’ And that was our social media plan…..

“Early on [in the flight] Evan said, ‘Hey dad, you have to record Space Oddity.’ So I told him I would, and I recorded a vocal version of it. Some musician friends of mine took my vocal and put some instrumental underneath. And that mixed with my re-vocal and guitar made for what I thought was a killer audio track. Of course, this was just a personal project, but now what else was I going to do with it?

“In order to do anything else, we had to get permission from David Bowie. With just a few weeks left in the flight we got permission — now I had to make a video! So how do you make a rock video? I had no idea. So I was racing around on the weekend, filming myself floating around singing and playing guitar, and sent it down to my son. He and an editor put it all together in about a week. And because of the big rush and issues that came up [toward the end of our mission], we ended up releasing it the day before we came home.”

Thanks to his tweets, photos, and, of course, the video, Chris Hadfield made spaceflight cool and fascinating once again. But for everyone who has dreamed of shooting a rock video in space — sorry, it’s now a case of “been there, done that.” Perhaps the next opportunity will be a remake of Walking on the Moon, performed from the lunar surface.

Paul Deans
Editor, Mercury
New

One of the great constants of the universe is change.

Sometimes, old things become new again, even in the sky. Consider Nova Delphini 2013. Last August, quite unexpectedly (as is always the case), a new star appeared in the sky near the little kite shape of the celestial dolphin. In a matter of a day or two, it rose in radiance to around magnitude 4.5 — naked eye in a decent sky, and that’s nothing to sneeze at. Hardly 30 such “new stars” have been so bright in all of the recorded history of the sky.

Thus, it was something that must be seen, even for someone living on the foggy ocean side of the San Francisco peninsula (like me). We simply don’t see much sky in the summer when the marine layer takes hold, retreating out to sea in the morning (if we’re lucky) but surging back into shore in the evening. And this summer we had a particularly persistent variety that had already given us a solid month of cloudy night skies when the new star declared itself. So on the night of the 17th, three days after its discovery, I got in my car and drove down to a parking lot in San Mateo — on the sunny side of the peninsula — to view the wonder while it was still near maximum brightness.

The sky was indeed clear there but brightened both by city lights and the waxing gibbous Moon, rendering all fourth-magnitude stars invisible to the eye alone. So I hauled out my binoculars, located the arrow of Sagitta high in the sky, and traced from the starry shaft — for the arrow was pointing almost directly at it. And there it was, outshining its sprinkled field, an easy find!

I hauled out my small telescope and trained it on the dusky white star, while my mind wondered thousands of light-years distant and thousands of years in the past. For far away and long ago, this star was already a very old star, having aged to a compact white dwarf dotage only to gather material from a younger companion with which it shared its life. Eventually the white dwarf relieved itself of the additional burden in a violent explosion, brightening briefly to perhaps 100,000 times its previous luminosity, its message of light screaming across the gulf of space and arriving on August 14 to become nova — “new.”

An old thing become new again — a reminder that one of the great constants of the universe is change.

Change happens on Earth, too, of course — all the time. And for the ASP, I initiated some myself in early September when I...
announced my plans to depart the position of Executive Director next February to pursue other interests. It provides an opportunity for the Society to welcome new leadership to keep the organization shining bright, to build on the solid foundation we have so carefully crafted these past six years to advance the ASP to new levels of achievement.

Nova Delphini has since faded back into the night, its celebrity status counted in a few weeks. But the ASP will celebrate its 125th birthday next February 7th, a testament to its staying power even as the ephemera of the sky (and the ASP’s executive directors) come and go. This is due in no small measure to the generations of supporters who have made of it a relevant and appealing forum for channeling their love of the cosmos. With the continued support of its stakeholders and of you — may it continue ever so.

My part in this particular story is coming to a close; in the way of things, it is also time for this old salt to become new again. But the story goes on. Thank you for being such good companions on the journey. I wish you all good things for the chapters yet to be written, under the sky we all love. ☼

JAMES G. MANNING is the Executive Director of the Astronomical Society of the Pacific.

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In honor of the ASP’s 125th anniversary in 2014, the organization is designing and publishing for sale a limited edition commemorative wall calendar featuring stunning astrophotography submitted by our own Night Sky Network community members and other sources. In addition to “what to look up for” each month, this large calendar will also include key dates, milestones, and “firsts” from the ASP’s extensive and diverse history.

The calendar is being sold to help raise funds for ASP programs and services, and will make a perfect holiday or year-end thank you gift for friends, family members, colleagues, and clients! Size: 13” x 10.5”.

One calendar for $20
Three calendars for $15 each (25% discount)
Five calendars for $10 each (50% discount)
(Shipping and handling charges apply)

Please visit the ASP’s AstroShop to pre-order your calendars today!
Milton’s Universe

It seems that everyone has misinterpreted Milton’s universe for the past 260 years.

John Milton’s *Paradise Lost* is one the greatest examples of English literature ever composed, and its astronomical allusions have been studied for centuries. A new book by Milton scholar John Leonard — Vol. 2 of his 2013 book *Faithful Labourers* (Oxford University Press) — claims that nearly all the scholarly analysis of Milton’s universe is wrong...very wrong.

Generations of Milton scholars were too clever by half, argues Leonard. Time and again he shows that they were guilty of historical error, illogic, and misreading — sometimes all in the same paragraph. Scholar after scholar misrepresents what Milton meant, thereby creating a vision that they admit cannot be reconciled with what Milton wrote. Their solution — blame Milton for inconsistency! “Something has gone wrong when literary criticism gets into a muddle like this,” Leonard says with obvious sadness.

Leonard is world-renowned as a scholar of Milton’s poetry. He received his PhD in 1986 at Trinity College, Cambridge, and is now Professor at the University of Western Ontario in London, Ontario, Canada. He served a term as President of the Milton Society of America in 2003.

There is lots of blame to go around for the current muddle about what Milton meant in *Paradise Lost*, but Leonard says David Masson, who wrote a three-volume work about Milton in 1874, built the bedrock of the false edifice. So strongly was he identified as the greatest authority on the subject that scholars ever since have either slavishly followed his lead or been very reluctant to even suggest there might be a chink in the armor. “Masson writes with great enthusiasm,” says Leonard, “which helps explain why his model has enjoyed so much lasting success, but that model robs both the outer and inner spaces of Milton’s universe of their wonder and majesty.”

The ideas of Copernicus were still fairly new and contested when Milton was writing in the mid-1600s. An example of this is a book by Alexander Ross in 1646, provocatively entitled *The New Planet no Planet*, in which he says Earth is no wandering star “except in the wandering heads of Galileans.” Ross attacks the Copernican system as ridiculous, erroneous, and impious.

Most Milton scholars have simply assumed he, like Ross, was not receptive to the new Sun-centered system. Leonard shows he did in fact adopt the Copernican system in *Paradise Lost*. This was not lost on early scholars of Milton. “The Jonathan Richardson, father and son, offer some of the best commentary ever written about Milton’s universe,” Leonard says. Their 1734 analysis made it very clear that Milton was being ironic when he talked about the 10 Ptolemaic spheres that comprise the universe. He was not supporting the idea that Earth was surrounded by spheres — he was making a joke about it! Why subsequent generations of
scholars ignored them is a sobering reminder that many seemingly intelligent people, in both science and literary studies, waste much of their lives defending ideas that have no basis in reality.

Perhaps Milton scholars should have clued into the fact that Milton actually spent time with Galileo during a visit to Italy! Galileo makes an appearance in Milton’s poem, and he clearly regarded the Italian as a great man who had no use for the Ptolemaic system.

In the 1930s another great Milton scholar, Grant McColley, made a thorough muddle of what Milton was saying. “When he attends to Milton’s words he makes elementary mistakes,” writes Leonard, even though McColley had “unrivalled knowledge of the astronomical options that were available to Milton.”

Also in the late 1930s Francis Johnson, who “shares McColley’s view that Milton’s astronomy was woefully out of date,” wrote the influential book Astronomical Thought in Renaissance England. McColley and Johnson are superb scholars, but they are not good critics, writes Leonard. “McColley’s attempts at close reading miss the obvious, while Johnson does not even try to read closely. The simultaneous publication of their studies nevertheless delivered a double blow from which Milton’s universe has yet to recover.”

While doing this research, Leonard related to me that: “I came to believe that everyone has got Milton’s universe dead wrong for the past 260 years. Far from adopting a medieval picture, Milton ridicules it by placing it in the Paradise of Fools. It all comes down to a misreading of three lines that are a joke!”

CLIFFORD J. CUNNINGHAM was recently seen in Denver, revealing before the American Astronomical Society his discovery of the identity of the man who created the word “asteroid.”

Algol: The Oldest Known Variable Star?

The ancient Egyptian scribes may have recorded its variability in their calendars.

The eclipsing binary Algol was discovered in 1669. In 1783 John Goodricke determined its 2.867-day orbital period without a telescope. But a research group led by Lauri Jetsu and Sebastian Porceddu from the University of Helsinki in Finland thinks that the ancient Egyptian scribes may have been aware of Algol’s variability and may have been the first to record its period. The team’s results were announced last year, but their peer-reviewed paper was just published in the August 2013 Astrophysical Journal.

The Egyptian scribes were responsible for keeping precise time by observing the stars, determining lucky and unlucky days, and performing accurately timed rituals to appease the gods. They kept meticulous records from 2181 BC to 332 BC. The Cairo Calendar (CC), dating from 1271–1163 BC, describes a cyclic transformation of the Eye of Horus, or “the Raging one,” which was supposed to have a good or bad influence on the lives of humans. Changes of “the Raging one” are recorded as occurring during the course of a few
days, which is consistent with the period of a bright variable star. But deciphering astronomical information to compare with modern-day knowledge is a challenge involving both statistics and astrophysics.

The ancient Egyptian year consisted of 365 days and three seasons: flood, winter, and harvest. There were 10 months with three weeks each. Weeks were 10 days long, so a month had 30 days. Each day was divided into three periods: morning (beginning at dawn), midday, and evening. Each of these daily periods was given a prognosis of lucky or unlucky. A 360-day year was ascribed to the gods but the scribes added five additional days (which were not given a prognosis) to the year to match the length of the solar year.

Jetsu and his colleagues had to convert those CC days to Gregorian calendar days, and then determine which of the three periods corresponded to dark time. Converting to Gregorian days was not a trivial task, because they had to determine what day in the CC coincided with January 1 in the Gregorian calendar. In addition, each day in the CC consisted of 12 hours of day and 12 hours of night, so they had to ascertain which period of the day corresponded to astronomical dark.

After working out days and times, they were able to perform a time series analysis of lucky and unlucky prognoses. They identified two real periodicities — 29.6±0.2 days and 2.850±0.002 days. The first corresponds to the lunar cycle, and the second is close to the period of Algol. But is this periodicity really a record of the variability of Algol? To test their hypothesis, Jetsu and team turned to astrophysics and astronomy.

First, they examined the observed periodicity with the currently accepted period of Algol, which is 2.867328 days. Mass transfer from the less massive to the more massive star in the Algol system should lead to an increase in the period of the system. If the period of Algol was 2.850 days in 1224 BC, then the calculated mass-loss rate would be consistent with evolutionary models. They also show that changes in Earth’s rotational rate since 1224 BC would have a negligible effect on the observed period of Algol.

The team also examined candidates from the General Catalog of Variable Stars. Naked-eye observers should be able to see objects with maximum visual magnitudes less than 4.0 that have a variability of at least 0.4 magnitudes. The period of variability should range from 1.5 to 90 days. The star should not be too close to, or below, the horizon. The variability of the star must be predictable, detectable during a single night, and must change the appearance of the constellation. Finally, the ancient Egyptian scribes needed to be able to determine its period. Application of the above criteria leaves only Algol and Lambda Tauri.

How did Jetsu et al finally arrive at Algol? They looked to astronomical history as a guide. The variability of Algol was discovered in 1669, and its periodicity was determined in 1783. Lambda Tauri was not discovered until 1848, and its period was not determined until 1920 because there were no suitable comparison stars nearby. So, it makes sense that those Egyptian scribes would have been able to discover the variability and period of Algol. The team has another paper in progress, so stay tuned for more.

JENNIFER BIRRIEL is an associate professor of Physics in the Department of Mathematics, Computer Science & Physics at Morehead State University in KY. She briefly pondered a career in archeoastronomy after reading about the potential astronomical significance of Stonehenge back when she was in high school.
More than six months ago, the “sequester” took place. The failure of Congress to resolve budget disputes resulted in indiscriminate, across-the-board cuts to all government programs including NASA, the main source of funding for planetary science. The effects have been deep and varied and will continue, even if sequestration is reversed.

The most immediate impact was a suspension of all travel by researchers who work at NASA centers. Mere days after the sequestration, the annual Lunar and Planetary Science Conference (LPSC) took place in Houston, Texas. This meeting each March is one of the largest gatherings of planetary scientists in the country and is a key event for sharing ideas and forming collaborations. NASA scientists waited until the last possible minute, hoping for a special dispensation to allow them to make the meeting. Two administrators from NASA Headquarters, John Grunsfeld (Associate Administrator for the Science Mission Directorate) and Jim Green (Director of the Planetary Science Division), gave up their own travel to allow two more researchers to attend.

As a result, several talks and sessions were canceled, and at least one talk was given by someone — a colleague who was filling in as best he could for a scientist denied travel — who was not part of the study. Posters had notes pinned to them reading: “I’ve been sequestered,” directing questions to e-mail addresses or to co-investigators who were trying to present multiple posters simultaneously. Since then, at least one conference has been made “virtual” (the annual NASA Lunar Science Forum in July), and one (the planned 8th International Mars Conference) has been postponed until 2014.

In past decades, the planetary science community has sent spacecraft throughout our solar system. These probes, orbiters, and landers often continue functioning long past their scheduled missions. The rover Opportunity was originally slated to last 90 Martian days. A decade later it is still rolling, having traveled 22 miles across the surface of the red planet. Cassini’s primary mission ended in 2008, but it has since provided another five years of observations of the Saturnian system. These robots cost millions, sometimes billions, of dollars, and the longer they return scientific data, the more ‘return’ taxpayers get for that money. If successful missions are shut down (or not extended), the spacecraft cannot be reactivated. They, and all their potential discoveries, are irrecoverable.
After data are gathered, it must be analyzed. Analysis is where we receive our return on investment — we learn from what we’ve collected. And it’s how many planetary scientists spend their careers. The majority of their work is funded by competitive grants. Scientists or teams of scientists submit proposals for research to various programs within NASA, and panels of reviewers decide which proposals to fund. For various reasons the rate of success for grant proposals has been dropping for several years, and the sequester has simply added to the pressure. It’s another variable in the already unpredictable process of the annual federal budget. As a result, scientists are hedging their bets by submitting more proposals, to more programs, in the hope that one of them will be funded.

All of these factors combine to weaken our country’s planetary science workforce. The United States has long led the world in solar system exploration, developing an invaluable community of scientists, engineers, contractors, and technicians in the process. Collectively, they have literally centuries of skill and expertise. A reduction in funding pushes them to leave the field, or even the country, in search of greener pastures. Promising students — the next generation of researchers — lack teachers and opportunity, and so find other paths. This drain on personnel is not easily reversed. Even in a hypothetical future with restored funding, it can take as long as a decade to train a replacement for a lost expert. We in the planetary community are still working as hard and as well as we can. Curiosity continues to send back amazing data from Mars. Dawn continues on its way to Ceres. New Horizons is on the last leg of its journey to Pluto. With sequestration in place, however, progress gets harder every day.

EMILY JOSEPH is a Research Assistant, with an emphasis on Mars, at the Planetary Science Institute.

Black Hole Rejection

Scientists uncover why some black holes don’t seem to want you.

Have you ever been down so low that you thought even a black hole would reject you? Perhaps you can find some solace in the fact that our entire galaxy also feels the same way sometimes.

There’s a black hole in our galaxy’s center that doesn’t seem to care much for most of the gas, dust, and stars surrounding it. Observations reveal this black hole, associated with a bright source called Sagittarius A* (pronounced A-star), pulls in less than 1% of the gas within its gravitational grasp. Such black hole rejection has stymied astronomers, who have struggled to explain why some black holes are so welcoming to matter — think quasars, the most active and gregarious black holes known — and why some black holes are so picky.

Now, new results from NASA’s Chandra X-ray Observatory have provided some clues. A paper based on a five-week observation...
of Sagittarius A*, led by Q. Daniel Wang of the University of Massachusetts in Amherst, appeared in August in the journal Science. In short, the Chandra team found that gas available to Sagittarius A* is too diffuse and hot to capture and pull in, in stark contrast to the cooler and denser gas reservoirs powering quasars and producing huge amounts of radiation.

Black holes are broadly grouped into two categories: stellar-size, the collapsed remains of massive stars still containing the mass of several suns; and supermassive, with the mass of millions to billions of suns, residing in the center of perhaps all galaxies. Among supermassive, there is a category associated with Active Galactic Nuclei (AGN) — a descriptive name pointing to something (assumed to be a black hole) pulling in copious amounts of matter from the galaxy’s core and, in the process, releasing abundant radiation often across the entire spectrum. The AGN family includes quasars, blazars, and Seyfert galaxies. Sometimes the black hole will generate particle jets that shoot clear out of the galaxy.

Then there’s ho-hum Sagittarius A*, the supermassive black hole of about four million solar masses in our galaxy’s nucleus that seems to care little about most of the matter around it. Quiet and boring as it might be compared to quasars, Sagittarius A* is at least close — within 26,000 light-years of us — and makes for a nice laboratory to study black holes.

Wang’s team took advantage of one of the longest observations ever granted by Chandra schedulers. By combining five-week’s worth of data, the astronomers formed a picture of all the activity, or perhaps non-activity, surrounding Sagittarius A*. The region does have stars to feed the black hole — hundreds that have been identified and thousands more inferred but too dim to see. The gas and wind from all those stars should make Sagittarius A* a million times brighter than it is.

“It is as though you filled up your car’s gas tank, drove 2 feet, and ran out of gas,” said Jeremy Schnittman of NASA Goddard Space Flight Center, in an accompanying Science commentary. “Is there a massive leak in the fuel line, or is the mileage really that horrible?” Wang’s team ruled out whole low-mass stars as being the fuel for Sagittarius A*, which had been a theory. They found no signals in the emitted radiation indicating the presence of such stars, namely an iron spectral line. What they did find was indicative of very hot, thin gas from colliding stellar winds.

This extremely hot gas flows towards the black hole like, well, steam down a drain, Wang said. Most of it, 99%, dissipates before reaching the black hole — the leak that Schnittman spoke of. Scientists say this theory can be tested by the end of 2013 as a cool gas cloud comes within reach of Sagittarius A*. That should flow in like cool water down a drain, and observatories are gearing up to watch.

Hmmm. Maybe Wang’s discovery makes matters worse. We’re being rejected not in favor of something hot and sexy but rather something cold and ordinary.

CHRISTOPHER WANJEK, a freelance writer based in Baltimore, knows all too much about rejection.
During some recent reading, I came across the term *mathemagenic*, which means “gives birth to learning” from the Greek roots *manthanein* (to learn) and *genos* (birth). While we would all like to be mathemagenic geniuses, it was the word offered in opposition that caught my attention: *mathemathantics*, which means, “killing learning.” I do not propose we use these terms, but the concept of killing learning deserves some exploration.

We all have encountered the frustrating situation where a pre- and post-test assessment indicates that students did more poorly on the post-test than on the pre-test. Or perhaps you had two classes wherein you tested an improved teaching technique with one class while using the older method with the “control” class, only to have the control class perform better. These examples demonstrate the mathemathantic effect.

Some apparent mathemathantic results are easily explained (and are not mathemathantic). Sometimes the pre- and post-test are poorly aligned with the concepts being covered. Often the best-practice method is incorrectly administered. But these are teaching blunders and not the enigmatic mathemathantic condition where students do worse because of my best effort.

Hardly anyone publishes the results of educational research where learning decreased, so few of us know about this effect and what to do about it. In addition, Richard Snow of Stanford University pointed out 40 years ago that what might be mathemathantic for one group might be mathemagenic for another.

Richard Clark (in *Learning and Instruction*, 1989) has summarized, from the educational research literature, what researchers believe to be the causes for mathemathantics in several learning situations. They described students as high or low ability and as independent or conforming thinkers, and the learning environment as having high or low structure and high or low cognitive load.

When high-ability students were forced to use new learning strategies that replaced their self-created learning structures (automatic processes), the teaching intervention resulted in lower learning. Not only was learning using the new procedure less successful, but it interfered with older knowledge and weakened performance on previously successful tasks. The lesson: High-ability students need less structure in order to utilize their own models and learning strategies.

But low-ability students need more structure. Left to their own, they build faulty mental models if inadequate learning strategies are provided. Teachers who base their instructional methods on what works for the high-ability learners often find these methods work to the detriment of the low-ability students. Sometimes the methods are too abstract for this group or the steps are chunked into pieces that are too big. We need to provide more concrete instruction to this group and to be more explicit about each step of reasoning.
Failure avoidance can also drive mathemathantic effects. Conforming students avoid failure by seeking highly structured and directed learning experiences. In unstructured settings, they may invest less effort and, thus, score poorly. (Failure, then, does not refer to the score but the learning return on investment perceived by the student.) Independent learners use their own learning methods to be successful, but in situations where instructors tightly control the learning environment, the independent learner may invest less effort and thus score poorly. For example, frequent in-class testing might benefit the conforming students, but some studies show the independent learners achieved less.

The idea of mathemathantics should flavor how we approach our teaching methods. Instructors should worry less about when to apply intervention and spend more effort on providing the intervention to the right group. One size does not fit all, and students are not rewarded equally by the same exercise.

We need to allow independent and high-ability learners the freedom to use their own strategies in class activities. At the same time, we need to provide explicit instruction and step-wise procedures for low-ability and conforming students — this may exist in the form of additional course materials on a website, or extra instruction. The instructor needs to assure the high-ability students that they are not missing anything regarding the extra materials (to counter failure avoidance) and assure the low-ability students that using the extra materials means they are doing what they need to do to ensure their success. So we need two sets of standards operating within class so both sets of students can “march to the appropriate drummer.” And we need researchers to study mathemathantics more closely to see whether our best practices are aligned properly to help all groups of students succeed.

DAVID BRUNING teaches astronomy at a Midwestern state university. He now has a word for the failure of those well-intended introductions of “best practices” wherein students did not succeed according to expectations.

**Dance Inspired by Astronomy and Physics Research**

*During the summer of 2013, for the fourth year in a row, researchers at the University of California, Berkeley partnered with Kathryn Roszak's Danse Lumiere to offer a weeklong Dance/Science Summer Camp. Science, and astronomy in particular with its stunning visual beauty, has inspired art for a long time. However, in this unique camp, it is movement that takes center stage. The motions that are evident in many aspects of astronomy and physics inspired the choreography and movement in dances created during the camp. This collaboration started in the summer of 2010 by regular...*

**Dance Inspired by Astronomy and Physics Research**

*By Matt Fillingim*
“Reaching Out” contributor Bethany Cobb, then a NSF Postdoctoral Fellow at UC Berkeley. (Bethany wrote about her initial collaboration with Kathryn Roszak’s Danse Lumiere during 2009’s Year of Astronomy in the Winter 2010 issue of Mercury.) About the time Bethany left for a new position at George Washington University, I happened to run into Kathryn Roszak. In addition to discovering that our children were at the same school, and that we were both teaching at the University’s Osher Lifelong Learning Institute (which Bethany also wrote about in the Summer 2010 issue), we also realized that we both knew Bethany. After a few conversations, I decided that I would try to fill the void left by Bethany and help with 2011’s Dance/Science Camp. Since 2011’s session was so successful, we decided to try to keep it going during the summer of 2012 and again this past summer (2013).

With materials and activities graciously loaned to me by colleagues at the UC Berkeley’s Space Sciences Laboratory Center for Science Education, I worked with students ages 9 to 12, introducing them to the movement and dynamics found in many areas of current astronomy and physics research. Kathryn, a dancer, choreographer, and the artistic director of Danse Lumiere, worked with the students to create dances inspired by what they saw. Near the end of the camp, the students themselves even had the opportunity to choreograph some of their own dances.

During the recent camps, many of the topics explored revolved around magnetism (since that is one of my areas of research). We discussed the dynamic magnetic field of the Sun as revealed by recent Solar Dynamics Observatory images, the effects of the Sun’s magnetic field interacting with Earth’s magnetic field to create the ethereal aurora borealis (northern lights), and comparisons of Earth’s large, global-scale magnetic field with the localized, small-scale, “hidden” magnetic field of Mars. In addition, we talked about current theories regarding the formation of the Moon, and substantial time was devoted to the most cutting-edge and timely science — the discovery of the Higgs Boson at the Large Hadron Collider. We even watched some footage from the webcast of the recent University of California panel explaining the findings.

After talking about these different topics, looking at data, pictures, and, of course, animations, the students were then encouraged to express what they saw in movement. The movements were incorporated into the dance choreography, and in some cases the students themselves developed the choreography. At the end of the week-long camp, and after much rehearsal, the students performed the pieces for their families and friends. As part of the final show there was also a performance — inspired by the properties and motions of magnets — created and developed by a professional dancer.

During its short four-year history, this Dance/Science Camp appears to have made a significant impact on the students’ interest in astronomy (if parents’ feedback is any indication). We hope that this camp will continue to grow in popularity, scope, and impact.

MATT FILLINGIM is a research scientist at the Space Sciences Laboratory at the University of California, Berkeley, and an adjunct instructor at Berkeley City College.
My Sky Tonight: Exploring Early Childhood Patterns of Engagement with Astronomy Concepts

Three- to four-year-old children ask an average of 76 information-seeking questions per hour.

The Astronomical Society of the Pacific is spearheading a new $2.5M National Science Foundation funded research project entitled “My Sky Tonight,” designed to foster a love of astronomy in preschoolers. During four and one-half years, the project aims to reveal the hurdles to early childhood science learning, and develop ways to promote pre-school age science learning through astronomy.

Astronomy for 3- to 5-year-olds in museums! Why?
• Because the museums are asking for it. Armies of strollers descend on museums daily. Science museums want relevant content for young children and children's museums want astronomy content.
• Research shows that children are interested. The project is expanding our understanding of young children's understanding of the universe. They are more aware than many imagined.
• Here we present on the first year of a five-year project.

Goals of the Project
• Develop a toolkit of interactive astronomy experiences for 3- to 5-year-olds and their families in museum settings and beyond.
• Build the informal science educators' confidence and capacity to share appropriate astronomy experiences with young children using online Professional Development.
• Advance the field's current understanding of children's ability to interact with astronomy concepts.

Some Preliminary Findings
• Preschool children have a lot of good astronomy knowledge. They talk about astronomical concepts with enthusiasm and come with many previous ideas.
• The tools of astronomy are both iconic and engaging. Even the very young enjoy looking through binoculars and telescopes.

by Vivian White & Anna Hurst, ASP
and are able to see features.

• Informal Science Educators are diverse in astronomy knowledge and their comfort level with early childhood engagement. The toolkit and Professional Development will address both of these areas.

• The astronomy capabilities and interest variation in our target age group (3–5) is dramatic. Activities will need to reflect a range of abilities and engagement levels.

• Parent involvement and education is key to success. Activities are designed to involve the parents and encourage them to learn more after their visit.

• The venues where museums plan to use these activities vary from informal, unfacilitated stations to multiple-day workshop settings. The activities will reflect these needs by being scalable.

Early Childhood Researchers Study…

• Astronomy conversations in diverse museums and preschools.
• Longitudinal family diary study.
• ISE Practitioners’ goals and pedagogy.
• Impact of toolkit on families.

Astronomy Educators Produce…

• Interactive toolkit of a dozen hands-on activities for use by informal science educators in museums
• Professional development for Informal Science Educators in the Astronomy from the Ground Up community and beyond.

Museum Educators Contribute…

• Help with development of activities and professional development.
• Events held in partner museums to aid activity development.

Formal Evaluation Investigating…

• Process evaluation of team.
• Formative evaluation of materials and training.
• Summative evaluation with ISE providers, children, and families.

This poster paper was presented at the ASP’s annual meeting in San Jose, CA, in July 2013. If you’d like to learn more about this project, please contact the authors: Vivian White or Anna Hurst.
ASP 2013 San Jose

This special section of Mercury features reprints from five poster papers, plus a transcript of Alex Filippenko’s Monday night public talk on Comet ISON — all part of the ASP’s Ensuring STEM Literacy conference held in San Jose, California, July 2013. In addition, three conference plenary session videos are available on the ASP’s website. [Paul Deans x7]
Astrobites: The Astro-ph Reader’s Digest for Undergrads

Alice Olmstead (University of Maryland, College Park) and Susanna Kohler (University of Colorado at Boulder)

Astrobites (http://astrobites.com) is a daily blog aimed primarily at undergraduates interested in astrophysical research and written by a team of graduate students located at diverse institutions around the world. Nearly every day we present a journal article recently posted to astro-ph in a brief format that is accessible to anyone with a general background in the physical sciences. In addition to summarizing new work, Astrobites provides valuable context for readers not yet familiar with the astrophysical literature. Special posts offer career guidance for undergraduates (e.g., applying for an NSF graduate fellowship) and describe personal experiences (e.g., attending an astronomy summer school). We will discuss the Astrobites format and recent readership statistics, as well potential methods for incorporating Astrobites into the classroom.

**Astrobites Authorship**

Astrobites is entirely graduate-student run and focused on making current astrophysical research accessible and exciting for undergraduate physical science majors. Founded by a group of five graduate students at Harvard in December 2010, it has since included 41 regular authors at 17 institutions who together have written more than 700 posts. About three-quarters of our posts summarize recent astronomical articles from astro-ph; the other one-quarter address topics such as career navigation and personal experiences. We also encourage undergraduates to submit posts about their own research for publication on our site.

**Astrobites Readership**

Astrobites currently receives about 30,000 recorded pageviews per month, where any view on an Astrobites webpage is counted as a pageview. Readership via RSS feed, which counts for about two-thirds of our viewership, is not included.

**Astrobites Demographics**

We conducted a survey of our readers in September 2011. Half of our readers are students but only one-fifth are undergraduates, our original target audience. Of the 64 students surveyed, 54 plan on a career in astrophysics.

We find that word of mouth brings in the most readers. Referrals by Phil Plait via Bad Astronomy cause visible spikes in site views and are the single biggest source of long-term Astrobites readers. Popularity on news conglomeration sites (e.g., reddit) produce temporary increases in site views but very few of those referred become regular readers.
Astrobites in the Classroom

Participation in astronomy research is a key part of an astronomy major’s undergraduate experience. Yet acclimating to the research process and culture is challenging and often intimidating. Sanders et al. 2012 suggest several ways to use Astrobites as a classroom tool to gently increase immersion in astronomy research. They are:

1. The instructor gives reading assignments that relate to concepts discussed during class.
2. Students produce written summaries of astronomy research papers in the style of Astrobites. Existing posts can help students discover what interests them and provide background.
3. Student give in-class presentations of current astronomy research. As in #2, Astrobites can provide inspiration and background. If students select Astrobites-reviewed papers, their classmates can learn about the topic ahead of time to encourage meaningful student dialogue.
4. Students use the comments section of Astrobites as an online discussion forum. By posting comments publicly, they draw on the expertise and enthusiasm both of our authors and our broad audience of astronomy researchers. Comments by readers at any level are welcome.

Get Involved

Are you an educator interested in using Astrobites in your classroom? Have you done so already? Would you like help from us? Do you have new ideas to contribute? Let us know! Send us an email at astrobites@gmail.com.

Training Young Astronomers in EPO: An Update on the AAS Astronomy Ambassadors Program

Andrew Fraknoi (Foothill College), Richard Tresch Fienberg (AAS), Suzanne Gurton and Anna Hurst Schmitt (ASP), Dennis Schatz (Pacific Science Center), Edward E. Prather (CAE/Univ. of Arizona)

The American Astronomical Society (AAS), in partnership with the Astronomical Society of the Pacific (ASP), members of the Center for Astronomy Education (CAE), and other organizations active in science education and public outreach (EPO), has launched a series of professional-development workshops and a community of practice designed to help improve early-career astronomers’ ability to effectively communicate with students and the public. Called Astronomy Ambassadors, the program provides mentoring and training experiences for young astronomers, from advanced undergraduates to
new faculty; it also provides access to resources and a network of contacts within the astronomy EPO community.

By learning how to implement effective education and outreach strategies, Astronomy Ambassadors will become better teachers, better presenters at meetings, and better representatives of our science to the public and to government. And because young astronomers are a more diverse group than those who currently do the majority of outreach, they will help the astronomical community present a more multicultural and gender-balanced face to the public, enabling members of underserved groups to see themselves as scientists.

AAS Astronomy Ambassadors are provided with a large library of outreach activities and materials that are suitable for a range of venues and audiences and that will grow with time. We call it the MOOSE, or Menu of Outreach Opportunities for Science Education. For much of the MOOSE we are using resources developed by organizations such as the ASP, the Pacific Science Center, and the CAE for other outreach programs, though some resources have been created by lead author Andrew Fraknoi specifically for this program.

The first Astronomy Ambassadors workshop was held at the 221st meeting of the AAS in January 2013 and served 30 young astronomers chosen from more than 75 applicants. Incorporating feedback from workshop participants and lessons learned from the reports they’ve submitted after conducting their own outreach events, we are now planning the second workshop to be held January 4–5, 2014, at the 223rd AAS meeting in Washington, DC.

Putting a Face on Science
The Astronomy Ambassadors project was the brainchild of then-AAS President (now Past-President) Debra M. Elmegreen. Among other motivations, she was alarmed at the results of Research!America’s 2011 “Your Congress – Your Health” poll, which revealed that more than 80% of US citizens don’t know a scientist personally and consequently feel little or no direct connection to the scientific enterprise. The AAS Council agreed with Elmegreen that we should take action to address this problem.

The First Class of AAS Astronomy Ambassadors
One of our goals is to put a young, enthusiastic, and diverse face on the science of astronomy. Accordingly, the primary candidates for Astronomy Ambassadors training are early-career AAS members: mainly graduate students and first-time postdocs, but also some advanced undergraduates as well as new faculty members.

We strive to include ambassadors of both genders, from a variety of cultural backgrounds, from institutions large and small and urban and rural, and to encourage ambassadors to seek out venues with diverse audiences for their outreach activities.

In the 6½ months since the workshop, 18 of the ambassadors have logged a combined 64 EPO events, while 12 ambassadors have not yet logged their first event. The four most active ambassadors have, between them, logged 38 events, i.e., 59% of the total. Eight more ambassadors have logged at least two events, while six have logged one event. Here’s a demographic summary of the first class of AAS Astronomy Ambassadors:
Whom Are Ambassadors Serving?
The opportunities for outreach are many, both in and out of the classroom. Adults and family groups flock to community centers, science museums, planetariums, nature centers, national and regional parks, fairs and festivals, science-institution open houses, etc., where they can be engaged in science, technology, engineering, and mathematics (STEM) activities. And students can be found not only in formal classrooms, but also in afterschool programs and summer camps. The tools emphasized in the workshop are most appropriate for the general public and middle- and high-school students.

A Community of Practice
Using infrastructure already developed for the ASP’s Astronomy from the Ground Up (AFGU) program, we’ve built a forum dedicated to tools for, and communication among, AAS Astronomy Ambassadors. Participants are part of an online community that regularly exchanges ideas, resources, and experiences, not only with each other but also with their workshop trainers.

As the program grows — as new cohorts of Ambassadors “graduate” from training and get involved with outreach — there will be an increasing number of participants in the online forum and more opportunities for sharing of successes and challenges and for group problem solving.

Eventually we expect to move the forum to the AAS website, where we’ll be able to take advantage of the AAS’s new communications infrastructure.

Second Workshop at the January 2014 AAS Meeting
The AAS Astronomy Ambassadors workshop content balances skill-building with a deeper understanding of outreach. It offers general tips for finding existing programs and materials for astronomy and science outreach and helps participants learn how to identify specific opportunities in their own communities.

Workshop sessions also assist young scientists in gaining a better understanding of how people learn and what makes outreach to nonscientists effective. By building on participants’ existing communication skills and natural enthusiasm for science, workshop activities build confidence in the participants for doing public outreach. With this in mind, our second Astronomy Ambassadors workshop will be offered on the weekend preceding the 223rd AAS meeting in Washington, DC, 4–5 January 2014.

Evaluation
In addition to the event logs that Astronomy Ambassadors report for their outreach activities, we conducted pre- and post-workshop surveys, observations of the workshop, lunchtime focus groups with participants, and later telephone interviews with a subset of
participants, all as part of a formative evaluation plan. These efforts are helping to refine our planning for future workshops.

Results from the post-workshop survey are encouraging. More than 90% of respondents rated the inaugural workshop as good or excellent. Most also thought that the content of the workshop was just what they were hoping for, except that they would have liked to see even more time devoted to learning about various questioning strategies, to discussing fears and obstacles in carrying out outreach events, and to identifying sources of funding and other types of support for their outreach efforts. Participants with less prior experience in EPO found the workshop most valuable, so we plan to select participants with less outreach experience in the future.

How Can You Become Involved?

If you’re part of our target audience to become an Astronomy Ambassador, watch for announcements from the AAS for future workshops. If you’re an experienced EPO professional and are interested in contributing outreach materials or techniques that you have developed and that could be featured on the Astronomy Ambassadors website and/or in our workshops, contact Suzanne Gurton, ASP Education Manager, sgurton@astrosociety.org.

For general inquiries about Astronomy Ambassadors, contact Rick Fienberg (rick.fienberg@aas.org) or Gina Brissenden (gina.brissenden@aas.org).

More Information

http://aas.org/outreach/aas-astronomy-ambassadors-program
http://www.pacificsciencecenter.org/Portal-to-the-Public/portal
http://www.astrosociety.org/education/programs/
http://astronomy101.jpl.nasa.gov

Student Engagement and Success in the Large Astronomy 101 Classroom

Joseph P. Jensen (Utah Valley University)

As Utah Valley University (UVU) struggles to accommodate an ever-growing population of diverse students, more classes are being taught in a new, well-designed auditorium with stadium-style seating, multiple displays, excellent acoustics, and all the technological bells and whistles a modern professor might want.

My assignment to teach Elementary Astronomy (“Astronomy 101”) in the large auditorium during the fall 2012 semester presented an opportunity to compare how the engaged teaching methods I was using in a smaller classroom work in the large auditorium setting. The small “control” class had 42 students and was taught in the intimate setting of a small campus planetarium. The second class had nearly 300 students, was taught in the large auditorium, and had six undergraduate Instructional Assistants. In all other aspects,
I attempted to teach the two classes as identically as possible, using the same presentation materials, homework assignments, think-pair-share questions, tests, and access to teaching assistants (peer tutors). In this article I describe the quantitative performance of the students in the large class compared to the small one.

Challenges to Student Success in the Large Classroom

In the large auditorium, it is easy for students to hide in a sea of faces. The impact of that anonymity is perhaps the most significant factor that contributes to a host of other related issues. When students feel anonymous, they are less likely to attend class and more likely to cheat on homework or exams. Anonymity results in a lack of interaction with the professor and with other students, which breeds apathy, a lack of responsibility and accountability, and passivity towards academic performance.

I adopted some simple strategies to try to prevent students from feeling anonymous in the classroom.

• I asked students to wear name tags to allow me to interact more personally with them, and I gave a few points now and then to encourage continued use during the semester. The small class was also asked to use name tags (though they were not used much once everyone got to know each other after a few weeks of class).

• I also asked the students in the large class to self-organize into “neighborhoods” according their availability to meet outside of class. Undergraduate teaching assistants worked as peer tutors and conducted office hours and review sessions with these groups.

• I adopted a classroom response system (“clickers”) and used our online course management system to track student participation and interact with them efficiently and frequently.

Anonymity is not the only challenge to professors and students interested in student success. Technical issues can also throw a wrench in the works. Large classes are necessarily dependent on technology to run efficiently, both during the presentation (microphones, projectors, etc.) and for management of course materials (online homework systems, messaging, and assessment).

Problems that are a nuisance in a small classroom can become critical when they affect hundreds of students.

Students who can’t hear, or can’t access course materials, or have problems connecting to the Internet during an exam become frustrated, disenfranchised, and sometimes even give up on the class.

Did the Strategies Work?

• Name tags and group assignments weren’t enough to connect with a significant fraction of the students. Many wanted to be anonymous.
• The percentage of students that felt voluntary review sessions with Instructional Assistants helped them was only 50%. Students don’t always trust peer tutors.
• Students responded positively to clickers (88% positive), online homework (78%), and computer testing (60%) in spite of serious glitches. The immediate feedback provided by these technologies is powerful!
• Engaged teaching methods worked well, even though student resistance in the form of apathy and poor attendance persists.

## Student Attendance and Performance

Student performance in the small class exceeded that in the large class in all quantitative metrics. While it is not practical to conduct detailed experiments to isolate all the variables, attendance stands out as the most important difference between the two classes. Attendance in the large class dropped faster and to lower levels than in the more personal, smaller class.

Student performance was quantified in a number of ways:

- **Anonymous Assessments.** We administer a 10-question multiple-choice pre/post-test for all Astro 101 classes at UVU. Learning gains were significantly higher in the small class. The news wasn’t all bad, however; students in the large class still did better than the average of all Astro 101 students at UVU (the majority of whom were taking the class in a traditional lecture setting). Engaged teaching methods do improve gains in the large auditorium.

- **Grades.** Course grades were assigned based on multiple-choice tests, homework, and class participation. Students in the large auditorium failed at a rate three times higher than in the smaller class. I attribute this primarily to students giving up and no longer attending (i.e., they no longer took tests or did homework).

The rate of A’s was 50% higher in the small class than in the large class.

- **Formative Feedback.** The University conducted surveys of the students in both classes to get a better idea of what they thought of the class, and what suggestions they had for improving it. Students reported that the two largest impediments to learning were noise in the classroom and the size of the class.

### Conclusions

Lower attendance is the most important factor leading to higher failure rates, lower learning gains, and lower participation rates in the large auditorium class. Engaged techniques produce enhanced learning results, even in the large class, but alone are not enough to guarantee student engagement and success.
Astronomy: State of the Art (ASOTA)

Chris Impey, Matthew Wenger, Carmen Austin (University of Arizona)

“This astronomy for beginners course is for anyone who loves astronomy and wants to get up to date on the most recent astronomical discoveries. Join Professor Chris Impey and our team of instructors from Steward Observatory at the University of Arizona to learn the science behind the latest astronomy news headlines, to enrich your understanding of the universe, and to glimpse the future of this exciting area of research. Lecture material will be augmented by discussion, live Q&A, and guest lectures. Find us on Facebook, Google+, YouTube, and follow us on Twitter.”

We present the preliminary results of a seven-week massive, open, online course (MOOC) in astronomy that was conducted during spring 2013. More than 3,300 students have enrolled in the course, which is hosted on the online course platform Udemy. More than 10 hours of video lectures were produced and deployed along with supplementary readings, podcasts, and live online discussions.

Inception and Plan

We created Astronomy: State of the Art (ASOTA) because we wanted to:

- Provide a convenient means for anyone to expand their knowledge of astronomy
- Learn about internet-based education

Internet use has grown in leaps and bounds in the past decade. The Internet is used for storing and sharing all kinds of information, giving it the potential to be a powerful tool for education. The next step is to figure out the best way to get educational material to the students who seek it. With ASOTA we sought to devise how to educate via the Internet most effectively.

- Use Udemy as the platform for our MOOC
- Release seven sets of lectures during seven weeks
- Weekly focus works its way up, beginning with telescopes, then going to the solar system and working up to cosmology
- Hold live Q&A sessions weekly
- Include supplementary reading, quizzes

Social Media

We integrated various social media platforms into ASOTA in an effort to make ourselves highly accessible to students. The most obvious to use were Facebook and Twitter. Our Facebook page is the most accessed of our social media profiles outside of Udemy. We use it to notify students of live sessions, share news in the astronomy community, and communicate with students about ASOTA. We use Twitter similarly, but have about a quarter as many followers.

We uploaded all of our lecture videos to a YouTube channel in addition to Udemy, and we record live sessions to upload to our YouTube channel as well. We used SoundCloud for our interviews with astronomers.

Student Reviews

“Dr. Impey’s course is a marvelous and rewarding experience. Combining education and information transfer with a bit of humor...
and entertainment, this MOOC, my first, far exceeds my expectations.”
— Clayton A. Feldman, MD

“Beautiful introduction to the most timely and interesting topics in astronomy today. Anyone with the slightest interest would be well served by taking this course.”
— Andrew Kerr

“I am really enjoying this course particularly because some of the weekly topics have just happened to line up directly with new items in the field of astronomy — for example, exoplanet detection immediately preceded the Kepler discovery of Kepler 62e and 62f. Perfect! The course really helps give context to discoveries and advances being made daily.”
— Eryn Cangi

“Chris Impey’s professional experience is clearly reflected by the course content, design, and teaching methods of Astronomy SOTA. His replies to the questions are quick and concise! Simply superb experience with my first MOOC course.”
— Krish Nasa

Review
Most of our students were in the US, with the majority in Arizona and California. People from nearly 100 countries at least visited ASOTA’s course page. Outside the US, the countries with the most students were Mexico, Canada, South Africa, and the UK.

We found MOOCs can be a great way to convey information to highly motivated learners. Participation seemed to be much higher during the weekly-lecture-release phase than the following own-pace-only phase. Even after a surge in enrollment a few weeks into the second phase, the number of visits to the page never returned to the near 2,000 visits per week we saw during the first phase of the class.

Future
We plan to host more MOOCs to continue to educate and refine our methods. With our first MOOC, we’ve only begun to answer our questions about education on the Internet, and this project has raised a few more. Some of our questions include:

• Is letting students go at their own pace best?
  If not, what amount of instruction is best?
• How do we keep students engaged?
• What is the best way to interact with students?
• What effect would charging for the course, using ad campaigns, or offering certificates of completion have?
• What ways can we get the word out more effectively?

Udemy plans to offer certificates of completion soon. We may be able to offer them to ASOTA students. The next platform we want to try is Coursera.org.

The number of visits each week started very high, but dropped quickly for the first few weeks of the course. Then, the number of visits slowly declined. Following a noticeably steeper decline at the end of the first phase of the course, the number of visits per weeks has remained steady.

The percentage of new visits has grown during the second phase of the class. This suggests students who took the course during the first phase were more likely to return frequently.

Enrollment was huge near the launch of the course, and steady for a long time after the initial surge. A few smaller surges in enrollment have happened since then. These are most likely caused by the course URL being shared on popular websites.
Wibbly-Wobbly, Timey-Wimey Stuff: Teaching with a Time Lord

Kristine Larsen (Central Connecticut State University)

November 2013 marks the 50th anniversary of the premiere of Doctor Who, the longest-running science fiction television series in history. This BBC series follows the adventures of “the Doctor,” a two-hearted millennium-old Time Lord from the planet Gallifrey, as he explores space, time, and alternate universes in the TARDIS (short for Time and Relative Dimensions in Space). His myriad (often human) companions marvel that the TARDIS (which has the exterior appearance of a 1960s British Police Box) is much bigger on the inside. Time Lords have the ability to completely renew their own exterior appearance and to some extent their personality (known as “regeneration”), allowing for a number of actors to serially portray the Doctor.

This poster will give examples of astronomical topics in Doctor Who that are often covered in Astro 101 type courses as well as suggestions for integrating these examples into the classroom. For the sake of brevity and to capitalize on the popularity of the 2005 revival, only episodes starring the 9th, 10th, and 11th doctors (portrayed by Christopher Eccleston, David Tennant, and Matt Smith, respectively) will be included.

Time Travel
Not surprisingly, time travel itself, including issues of paradoxes, causality, and free will, are often discussed within the series. For example, in the episode “Turn Left” Donna Noble’s seemingly innocent decision to drive a different way at a traffic intersection has dire consequences for the entire universe, because as a result she is not in the proper place to save the Doctor’s life. In “Father’s Day” Rose Tyler travels back in time and tries to save her father from being killed in a car accident, but discovers that history cannot be changed without consequences. And in the most recent episode, “The Name of the Doctor,” Clara Oswald is warned not to enter the Doctor’s time stream, but as she notes, she had already done so (as witnessed by a number of past events), and therefore must do so now. These are just a few examples of episodes that can be discussed and analyzed in any course that touches upon theories of time travel.

Exoplanets and Astrobiology
Because the series takes place on a variety of planets (including Earth, Mars, and a number of fictional exoplanets), students can contrast the planetary bodies depicted in the series with known planets and exoplanets. An important example is the Doctor’s home world of Gallifrey, which orbits a binary star system. Students can compare and contrast it with currently known exoplanets in circumbinary systems such as Kepler-16, Kepler-34, and Kepler-35.

Doctor Who is known for the diversity of extraterrestrial species portrayed, both among allies and enemies of the Doctor. Each species is adapted to its planet of origin and has its own culture.
Discussions of life beyond Earth can include examples from *Doctor Who*; students can investigate and hypothesize what conditions would have led to the evolution of specific species (including genetically engineered species such as the Daleks).

**Contacting ET and Exploring Other Worlds**

In the episode “The Christmas Invasion,” the fictional British Rocket Group’s first Mars probe (Guinevere One) is captured by the warlike Sycorax, and a vial of A+ blood placed on board the spacecraft is used to control all humans of that blood type on Earth. The blood is included with human, bird, and whale songs, greetings in 120 human languages, water, and wheat seeds — an obvious nod to the Voyager spacecraft picture disk and Pioneer 10/11 plaque. Students can compare and contrast the fictional and real-world attempts at ET communication.

In “The Waters of Mars,” a Mars base named Bowie (yes, after the musician) is threatened by an alien presence called The Flood. Students can compare the structure of Bowie Base to real world prototypes of possible Mars bases, and compare the depiction of Martian surface conditions to astronomical fact.

**Black Holes and Worm Holes**

Black holes are a staple in science fiction. In the episodes “The Impossible Planet/The Satan Pit,” the Doctor and Rose Tyler visit a scientific base on an impossible planet, one in a stable orbit near a black hole. A mysterious energy source deep within the planet counteracts the gravitational pull of the black hole. We often rattle off in class without further explanation that if the Sun suddenly became a black hole, Earth’s orbit would not appreciably change. This is an interesting fictional counter example that can facilitate discussions of the spatial extent of the influence of a black hole. If wormholes are a part of the class content, the episode “The Planet of the Dead” can be used to illustrate the point that current theoretical models of traversable wormholes predict that they will be accompanied by harmful radiation.

**The Formation of Earth**

While you and I certainly weren’t around to witness the formation of Earth 4.6 billion years ago, the Doctor and Donna Noble conveniently visit this important astronomical event in “The Runaway Bride.” Unfortunately for the human species, the planetesimals that form Earth coalesce around the Racnoss spacecraft! Ignoring that obvious bit of creative license, this scene can be used to illustrate the planetary formation process and engage the students in testing their understanding of the topic by watching for other scientific inaccuracies. In “Hide” the Doctor and Clara Oswald briefly visit the infant Earth (at the time of the so-called magma ocean). Astute students will note that the Doctor gives the incorrect age for Earth.

**The Death of Earth**

When asked what event they would want to visit in person, students may request the obvious: the death of Earth. In “The End of the World” the Doctor takes Rose Tyler five billion years into the future to witness the destruction of Earth (as it is enveloped by the Sun). Rose is understandably upset by the event, so the Doctor later takes...
her to New Earth, humanity’s new home, in the eponymous episode. Students can critique “The End of the World” for astronomical facts and fictions, and discuss the decisions humanity might face if it still exists when the Sun leaves the main sequence.

An interesting “what if” scenario is depicted in “Dinosaurs on a Spaceship” where the Doctor, Amy Pond, and others discover that a spaceship is an “ark” built millions of years ago by the reptilian Silurians when a large asteroid threatened Earth. What if aliens had landed on Earth 65 million years ago and tried to save the dinosaurs from extinction?

The Birth and Death of the Universe
Another astronomical event that students may express an interest in viewing firsthand is the death of the universe. In the common imagination, this is usually depicted to be when the last stars burn out. In “Utopia” the Doctor, Martha Jones, and Captain Jack Harkness journey farther than the TARDIS has ever done before, 100 trillion years into the future when the last stars burn out. Is this date accurate? Is the depiction of the end of the Stelliferous Era true to the science? You won’t know if you and your students don’t view it!

As for the birth of the universe, in “The Big Bang” the Doctor has to use the restorative field of the Pandorica and the exploding TARDIS to reboot the universe, in a sense creating a second Big Bang. Taken in tandem, these episodes can be compared to the classic Isaac Asimov short story “The Last Question.” (However, Asimov’s view of the future of humanity is far rosier than the Toclafane of Doctor Who.)

Other Astronomical Nuggets
The following are examples of other episodes with right (and wrong) astronomical content that can be used to spark class discussion, as writing prompts, or exam questions:

• “Tooth and Claw” — a telescope is used backwards to magnify moonlight and destroy an alien werewolf.
• “The End of Time” — the planet Gallifrey (several times the diameter of our planet) materializes next to Earth with few deleterious effects.
• “The Stolen Earth/Journey’s End” — 27 planets and moons are moved from their original positions into a new configuration in order to funnel their gravitational fields into a weaponized energy source.
• “The Beast Below” — solar flares burn Earth’s surface and render the planet uninhabitable for centuries.

Conclusion
With the imminent departure of Matt Smith and the introduction of his replacement (highly acclaimed Scottish actor Peter Capaldi), fans of the series will be eagerly tuning in during the 50th anniversary celebration this Fall semester. Consider adding the escapades of the eccentric Time Lord to your repertoire of teaching tools — your students will thank you for it!

For more information on the series, consult the BBC’s official Doctor Who website or the fan-based Doctor Who wiki site. [Source: Wikipedia, Stuart Crawford.]
Is Comet ISON, coming to December’s morning skies, really the “Comet of the Century”?
By Alexei V. Filippenko

Comet McNaught over the Pacific Ocean, taken from Paranal Observatory (Chile) in January 2007. [S. Deiries/ESO]. This article is based on Alex Filippenko’s presentation to the Astronomical Society of the Pacific’s July 2013 annual meeting in San Jose, California.
Comet ISON was discovered on September 21, 2012. Right away people got really excited about it, and some rather fantastic headlines — unfortunately inspired, in part, by astronomers — appeared just about immediately after it was announced. “New Comet Might Blaze Brighter than the Full Moon.” Well, that’s technically true; it might! Then, “Newly Spotted Comet May Outshine the Full Moon.” So, will it? Read on.

Comets appear as diffuse, luminous patches in the sky, often with long tails. In fact the word comet comes from the Greek aster komētēs, which means “long-haired star.” In ancient cultures, comets have been widely viewed as bad omens — messengers of the gods proclaiming that there’s going to be some sort of terrible disaster coming; essentially harbingers of doom, death, and destruction! In William Shakespeare’s Julius Caesar, Calphurnia tells Caesar: “When beggars die, there are no comets seen; the heavens themselves blaze forth the death of princes.” And even among some people today, this is still believed to be the case.

Comets move slowly among the stars from night to night. They’re typically visible over a few weeks, sometimes only a few days, or maybe a month or two in the best cases. But they don’t go streaking across the sky like a meteor. A meteor is typically just a little grain of sand or a pebble, zipping through the atmosphere at such a high speed that it burns up and glows as it does so.

The Tale of a Tail
On the other hand, a comet is basically a dirty iceball, or icy dirtball, depending on the relative mixture of ice and dust and rocky material, and it comes in from the deep freeze of the outer solar system. As this dirty iceball (the nucleus) gets closer to the Sun, the ices (frozen gases such as carbon dioxide, methane, ammonia, and water) start sublimating — they vaporize, going directly from a solid to a gas and form a diffuse region around the nucleus called the coma. The dust also comes off (because the ices that glued together the rocks and dust sublimate), and it becomes visible by reflecting sunlight. The gases fluoresce and also become visible.

The nucleus of Comet Halley was imaged (right) in 1986 by the Giotto spacecraft. This peanut-shaped object, about 10 miles along its longest side, is definitely an icy dirtball that is outgassing as it’s exposed to the Sun.

Initially the gas and dust come off in the direction that faces the Sun. But then they feel the solar radiation pressure (the pressure of photons from the Sun) and also the pressure of the solar wind, the charged particles that come streaming from the Sun. The solar radiation pressure and the solar wind push the gas and dust away from the comet, forming a tail that points away from the Sun — even when the object is on its outbound path. A comet’s tail is not being swept back by the interplanetary medium (the gas between the planets); it’s not like, say, Fabio running hard with his hair being swept back by Earth’s atmosphere!

The dust particles reflect sunlight, and some comets have primarily

This composite image of the nucleus of Comet Halley shows jets originating from two regions of the nucleus. The night side of the nucleus can be seen silhouetted against a background of bright dust. [ESA/MPAE, 1986, 1996]
A comet’s orbit showing the different directions of the gas and dust tails as the comet swings around the Sun. Notice that the comet’s ion tail precedes the comet as it moves away from the Sun. [Source: Wikipedia/Fredrik]

A dust tail. Often the tail appears curved. A great example is Comet McNaught in 2007 (see page 31), most of whose tail was dust. Its curved tail appeared striated because the nucleus went through many outbursts of dust — sublimation is not a steady process, and it sometimes occurs in rather discrete episodes.

Then there’s the gas or ion tail, and in a color image it tends to appear blue. This tail basically points straight away from the Sun; it doesn’t curve away like the dust tail. That’s because the ions are following the Sun’s magnetic field, which to a good first approximation is radial. Moreover, these ions are not very massive compared to the dust particles, so they go zooming away from the comet at speeds much faster than their orbital motion.

Most comets have both types of tails: Hale-Bopp (1997) is a classic example, while McNaught was mostly dust and Hyakutake (1996) mostly gas when they were at their prime.

**Home Sweet Home**

Comets come from the deep freeze of the outer solar system, from one of two or three (depending on how you count them) general regions. The first is the Kuiper Belt, a region of icy dirtballs at and beyond the orbit of Neptune. Indeed, Pluto has been reclassified as a Kuiper Belt Object, one of the biggest (a “dwarf planet”) but certainly not the only big one out there.

Farther away, and in a thicker doughnut or torus, resides the “scattered disk” of the solar system from which many comets come. This region is largely separate from the Kuiper Belt, but sometimes people group the two together because they form sort of a double doughnut. The Kuiper Belt and the scattered disk are the sources of most comets that approach roughly along the plane of the solar system.

But long ago it was noticed that there are many comets that come in, we think for the first time, from pretty much random directions. So Jan Oort (a famous Dutch astronomer) predicted that there’s a vast cloud, extending out to maybe a light-year from the Sun, of
Comets in a roughly spherically symmetric distribution. There could be a trillion of these things out there, simply orbiting the Sun at great distances.

Occasionally they gravitationally nudge one another, sending them either out of the solar system or in toward the Sun. Or a passing star might gravitationally influence these comets, again sending them inward or outward. As they approach the Sun, they initially speed up very gradually because of the increasing gravitational pull. Then they quickly speed up, whip around the Sun, and head back out, either never to be seen again, or possibly perturbed by Jupiter or Saturn into an orbital period of a few hundred or a few thousand years instead of millions of years.

**Comet 2012 S1 (ISON)**

Comet ISON is thought to be coming in from the Oort Cloud for the first time. Its designation is Comet 2012 S1, which means it was discovered in September, though that’s not what the “S” stands for. It means ISON was the first comet discovered in the second half of September, and “S” designates the second half of September. “A” is the first half of January, “B” the second half of January, “C” is the first half of February, and so on. But because the letter “I” isn’t included in the sequence, “S” corresponds to the second half of September.

ISON stands for International Scientific Optical Network. Amateur astronomers run it, but they’re doing professional-quality work. In astronomy, unlike many other fields of science, there can really be a “pro-am collaboration.” Amateur astronomers have made many professional-grade contributions to the field. They’re only amateurs in the sense that they’re not being paid to do it, the way, say, I’m paid to sit around and discover supernovae!

Vitali Nevski and Artyom Novichonok found this comet (on September 21, 2012) using a 16-inch telescope in their observatory (part of the ISON network) near Kislovodsk, Russia. Given that comets are usually named after their discoverer, you might wonder why this object isn’t called Comet Nevski-Novichonok.

Well, when they first identified the object, it looked pretty compact (like a star), so they couldn’t tell whether it was comet-like or asteroid-like. They just reported that they had spotted something new. The next day other observers confirmed the object and showed that it was almost certainly a comet. So in a sense a number of people contributed to the discovery and classification, but as a result, Nevski and Novichonok got robbed of the name — all because they were honest and said they weren’t sure what they were seeing!

Looking at their discovery image (right), you might think that this is a pretty pathetic-looking thing, so why did people almost immediately get very excited? The reason is because when it was found, Comet ISON was still beyond Jupiter’s orbit, more than six astronomical units distant, and it was already really bright for a comet so far from the Sun. Most comets don’t reach that brightness until they’re much closer. So either this object is very big, or for some reason it’s unusually active, or maybe it’s just more highly reflective than the typical comet — or some combination of those three possibilities. The simplest interpretation is that it’s big and thus reflects a lot of light.

Once the comet was discovered, pre-discovery images were found in a number of deep-sky surveys. From them a trajectory could be calculated, and it was determined that on November 28, 2013, the comet would pass just a smidgeon, less than one solar diameter,
from the Sun’s “surface.” (In fact, the Sun has no solid surface. Instead, the photosphere, where the gases become opaque, is considered to be the solar “surface.”) This makes ISON a Sun-grazing comet. So if it’s big, and it’s going to get that close to the Sun, that means it’ll sublimate like crazy, releasing lots of dust and gas, and it should become tremendously bright.

And hence came those headlines I mentioned at the start of this article, including “New Comet Might Blaze Brighter than the Full Moon.” Will it?

Well…perhaps. When it’s right next to the Sun, its sublimation rate should be enormous, the Sun-comet separation will be small, and the coma and tail will reflect a lot of sunlight, so the comet might become as bright as the full Moon. However, at that moment in time it’s going to be in the direction of the Sun — a mere degree away! If it is that bright, really astute, experienced observers who know what they’re doing may see ISON in the daytime. But the comet is not going to be blazingly bright in the middle of the night, and its brightness is going to rapidly decline after it whips around the Sun and starts moving away. So it was completely misleading to publish such headlines.

Comet of the Century?
The other misleading headline was “The Comet of the Century.” At least the TIME magazine article, which appeared in December 2012, came with a question mark. Why was it called the “Comet of the Century,” and why do we now think: Maybe not?

Here’s one problem. If the comet is coming in from the Oort Cloud for the very first time (as suggested by its orbit, which is an extremely eccentric ellipse that’s essentially a parabola), it may have a layer of volatile ices on its outer surface. Ices are not just water — astronomers include frozen methane, ammonia, carbon dioxide, carbon monoxide, and so on — and they have different sublimation temperatures. If the comet has been in the deep freeze for 4.6 billion years and is on its first approach toward the Sun, this outer layer of volatiles has not yet been vaporized.

Out beyond Jupiter, the comet was sublimating the most volatile...
surface ices. That’s the early burst, and it isn’t necessarily going to be representative of the growth of outgassing while the comet gets even closer to the Sun. Indeed, the comet didn’t brighten much in March through May 2013. There are other possibly detrimental factors to consider, as I discuss on the next page. So people started tempering their predictions of just how bright it’ll be, and few (if any) knowledgeable people now say that it’s likely ISON will be the “comet of the century.”

Nevertheless, by spring of this year the comet was within range of amateur telescopes, and people started following its progress. The Swift satellite took some data on January 30th, and an analysis of the amount of outgassing showed that the nucleus is about three miles (five kilometers) in diameter, not as big as Halley’s Comet or Hale-Bopp (which was about 20 to 25 miles across). But Hale-Bopp didn’t come as close to the Sun as ISON will, so a three-mile-diameter comet grazing the Sun is still something to be excited about. While its size is pretty typical for a comet, its path is atypically close to the Sun, which is why it might brighten and sport a very long tail. Comet Lovejoy in 2011 was a considerably smaller sungrazer, but it became a very nice comet for people viewing from the Southern Hemisphere.

The Show

So Comet ISON could be an excellent comet, but what is it doing this summer? The problem is, we don’t know. Starting in May, it was situated too close to the Sun for most telescopes to monitor. We will get an update sometime in August, and certainly by early September it should be visible (in the constellation of Cancer) through small telescopes. So everyone’s waiting to see how much it has brightened (see the Comet ISON Update on page 38).

On November 17 and 18, the comet will be about 2° from Spica (in Virgo) and, if we’re lucky, it will sport a nice, sizeable tail shortly before sunrise. But the biggest tail should appear after it passes perihelion (the point of closest approach to the Sun).

So in November, start getting up in the morning to monitor its progress. Then between November 27th and 30th — zoom, it will go zipping by the Sun. And right at closest approach, it may (if we are very lucky) be the brightness of the full Moon. But by the time it’s heading away from the Sun its brightness will have plummeted, and that’s what the newspaper articles did not tell you. On the other hand, by this time it will be sublimating rapidly and it should have a long tail. This is when we might see a very nice show.

But there’s a competition here between two effects. With every passing day, the comet is higher above the eastern horizon (in the morning) and heading into a darker sky. On the other hand, it’s receding from the Sun, so the amount of outgassing is decreasing; also, less sunlight is reaching the particles and reflecting off them.
So from December 5th to 15th will, I think, be the best time, and perhaps December 10th and 11th might be the sweet spot (about 45 minutes before sunrise). By the way, in early December it should (we hope!) be visible to the naked eye, though if you want to see fine structure near the nucleus and in the tail, use binoculars or a telescope. But how bright will it be at its peak?

The best estimates for maximum brightness at the time this article was written (July 2013) seem to be about magnitude –5 or so, which means that it may be somewhat brighter than Venus — but again, remember that it’s then in the direction of the Sun. Of course, many amateur astronomers have seen Venus during the day, as have I, but it takes some effort. Moreover, all of Venus’ light is concentrated into a point, whereas with Comet ISON the light is spread out, making it harder to spot.

Variables that Confound Predictions
So, what is it really going to look like when it’s in December’s morning sky, half an hour to an hour before sunrise? The problem is there are many variables. One real possibility is that it will be completely destroyed by the Sun before or at perihelion! It’ll disintegrate, and all of its material will become so dispersed that there’ll be very little left to see; moreover, there will be no new source of material. We want the dust to be relatively concentrated and continually replenished — not the case if the comet is completely destroyed.

The comet’s composition is also an issue. If it doesn’t have much dust, it won’t have a bright dust tail. It might have a nice ion tail like Comet Hyakutake, but most people prefer to see a prominent dust tail like the one on Hale-Bopp. How much dust will be released after the ices sublimate? We really don’t know.

Will the comet break apart into several pieces? This could be good because then there’s more surface area over which ices are sublimating and more dust is being released. A great example of this was periodic Comet Holmes. Almost overnight, on October 23, 2007, it brightened by a factor of a million — it suddenly became a naked-eye object. That’s because the comet had a major ejection of material. Most of the material that contributed to its brightness was dust, and for a while Holmes became a relatively bright comet. Similarly, Comet West was a wonderful sight after its nucleus broke apart in 1976. So if ISON does that, then it could well be a gorgeous comet.

Then there’s Comet Kohoutek in 1973/74 — The Comet of the Century! Not. It wasn’t bad compared with run-of-the-mill comets — you could actually see it with the naked eye. But the point is there was much ballyhoo about this particular comet. Before it arrived, people called it the “Comet of the Century,” but it partly fizzled — it simply did not become as bright as predicted. And so in the public eye, it was a complete failure.

There are a lot of variables, so forgive us astronomers if we can’t tell you exactly what Comet ISON is going to look like. We can tell you its trajectory for the next few months, and where it will go if it survives...
perihelion passage, but we can’t tell you what it will look like. David Levy, a famous comet hunter, has this wonderful quote: “Comets are like cats. They have tails and they do precisely what they want.”

My Fearless Prediction
So what’s my prediction (as of July 2013) as a non-expert (remember, my fields are supernovae, black holes, and the accelerating expansion of the universe) after reading some of the literature and looking at the behavior of some previous comets, including ones in my own lifetime?

I think there’s a reasonable chance that Comet ISON will become the best comet visible in dark skies in the Northern Hemisphere since Comet Hyakutake in 1996 and Comet Hale-Bopp in 1997. If Comet ISON ends up being as bright as they were, great! However, I have some doubts, supported by the fact that it didn’t brighten much in the first five months of 2013. If it ends up not being better than Comet Holmes in 2007, I’ll be disappointed, though that would still be a pretty nice comet relative to most others.

The reason I say Northern Hemisphere is that the Southern Hemisphere has had two excellent comets in recent years: Lovejoy in 2011 and especially McNaught in 2007. But in the Northern Hemisphere we’ve been deprived of bright comets. And so if ISON becomes the Lovejoy of the Northern Hemisphere — hey, I’ll be very happy, even if it isn’t quite the “comet of the century.”

ALEX FILIPPENKO is a Professor of Astronomy at the University of California, Berkeley. He has been voted the “Best Professor” on campus a record nine times, and he was the 2006 National Professor of the Year. In 2010 he won the ASP’s Emmons Award for excellence in college astronomy teaching. Several major prizes have recognized his research accomplishments, which are documented in more than 700 published papers, and he is an elected member of the National Academy of Sciences.
Life on Earth May Have Come From Out of This World

Lawrence Livermore National Laboratory

A group of international scientists including a Lawrence Livermore National Laboratory researcher have confirmed that life really could have come from out of this world. The team shocked compressed an icy mixture, similar to what is found in comets, which then created a number of amino acids — the building blocks of life.

This is the first experimental confirmation of what LLNL scientist Nir Goldman first predicted in 2010 and again in 2013 using computer simulations performed on LLNL’s supercomputers, including Rzereal and Aztec.

Goldman’s initial research found that the impact of icy comets crashing into Earth billions of years ago could have produced a variety of prebiotic or life-building compounds, including amino acids. Amino acids are critical to life and serve as the building blocks of proteins. His work predicted that the simple molecules found in comets (such as water, ammonia, methanol, and carbon dioxide) could have supplied the raw materials, and the impact with early Earth would have yielded an abundant supply of energy to drive this prebiotic chemistry.

In the new work, collaborators from Imperial College in London and University of Kent conducted a series of experiments very similar to Goldman’s previous simulations in which a projectile was fired using a light gas gun into a typical cometary icy mixture. The result: Several different types of amino acids formed.

“These results confirm our earlier predictions of impact synthesis of prebiotic material, where the impact itself can yield life-building compounds,” Goldman said. “These results present a significant step forward in our understanding of the origin of the building blocks of life.”

Comets contain elements such as water, ammonia, methanol, and carbon dioxide that could have supplied the raw materials, in which upon impact on early Earth would have yielded an abundant supply of energy to produce amino acids and jump start life. [Lawrence Livermore National Laboratory]
Phaethon Confirmed as Rock Comet

*European Planetary Science Congress*

The Sun-grazing asteroid, Phaethon, has betrayed its true nature by showing a comet-like tail of dust particles blown backwards by radiation pressure from the Sun. Unlike a comet, however, Phaethon’s tail doesn’t arise through the vaporization of an icy nucleus. During its closest approach to the Sun, researchers believe that Phaethon becomes so hot that rocks on the surface crack and crumble to dust under the extreme heat.

Most meteor showers arise when the Earth ploughs through streams of debris released from comets in the inner solar system. The Geminids, which grace the night sky annually in December [see page 51], are one of the best known and most spectacular of the dozens of meteor showers. However, astronomers have known for 30 years that the Geminids are not caused by a comet but by a 5-km-diameter asteroid called (3200) Phaethon.

Until recently, though, and much to their puzzlement, astronomers’ attempts to catch Phaethon in the act of throwing out particles all ended in failure. The tide began to turn in 2010 when Jewitt and colleague, Jing Li, found Phaethon to be anomalously bright when closest to the Sun. The key to success was their use of NASA’s STEREO Sun-observing spacecraft. Phaethon at perihelion appears only 8 degrees (16 solar diameters) from the Sun, making observations with normal telescopes impossible. Now, in further STEREO observations from 2009 and 2012, Jewitt, Li, and Jessica Agarwal have spotted a comet-like tail extending from Phaethon. “The tail gives incontrovertible evidence that Phaethon ejects dust,” said Jewitt.

MORE INFORMATION

Geminid meteors over Pendleton, Oregon. [Courtesy Thomas W. Earle]
Changes in Comet Rotation May be Predicted With Greater Accuracy

Planetary Science Institute

Planetary Science Institute researchers have discovered a way to predict the changes in the rotational states of comets that could help scientists learn more about the approaching Comet C/2012 S1 (ISON), which will pass by the Sun on Thanksgiving Day and has attracted worldwide interest because it may become sufficiently bright to be seen by the naked eye.

PSI Senior Scientists Nalin H. Samarasinha and Beatrice E.A. Mueller have determined such changes are a function of a comet’s size, period, and solar energy it receives, but surprisingly not a function of the fraction of a comet’s surface that is active.

“You get more change if there is more solar energy and less change if it is spinning more rapidly to begin with or if it is a larger comet. Larger, rapidly rotating comets are not going to change their spin status very much,” Samarasinha said. “We expected that the fraction of the surface of the comet that is active would also be a controlling factor, but that proved not to be the case.”

Applying their method to Comet ISON, Samarasinha and Mueller conclude it will spin-up and will become a tumbling object as it gets close to the Sun. The spin-up of ISON could result in increased shedding of material from the nucleus as it is subjected to solar tides and intense heating during its close passage by the Sun.

“While these mass sheddings may result in interesting events for astronomers, we hope the nucleus of Comet ISON is sufficiently large to avoid complete disruption — an outcome common to many sungrazing comets,” Mueller said.

MORE INFORMATION

Comet Hartley 2’s nucleus is approximately 2 kilometers (1.2 miles) long. Jets can be seen streaming out of the nucleus. [NASA/JPL-Caltech/UMD]
Voyager 1 Reaches Interstellar Space

JHU-APL

NASA's Voyager 1 spacecraft officially is the first human-made object to venture into interstellar space. The 36-year-old probe is about 12 billion miles (19 billion kilometers) from our Sun.

New and unexpected data indicate Voyager 1 has been traveling for about one year through the plasma, or ionized gas, present in the space between the stars. Voyager is in a transitional region immediately outside the solar bubble, where some effects from our Sun are still evident.

“The crossing is like Voyager leaving the hot, million-degree atmosphere of the Sun and entering into a region dominated by the ‘cold,’ 5,000-degree atmosphere of the galaxy,” says APL’s Stamatios (Tom) Krimigis, principal investigator for Voyager’s Low-Energy Charged Particle (LECP) instrument. “It’s like the first time a satellite [Sputnik] went beyond Earth’s atmosphere to an altitude of some 600 miles; Voyager is now leaving the solar bubble at an altitude of 11.3 billion miles. It’s another historic milestone.”

“Now that we have new, key data, we believe this is humankind’s historic leap into interstellar space,” adds Ed Stone, Voyager project scientist based at the California Institute of Technology, Pasadena. “The Voyager team needed time to analyze those observations and make sense of them. But we can now answer the question we’ve all been asking: ‘Are we there yet?’ Yes, we are.”

Readings over the past year showed that solar particles had essentially all left and galactic particle intensities increased dramatically, says Matthew Hill, an LECP team member and space physicist at APL.
Earth’s Gold Came from Colliding Dead Stars

*Harvard-Smithsonian Center for Astrophysics*

We value gold for many reasons: its beauty, its usefulness as jewelry, and its rarity. Gold is rare on Earth in part because it’s also rare in the universe. Unlike elements like carbon or iron, it cannot be created within a star. Instead, it must be born in a more cataclysmic event — like one that occurred [in June 2013] known as a short gamma-ray burst (GRB). Observations of this GRB provide evidence that it resulted from the collision of two neutron stars — the dead cores of stars that previously exploded as supernovae. Moreover, a unique glow that persisted for days at the GRB location potentially signifies the creation of substantial amounts of heavy elements — including gold.

“We estimate that the amount of gold produced and ejected during the merger of the two neutron stars may be as large as 10 moon masses — quite a lot of bling!” says lead author Edo Berger of the Harvard-Smithsonian Center for Astrophysics (CfA).

Gamma-ray bursts come in two varieties — long and short — depending on how long the flash of gamma rays lasts. GRB 130603B, detected by NASA’s Swift satellite on June 3rd, lasted for less than two-tenths of a second.

Although the gamma rays disappeared quickly, GRB 130603B also displayed a slowly fading glow dominated by infrared light. Its brightness and behavior didn’t match a typical “afterglow,” which is created when a high-speed jet of particles slams into the surrounding environment.

Instead, the glow behaved like it came from exotic radioactive elements. The neutron-rich material ejected by colliding neutron stars can generate such elements, which then undergo radioactive decay, emitting a glow that’s dominated by infrared light — exactly what the team observed.

The team calculates that about one-hundredth of a solar mass of material was ejected by the gamma-ray burst, some of which was gold. “To paraphrase Carl Sagan, we are all star stuff, and our jewelry is colliding-star stuff,” says Berger.

MORE INFORMATION

This artist’s conception portrays two neutron stars at the moment of collision. New observations confirm that colliding neutron stars produce short gamma-ray bursts. Such collisions produce rare heavy elements, including gold. (Dana Berry, SkyWorks Digital, Inc.)
Bizarre Alignment of Planetary Nebulae

*European Southern Observatory*

The final stages of life for a star like our Sun result in the star blowing its outer layers out into the surrounding space, forming objects known as planetary nebulae. One type, known as bipolar planetary nebulae, create ghostly hourglass or butterfly shapes around their parent stars.

All these nebulae formed in different places and have different characteristics. And neither the individual nebulae, nor the stars that formed them, would have interacted with other planetary nebulae. However, a new study by astronomers from the University of Manchester, UK, now shows surprising similarities between some of these nebulae: many of them line up in the sky in the same way.

“This really is a surprising find and, if it holds true, a very important one,” explains Bryan Rees of the University of Manchester. “Many of these ghostly butterflies appear to have their long axes aligned along the plane of our galaxy. By using images from both Hubble and the NTT we could get a really good view of these objects, so we could study them in great detail.”

The astronomers looked at 130 planetary nebulae in the Milky Way’s central bulge. They identified three different types, and peered closely at their characteristics and appearance.

“While two of these populations were completely randomly aligned in the sky, as expected, we found that the third — the bipolar nebulae — showed a surprising preference for a particular alignment,” says Albert Zijlstra, also of the University of Manchester. “While any alignment at all is a surprise, to have it in the crowded central region of the galaxy is even more unexpected.”
Hubble Finds Source of Magellanic Stream

NASA/Space Telescope Science Institute

Astronomers using NASA’s Hubble Space Telescope have solved a 40-year mystery on the origin of the Magellanic Stream, a long ribbon of gas stretching nearly halfway around our Milky Way galaxy.

The Large and Small Magellanic Clouds, two dwarf galaxies orbiting the Milky Way, are at the head of the gaseous stream. Since the stream’s discovery by radio telescopes in the early 1970s, astronomers have wondered whether the gas comes from one or both of the satellite galaxies. Now, new Hubble observations reveal that most of the gas was stripped from the Small Magellanic Cloud about 2 billion years ago, and a second region of the stream originated more recently from the Large Magellanic Cloud.

A team of astronomers, led by Andrew J. Fox of the Space Telescope Science Institute, found a low amount of oxygen and sulfur along most of the stream, matching the levels in the Small Magellanic Cloud about 2 billion years ago, when the gaseous ribbon was thought to have been formed.

In a surprising twist, the team discovered a much higher level of sulfur in a region closer to the Magellanic Clouds. “We’re finding a consistent amount of heavy elements in the stream until we get very close to the Magellanic Clouds, and then the heavy element levels go up,” said Fox. “This inner region is very similar in composition to the Large Magellanic Cloud, suggesting it was ripped out of that galaxy more recently.”

This discovery was a wrinkle Fox’s team didn’t expect, because computer models of the stream predicted that the gas came entirely out of the Small Magellanic Cloud, which has less gravity than its more massive cousin.

MORE INFORMATION

Allsky view of the Magellanic Stream in radio and visible light (D. Nidever et al., NRAO/AUI/NSF and A. Mellinger, Leiden-Argentina-Bonn (LAB) Survey, Parkes Observatory, Westerbork Observatory, and Arecibo Observatory)
ASP Board Members Recently Elected

Kelsey Johnson is an Associate Professor of Astronomy at the University of Virginia, adjunct faculty at the National Radio Astronomy Observatory, and the founder and director of the “Dark Skies Bright Kids” outreach program. She is currently in her fifth year on the International ALMA Science Advisory Committee, for which she is both a former chair and current vice-chair. Her research is focused on star formation throughout the universe and in particular, the impact of different physical environments.

She received her PhD from the University of Colorado in 2001. After earning her doctorate, Johnson held a National Science Foundation Fellowship, followed by a Hubble Fellowship. Johnson has received the National Science Foundation CAREER award, a Packard Foundation Fellowship, a Distinguished Young Investigator FEST award, and an Excellence in Diversity award. The “Dark Skies Bright Kids” program, which she created and directs, was named a 2012 “Program That Works” by the Virginia Math and Science Coalition. She gives numerous public lectures and interviews each year, as well as participating in Space Science for Teachers workshops.

Alexander Rudolph is Professor of Physics and Astronomy at California State Polytechnic University (Cal Poly Pomona). He received his bachelor’s degree from Haverford College and his PhD in physics from the University of Chicago. Before joining the faculty at Cal Poly Pomona, he was on the faculty of Harvey Mudd College from 1994–2001. He is Director of the California-Arizona Minority Partnership for Astronomy Research and Education (CAMPARE), an NSF-funded program to promote minority and female involvement in undergraduate research in astronomy, planetary science, and astrobiology. This program consists of students from 14 community colleges and universities in California participating in summer research with scientists from the University of Arizona Steward Observatory, the SETI Institute, and JPL/Caltech.

Rudolph is also involved in research into the effectiveness of interactive learning strategies in general education astronomy (Astro 101) classes. He has significant K–12 outreach experience, including yearlong partnerships with elementary school teachers (Projects ASTRO, FOSTER), conducting an Astrobiology workshop for elementary school teachers, and promoting interactive learning and the use of clickers at local schools in Pomona, California.
Astronomer Connie Walker specializes in science education and public outreach at the National Optical Astronomy Observatory (NOAO) in Tucson, Arizona. She conducts professional development for educators, develops curricula and kits for informal and formal science education programs, and convenes conference sessions and workshops on hands-on science and research for students and teachers.

Walker holds a BSc in physics and astronomy from Smith College, a Masters in electrical engineering from the University of Massachusetts, and a PhD in astronomy from the University of Arizona. Through her classroom experience she found that the dimensions to teaching and learning were multifaceted and required students to have hands-on, minds-on opportunities for critical thinking. Hired by the Education and Public Outreach group at NOAO to work on Project ASTRO and other programs, Walker developed ASTRO-Chile, which she manages. Under ASTRO-Chile, the dark skies awareness citizen-science program, GLOBE at Night, started as a joint light pollution study between students and teachers in Chile and Spanish-speaking students and teachers in Tucson. GLOBE at Night, which she directs, is now a worldwide campaign in its 8th year.

Through her EPO activities at NOAO, Walker was instrumental in the development of six optics education modules (kits and guides) called “Hands-on-Optics.” Presently she is having a blast working with students and their teachers in increasing dark sky awareness.

Katherine Bracher Receives the Fraknoi Supporters Award

After 39 years of service and support to the ASP, Andrew Fraknoi retired from the organization in 2012. He served for 14 years as the executive director of the ASP, created Project ASTRO and Family ASTRO, organized a series of workshops and conferences about the teaching of astronomy at the K–12 and college level (“Cosmos in the Classroom”), and developed a DVD-ROM collection of classroom astronomy activities (The Universe at Your Fingertips).

At the ASP’s 2012 Annual Meeting in Tucson, a new award was inaugurated and presented to Andy — the Andrew Fraknoi Supporters Award. At future annual meetings, an individual will be honored who has demonstrated exceptional service to and support of the organization. The ASP’s 2013 Fraknoi Supporters Award recipient is Katherine Bracher.

In presenting the Award at the ASP’s 2013 Supporter’s Lunch, Andy said: “Katherine (Kate) Bracher, who spent most of her career as Professor at Whitman College, is a Renaissance Woman (in both
senses of the word). She taught both astronomy and history to generations of students, and plays and organizes performances of Renaissance and Baroque music. She exemplifies long-term volunteer service to an organization, which the Andrew Fraknoi award is designed to recognize. She was an ASP Board member in the 1990s, and served for many years on the Society’s History Committee. She wrote the ASP’s *Centennial History* in 1989 (which formed a special issue of *Mercury* and is still available online). For 30 years, from 1983 to 2013, she wrote the ‘Echoes of the Past’ column for *Mercury*, giving our members and readers glimpses of the rich history of our international society. She has been the historical memory of the ASP for so long and with such skill, we don’t know how we will live without her.”

**ASP Executive Director Announces Plans to Depart**

James Manning, ASP Executive Director, has announced plans to resign from the position effective February 7, 2014 — the 125th birthday of the ASP. Manning has served as Executive Director since 2007.

“I’m very proud of the work the staff and I have accomplished during my tenure,” Manning said. “We established a firm financial, operational, and programmatic foundation for the Society during an ongoing period of economic challenges in both the nonprofit and public sectors. We’ve taken the ASP in new strategic directions, grown and expanded existing programs and created new ones, grown our digital presence via social and mobile media, and developed sustainable partnerships with other organizations. We have also increased the ASP’s visibility and engagement on the national stage.

“But it’s time for me to pursue other interests, and to support and encourage new leadership to build on our accomplishments to carry the ASP into the next 125 years. I look forward to assisting in the transition to a new Executive Director.”

ASP Board President Gordon Myers thanked Manning for his hard work and dedication to ASP. “His work put ASP in a sound financial position and made it a leader in the astronomy education and public outreach community.”

The search for a new Executive Director is now underway.

**ASP Makes Plans to Celebrate its 125th Anniversary**

“On a chilly February evening in 1889 in San Francisco, astronomers from Lick Observatory and members of the Pacific Coast Amateur Photographic Association — fresh from viewing the New Year’s Day total solar eclipse north of the City — met to share pictures and experiences. Edward Holden, Lick’s first director, complimented the amateurs on their service to science, and proposed to continue the good fellowship through the founding of a Society ‘to advance the Science of Astronomy, and to diffuse information concerning it.’” Thus the Astronomical Society of the Pacific was born.

Today the ASP is excited to plan for its 125th anniversary year in 2014. The celebration will kick off with a dinner gala on Friday, February 7, in San Francisco, featuring keynote speaker Timothy Ferris. If you will be in San Francisco on the 7th and would like to attend, please contact Kathryn Harper, Director of Development and Communications, at kharper@astrosociety.org.
NEW MEMBERS — The ASP welcomes new members who joined between June 16 and September 15, 2013.

Technical Membership
Paul E. Barrett, Laurel, MD
Francis C. Fekel, Nashville, TN
Gary J. Ferdinand, North Chatham, NY
James Freeman, Brenham, TX
Steele Iain, Irby, Wirral, UK
Patrick J. Manley, Endwell, NY
J. Allyn Smith, Clarksville, TN
Kenji Tanabe, Okayama, Japan
C S Williams, Fairmont, WV

General Membership
Thomas B. Ake, Gambills, MD
Marcia F. Bartusiak, Sudbury, MA
Anna Batalao, Union City, CA
Judith Beck, Asheville, NC
Samantha Christensen, Flagstaff, AZ
Stephen Cooperman, Woodland Hills, CA
Lara Cross, Houston, TX
Hilarie Davis, North Kingstown, RI
Chuck Dugan, Tucson, AZ
Jennifer Frost, Napa, CA
Heidi B. Hammel, Washington, DC
William L. Hansen, Alamo, CA
Leon P. Johnson, New York, NY
Marc Kamionkowski, Baltimore, MD
Michael J. Kaufman Santa Clara, CA

Kelly Lee, Jr., Sarasota, FL
Daniel Loranz, Reno, NV
Tim W. Lynch, West Orange, NJ
Blaine J. McCoy, Mount Vernon, WA
John R. McIntyre, Warminster, PA
Laura Misajet, Norberth, PA
Manfred Mueller, Kaneohe, HI
Tisa M. Pedersen, Sunnyvale, CA
Cia Romano, Tucson, AZ
Brooke Skelton, Powder Springs, GA
Robert M. Sowa, Pittsburgh, PA
Tad R. Thurston, Norman, OK
Mary L. Urquhart, Allen, TX
Matthew Wenger, Tucson, AZ

Student Membership
Ronald Capone, Lido beach, NY

Supporter’s Circle
Marc A. Gineris, Dallas, TX
Larry T. Woods, Walnut Creek, CA

Legacy Giving
Astronomy compels the soul to look upwards and leads us from this world to another.
— Plato

Leave a universal legacy...

Astronomy shows us that we are part of something much greater than ourselves, and that our actions on Earth have a lasting impact. A legacy gift to the ASP as part of your estate plan reflects this understanding, and will support future generations as they reach for the stars.

astrosociety.org/donate or (415) 715-1406

HELP EVERYONE REACH FOR THE STARS!
The Skies of November

During the month, Comet ISON will be speeding in toward the Sun. At the time this column was written (mid-October), brightness predictions were still uncertain. (Check the Comet ISON update sidebar on page 38.) But astronomers do know where it will be. On the 22nd and 23rd, the comet (in the dawn sky) passes some 5° to the right of Mercury and Saturn, and on the 24th it’s 5° to the lower right of those two planets. Unfortunately, all three objects are a mere 5° above the east-southeast horizon some 45 minutes before sunrise. Use binoculars to find brighter Mercury, then dimmer Saturn below it before hunting for ISON. On the 26th, Mercury and Saturn are a mere ½° apart.

Meanwhile Venus is about as high as it will get in the sunset sky this year, which isn’t saying much. Some 45 minutes after sunset, Venus is 15° above the southwest horizon. Fortunately it’s extremely bright and hence impossible to miss. The crescent Moon passes above it on the 6th.

Jupiter (in Gemini) rises in mid-evening and stands high in the south well before dawn. On the 21st the Moon rises just to Jupiter’s lower right. Mars rises after midnight and is well up in the southeast by dawn. The Moon, just past Last Quarter, is to Mars’s right as both rise on the 27th.

Finally, on the 3rd a total eclipse of the Sun sweeps across central Africa. Observers on the east coast of North America will see the conclusion of a modest partial solar eclipse at sunrise.

The Skies of December

If Comet ISON is going to put on a display, the beginning of December will be its time. Perihelion (closest approach to the Sun) is November 28th, after which ISON will pop back up into the dawn sky. As shown in the illustration (right), the comet will make a tempting target for astrophotographers on the 1st (if it’s bright enough) because of the nearby crescent Moon. But keep in mind that the comet will be only a few degrees above the horizon that morning, so unless it’s extremely bright, it won’t be easy to find.

This illustration, courtesy of Sky & Telescope, shows where the comet will be in the dawn sky during the first two weeks of December. But its brightness and tail length are speculative.
As explained in Alex Filippenko’s article on page 31, the best time to see it (especially if it’s not very bright) may be between the 5th and the 15th. On the 5th it’s already rising in a dark sky 90 minutes before the Sun; by the 12th it’s rising three hours before the Sun. But no matter how bright it is and how long its tail at month-start, as December progresses its brightness will fade and its tail will shrink. On the 21st, ISON passes some 6° from the globular cluster M13; even if the comet is faint, this will still make for a pretty sight in binoculars.

While you’re out looking for ISON during the first few days of December, you’ll likely notice Mercury in the east-southeast; the thin crescent Moon is nearby on the 1st. But Mercury rapidly vanishes into the solar glare and doesn’t reappear until next month (at sunset). Saturn is also present at dawn. By mid-month it rises nearly three hours before the Sun and is well up in the southeast by sunrise. The waning crescent Moon is to Saturn’s upper right on the 28th and lower left the next morning.

Meanwhile, Venus is still well up in the southwest as twilight fades but is beginning its descent toward the Sun. On the 5th the crescent Moon rides high above this brilliant planet. By early January Venus will be temporarily lost in the solar glare.

Approximately two hours after sunset, look to the east-northeast to see Jupiter rising. This giant planet is well-placed for viewing the rest of the night. On the 18th, the nearly Full Moon and Jupiter rise together. Finally, Mars puts in an appearance after midnight and is reasonably high in the south by dawn. On the morning of the 25th, the Last Quarter Moon is to the lower right of the red planet.

The Geminid meteor shower peaks during the night of the 13th/14th. This is the best meteor shower of the year, with upwards of 100 meteors per hour radiating from near the bright star Castor (brilliant Jupiter is nearby). Unfortunately, the Moon will be nearly full, which means only the brighter Geminids will be visible through the moonlight. But at least you don’t have to stay up late to see the display. At mid-northern latitudes, the radiant (the point from which the meteors appear to originate) is well up in the east by 9:00 pm.

Finally, winter solstice occurs on December 21 at 12:11 pm Eastern time; 8:11 am Pacific time.

The Skies of January
If there is such a thing as a “secret” meteor shower, then the Quadrantid meteor shower is the one. It’s not well observed in part because it occurs in early January, and because the meteor peak is very short, which means it’s easy to miss. This is a shower that’s only visible to northern skywatchers, as the radiant is in northern Boötes. In 2014 the nominal peak falls on the 3rd at 19:30 UT (12:30 Eastern time), which favors observers in Asia. But a note on the International Meteor Observers webpage indicates that the peak may occur several hours earlier, such that skywatchers in western North America may have a chance to see them. If it’s not too cold on the morning of the 3rd, why not look for meteors from this “secret” shower.

By now Comet ISON will have faded significantly, but it may still be visible in binoculars. On the 7th, the comet passes less than 3° from Polaris; can you still see it?
This month **Venus** does a crash dive past the Sun. On the 1st it sets an hour after the Sun, and the next evening the crescent Moon appears well above Venus after sunset. But by the 10th, the planet is gone from the dusk sky. By month’s end, Venus is rising nearly two hours before the Sun in the east-southeast, and at dawn on the 28th, the thin crescent Moon is to the upper right of this bright planet.

By mid-month Venus is replaced by **Mercury** in the southwest after sunset, though this little planet is much dimmer and harder to spot than it’s inner neighbor. Still, between the 18th and 31st, Mercury sets at least an hour after the Sun and so should be easily visible as twilight deepens. On the 31st a very thin crescent Moon sits 5° to Mercury’s lower right.

**Jupiter** is at opposition on the 5th, which means it rises at sunset and sets at sunrise. So this giant planet with its retinue of four large, bright moons is nicely placed for observing all night long. On the 14th the nearly Full Moon rises to Jupiter’s right.

**Mars** rises just before midnight in the east-southeast. Mars will be brightest in April when it’s at opposition, but it’s best appearance is still four years away. On the 22nd the red planet rises with the Last Quarter Moon to its lower right.

Rising before 3:00 am, **Saturn** is nicely placed in the south at dawn. On the 25th the crescent Moon sits about 1° to Saturn’s lower right.

Finally, the **Earth will be at perihelion** on the 4th (6:59 am Eastern time). But since the eccentricity of Earth’s orbit is only 1.7%, the difference in the apparent size of the Sun (vs. its apparent size at aphelion in July) will be negligible.

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**Star Charts**

If you’d like a star chart to help you explore the naked-eye night sky, you have several options: purchase a star wheel (**planisphere**) or **planetarium software**; download a PDF showing the sky this month; find an online star chart, or locate an app for your tablet or smart phone.

**PDF Star Charts.** **Skymaps** produces a well-done chart that goes beyond a mere monthly star chart. It includes a list of monthly highlights and observable celestial objects. The downside: each month is available only at the very end of the previous month. Another nice star chart is available from **Orion Telescopes and Binoculars**; you can download it one month in advance. If you’d like simple star charts (that don’t show the planets), a **set of 12** is available from the Canada Science and Technology Museum.

**Online Star Charts.** **Sky View Café** gives you control over the chart’s date, time, and location, plus a few other options. But the chart names only a few bright stars, doesn’t identify the constellations, and the printout of the resulting chart is poor. The star chart created on the **Tau Astronomy Club** website offers fewer options but a better printout. But it lists no star names and the stars are color coded based on their spectral type.

**Apps For Tablets and Smart Phones.** **SkySafari 3** ($2.99 for the basic version; iPad and iPhone) is a very well done star chart app and is the one I use consistently; here is a **PDF review**. **Star Chart** is a free iPad/iPhone app that shows a nice graphical representation of the night sky. Unfortunately, I have no experience with sky apps for Android or other OS mobile devices. If ASP stargazers have a favorite night sky app, regardless of the device, **I’d like to hear about it**.

— **P.D.**
Aurora During a Weak Solar Maximum

Despite the current solar maximum being so low (some astronomers think it’s the weakest solar cycle in 100 years), the Sun still blasts coronal mass ejections into space. One that struck Earth in early October produced a lovely display of the northern lights. This image was taken from southern Iceland on October 2, 2013.