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Ten Commandments for Presentations
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Here are 10 simple ideas that can help you create, and deliver, a superior presentation that will be remembered no matter the level of your audience.

The Uses of Astronomy
MARY CRONE ODEKON

How do you explain the uses of astronomy? On a summer day in 1856 in Albany, New York, the answer came in a two-hour manifesto delivered by famed orator Edward Everett.

Low-Level Observing
BRIAN OETIKER

You can observe interesting celestial sights near big cities and at low elevations. In fact, astronomical discoveries are being made at sites other than at remote, high-elevation observatories.

Astronomy in the News

A baffling eclipse, Kepler finds exoplanets, and galactic dark matter mapped — these are some of the discoveries that recently made news at the January 2010 American Astronomical Society conference.

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New Columnists; Survey Results

I'd like to welcome two new columnists who will be sharing the writing duties for a new column: “Reaching Out.” Given the Society’s emphasis on education and public outreach — something that is the focus of our annual gatherings — I think a column that explores E/PO ideas and opportunities is particularly appropriate.

First up is Bethany Cobb, a NSF Post-doctoral Fellow at UC Berkeley. I met Bethany at the ASP’s 2009 conference in Millbrae, where she presented a poster on UC Berkeley’s 2009 IYA outreach efforts and gave a talk about astronomy for mature, life-long learners. She was engaged in several outreach projects during the IYA, and her first column (on page 13) describes her involvement in a project called “The Star Dances” with choreographer Kathryn Roszak.

The other “Reaching Out” columnist is Jim Lockner, who comes highly recommended. He is an Associate Research Scientist with the Universities Space Research Association and is the Education/Public Outreach Lead for HEASARC (NASA’s High Energy Astrophysics Science Archive Research Center). He’s also the project leader for NASA’s “Imagine the Universe!” website. His first column will appear in the Spring 2010 issue.

Survey Results

In the previous issue, I asked readers to tell me how they read Mercury. I provided three options: print most or all of the issue and read the paper copy; read some/most of it on screen and print only the pages/articles of interest; or read all of the issue on screen and rarely print anything.

While I was a little disappointed in the low number of members who responded, it was significant to see that 50% said they read it all on screen. And of the 25% who said they print it out, most (as I expected) bemoaned the loss of the print issue.

One thing of particular interest was that several read-it-on-screen respondents indicated they’d be happy seeing Mercury move to a landscape format, regardless of whether it stays as a PDF publication or becomes an HTML-based magazine.

At the end of January, your Society’s Board of Directors met to discuss (among other things) the direction of Societal publications in this digital/electronic age. I’m writing this editorial prior to the meeting, so look for updates in future issues of Mercury.

ON THE COVER

Front: More than 12 billion years of cosmic history are shown in an unprecedented, full-color view of thousands of galaxies in various stages of assembly. See page 33 for more details. Courtesy NASA / ESA.

Back: In science fiction, space-station interiors are usually depicted as sparse and uncluttered. This interior view of the International Space Station reveals today’s reality. Courtesy NASA.
Apocalypse (S)Now

A storm provides time for a reflective pause.

Where were you during the Great Big Snows on the East Coast this winter? For the second storm (in early February; lucky Irishman that I am), I was in Washington D.C., with a ringside seat.

I'd flown in for a Groundhog-Day-and-Day-After meeting of a NASA advisory subcommittee I'm on and lingered to do some ASP business for a few days after. Somebody must have really annoyed the groundhog, because before I could make my escape, the distorted storm track in this El Nino winter dumped a giant load of white on the capital — a foot and a half at Reagan National Airport, and two feet and more to the north across the District to Baltimore and Philly. It started as a fine mist of snow at midday on Friday as an entire government shut its briefcases and laptops and headed for the hills. "It's not even sticking," a few souls proclaimed at first with bravado. But stick it did by nightfall — with a vengeance.

Snowmaggedon, Snowpocalypse — the storm took on many names (some not printable), and closed the city down. By Saturday morning, the world was thickly caked in white — every tree, every street, and the lines of curb-parked cars, attending the row houses on the side streets, buried in mounds of snow. It was beautiful.

I ventured out at midday, scavenging for food, and actually found a few restaurants doing a brisk business. Processions of people, bundled up against the cold and snow, filed down the middle of snow-laden streets where the footing was better, looking for food or fun or just wanting to be out in an epic snowfall. In a happy confluence of technology and free time, hundreds of people (several thousand altogether by some estimates) converged on Dupont Circle, not far from my hotel. There they held an equally epic snowball fight, the word having been spread by Facebook and when the press got wind of it — by the media. Vast flights of snowballs arched over the noisy crowd and splattered the defenders of the fountain in the Circle's central park. The occasional cars inching around the perimeter became irresistible targets as well, but everyone stayed merry.

The throngs of college students, Congressional aides, lobbyists, tourists, and day-jobbers all happily pummeled each other, equalized by the snow. It occurred to me that if we could have just gotten Congress itself out there in the middle of Dupont Circle, gleefully hurling balls at each other and having a beer together afterward, perhaps there would be more civility — and more progress — on the issues confronting the nation. A filibuster would have lasted about three seconds out there in the snow.

At dusk, as the snow finally stopped and the sky cleared to a cold night, I trudged down to the White House where the Obamas were digging out, the snowblowers still at work, the flag flying crisply above, and the windows of the upper-floor residence cheerily lit. On the Mall, the Washington Monument was a brilliant white against the low, orange glow of sunset, thrusting upward into the deep blue of the falling night, a single star twinkling alongside. To the east, the Capital Dome shined in the dark over an empty expanse of snow, with orange Mars near opposition glowing above it. And it was still beautiful.

And here, it struck me, was the antidote to the noise and wrangling and polarized bombast that is Washington these days. Throw...
a blanket of snow over it and let everyone stop for a moment and calm down.

These days, we’re all dealing with a “snowpocalypse” of one sort or another — economic, political, climatic (a hallmark of global warming being weather extremes), personal. On the space front, we have the president’s plan to cancel the current moon program and turn manned spaceflight over to the private sector, as the fifth-to-last shuttle took off just days after the snow. In the NASA subcommittee meeting I attended, we heard reports from exciting science missions in planning. Some of them will be winners and some losers — as the Decadal Survey Committee recommends to NASA later this year what should (and shouldn’t) be priorities during this tight budget year and during the next decade. There is much at stake. Hard choices must be made.

But snow melts. Things get sorted out. And we move forward. Whatever directions we take in space in the future, perseverance and civil discourse is required — as well as a large dose of science literacy — if we are to keep reaching for those shiny lights and, as a species, keep aspiring to something greater than ourselves. This is where our Society, and your support of it, can be a shining light itself. Let us keep it so.

On the way back from the Mall in the cold night after the snow, I noticed in a tall snow bank that someone had scrawled “Apocalypse Now.” I smiled and, editor that I am, took my own finger and traced a letter “S” in front of the “N,” and continued on my way.

After all, snow melts.

JAMES G. MANNING (jmanning@astrosociety.org) is the Executive Director of the Astronomical Society of the Pacific.
In the Publications of the ASP for February 1920, Robert G. Aitken wrote the following: “In consequence of the very interesting results obtained by the British observers of the total eclipse of the Sun on May 29, 1919…the Einstein theory of relativity has become one of the most popular of all topics in current periodical literature, both scientific and unscientific.” He went on to quote from a poem that appeared a month previous in the San Francisco Chronicle:

Twinkle, twinkle, little star,
How I wonder where you are!
You are less than ever fixed;
I am more than ever mixed.

Aitken was clearly unconvinced of the validity of Einstein’s theory. He went on to cite the three astronomical tests Einstein had proposed: “1. The distortion of the oval orbits of planets round the Sun… 2. The deviation of light-rays in a gravitational field… 3. The shifting of spectral lines towards the red end of the spectrum in the case of light coming to us from stars of appreciable mass.” He then discussed each in turn.

The orbit of Mercury had long been known to turn slowly, by an amount that could mostly be accounted for by Newtonian gravitation. However, a small amount remained unexplained, and this was just the amount extra that Einstein’s theory predicted. Hence Einstein and others considered this test confirmed. Aitken commented that there might be an alternative explanation — the dusty material around the Sun that makes up the zodiacal light could cause this perturbation.

The second test was carried out by Arthur Eddington at the 1919 solar eclipse. The theory predicted that as light rays from stars behind the Sun passed by its edge, they would be bent slightly, so that the star would appear to be displaced from its normal position. Eddington led an expedition to Principe Island, off the coast of Africa. His observations showed that this effect did occur, in roughly the amount predicted, and many seized on this as further support for relativity. But Aitken noted that: “it must be remembered…that the total displacements are extremely small, and that the absolutely unavoidable errors of measurement amount to a considerable fraction of the entire displacements.” He also remarked that there might be an alternative explanation, in the form of an extended atmosphere around the Sun.

The third test had not yet been successfully carried out in 1920 — observations of the Sun had not shown any red shift. So Aitken concluded that: “while two of the tests proposed by Einstein give favorable results, each of them may also be accounted for on the old Newtonian theory; and the third . . . gives an unfavorable answer. Recalling once more Einstein’s words, “If any deduction from it should prove untenable, it must be given up,” we may concur in the opinion recently expressed by a number of prominent American physicists that the theory of relativity has not yet been established.”

However, in 1925 Walter S. Adams at the Mount Wilson Observatory measured the red-shift effect in the spectrum of the white dwarf companion to Sirius. (White dwarfs have very high densities, and this enhances the effect.) Other white dwarfs were later shown to exhibit this red shift also. More recent successful tests include the gravitational lensing of distant quasars, the time delay of reflected radar signals from Mercury or Venus when the planet is located close to the Sun in the sky, and the precession of the orbits of pulsars in binary systems. So the theory of relativity today is generally accepted — until something better comes along!

KATHERINE BRACHER (bracher@whitman.edu) taught astronomy at Whitman College in Walla Walla, WA, for 31 years. Retired in 1998, she currently lives in Austin, Texas. Her research focuses on eclipses and the astronomy of the ancient world; her other principal interest is early music.
In my previous column I explored the origins of the telescope and its use in astronomy, and asked if Galileo was really the first to use it to look at the sky. An equally fascinating topic relates to Copernicus — was he actually the first to propose that the Earth revolved around the Sun?

There are many alleyways in the history of astronomy, peopled by all sorts of obscure figures. Why some became famous and revered while others languished in darkness can best be ascribed to a quirk of fate. One such denizen of obscurity is Celio Calcagnini. While a few scholars (such as Jan Papy in 2006) have researched him, the most detailed study of Calcagnini I have been able to trace was written in 1818, so it is not surprising his work is unfamiliar!

He was born in Ferrera, Italy, in 1479, just six years after Copernicus. Copernicus went to the University of Ferrara, and it was there he met Calcagnini. They shared dual interests — law and astronomy — and became friends. Copernicus graduated with a degree in law in 1503, and Calcagnini became a jurist and professor of astronomy at Ferrera. They remained in contact, and Calcagnini visited his friend in Poland.

In 1507 Copernicus began writing his book, which asserted that the Sun is the center of the solar system. Even before its publication in 1543, his views became known, which leads us to another obscure figure. John Widmanstadius, chancellor of eastern Austria, went to the Vatican to discuss the opinions of Copernicus with Pope Clement VII in 1533. In the presence of two cardinals, he explained to the Pope that the Earth revolves around the Sun. The reaction was not what you might expect — the Pope not only gave Widmanstadius a Greek manuscript but also appointed him as his secretary.

Calcagnini was the first Italian to support Copernicus, and he too sought an audience with the Pope. Paul III was well aware that his predecessor had looked favourably upon the Copernican system. He warmly received Calcagnini, who explained the revolutionary views of his close friend Copernicus. After Calcagnini’s return to Ferrera, the Pope sent him a kind message, which began a correspondence between them.

It was surely this personal approach that led Paul III to allow Copernicus to dedicate his book to the pontiff. In 1536, Cardinal Nicholas Schoenberg urged Copernicus to publish his work. Unfortunately the cardinal died the following year, and Copernicus prevaricated another seven years.

This left the field wide open. Many knew about Copernicus and his Sun-centered solar-system concept, but there was nothing in print. Enter Calcagnini. Although obscure today, he was famous in those days, and was known throughout Europe as an astronomer.

Calcagnini took two bold steps. First, he described the Sun-centered system in a concise seven pages. Second, he gave it a provocative title — Quod Coelum Stet, Terra Moveatur (loosely translated, it means the sky stands still, the Earth moves). “This firmament,” he wrote, “which you suppose to revolve with inexplicable velocity; this sun, these stars, which you imagine to be hurried on by a rapid motion, remain fixed, and supported on their poles, enjoy perpetual rest. This earth, on the contrary, which you fancy is fast and immovable, neither stands fast, nor does it rest on any denser element, as is believed by most people, but does itself move with incomparable velocity and eternally revolve, with our dwellings, our cities, with the mountains, the rivers, etc."

Unlike Galileo, Calcagnini faced no reprisals. Indeed he said that: “Cardinal de Cusa, a most judicious and learned man, held the same opinion in the last century.” It is even possible Calcagnini developed the Sun-centered system independent of Copernicus, but considering their close friendship, this seems unlikely.

One pertinent question remains — when did Calcagnini publish? Did he beat Copernicus to be the first in print? Scholars are divided on this question. The 18th-century Italian scholar Girolamo Tiraboschi claimed Calcagnini was first in print. But though Calcagnini’s treatise was likely written around 1530, it may not have been published until 1544, three years after his death. Copernicus likely received the first copies of his own book (On the Revolutions of the Celestial Spheres) on May 22, 1543. He died two days later.

To continue the story about how the ideas of Copernicus were opposed during the next few decades, readers should consult my column in the Summer 2009 issue of Mercury: “Copernicus vs. Tycho and Buchanan.”

CLIFFORD J. CUNNINGHAM was seen last year in Las Vegas chatting with two men who have travelled at warp speed — William Shatner and Leonard Nimoy. Clifford himself recently warped off to Hawaii.
Climate Change and Spiral-Arm Crossings

The newest model of Galactic structure casts doubt on earlier suggestions.

A few years ago, while writing a feature article on the dangers of cosmic radiation for Mercury (“Deadly Cosmic Storms,” Mercury, Jan./Feb. 2006), I ran across a journal article that suggested a link between ice-age epochs and the passage of our solar system through our galaxy’s spiral arms. Douglas Gies of Georgia State University and John Helsel (then a junior at Grady High School in Atlanta) used the Sun’s known position and speed to model Galactic parameters and determine that the Sun had traversed four spiral arms during the previous 500 million years. Each of these passages appeared to coincide with long-duration cold periods recorded in the geologic record.

How might passage through a spiral arm induce an ice age? Spiral-arm crossings are posited to increase Earth’s exposure rate to high-energy cosmic rays produced by supernovae resident in the arms. This increased cosmic-ray flux in Earth’s atmosphere leads to higher ionization rates in the atmosphere, which supposedly aids in cloud formation. More clouds lead to a cooler surface temperature on Earth and possible ice-age epochs.

The apparent correlation between terrestrial climate change and spiral arm crossings has remained a subject of debate during the past five years. This is because the results of the Gies and Helsel study depend on two critical assumptions. First, that increased cosmic-ray fluxes do, in fact, lead to increased cloud formation rates. But this remains a matter of much debate. (Earlier work by Nir Shaviv seemed to support their results: the iron-meteorite record indicated that Earth had experienced four large-scale increases in cosmic flux, and all four of these seemed to correspond to spiral-arm passages.) Second, that their model of the Milky Way’s spiral structure is correct.

Yes, we can say with certainty that the Milky Way is a spiral galaxy. In addition, our location within the galaxy and the orbital speed of the solar system about the galactic center are well determined. As they say, however, “the devil is in the details.” We don’t yet know how many spiral arms the Milky Way actually has.

Since the 1950s, Milky Way models have all included four major spiral arms. However, in mid-2008 an analysis of new images from NASA’s Spitzer Space Telescope reduced that number to two. Until quite recently, we did not know if the number of major spiral arms is two or three, or if the structures are even more complicated. Nor did we have a good handle on spiral-arm parameters such as position, shape, or velocities.

In light of new information, astrophysicists Andrew Overholt and Adrian Melott from the University of Kansas, and Martin Pohl from Iowa State University, recently re-examined the purported link between terrestrial climate changes and solar-system transits across spiral arms. The team points out that earlier Milky Way models feature symmetric spiral arms even though there is no observational evidence to support such symmetry. In fact, most models developed to date have been designed to “force fit” observational data to four symmetric spiral arms originating at galactic center.

The newest Milky Way model was recently put forward by Pohl and his colleagues Peter Englmaier of the University of Zurich and Nicolai Bissantz of Ruhr-University at Bochum. This model was used to produce a three-dimensional map of CO gas based on gas-flow dynamics. Their picture of the Milky Way is one in which the inner galaxy contains two symmetric spiral arms emanating from the central galactic bar. At roughly seven kiloparsecs from galactic center, each of these arms splits into two more arms. Thus the outer galaxy, where the solar orbit resides, contains four irregular, asymmetric spiral arms.

Overholt, Melott, and Pohl used the known solar system orbital velocity with the new Milky Way model to compute when the solar system crossed the galactic spiral arms over the past 500 million years. Assuming that all spiral arms have a common speed, and using the elliptical orbit found previously by Gies and Helsel, they found that the asymmetry of the outer spiral arms makes it impossible to reproduce the correlation between spiral-arm crossings and the 140-million-year climate-variation cycle.

So, asymmetry in the structure of the outer spiral arms effectively erases any periodic pattern with periods less than the orbit of the solar system around galactic center. This result holds even if the spiral pattern speed is allowed to vary. Yet, there remains a strong geologic record of a 140-million-year cycle of ice-age epochs with no plausible terrestrial origin. Given all the cosmic influences on Earth, there’s no doubt in my mind that we’ll keep looking for possible connections between Earth’s climate and cosmic influences.

Anyone up for a challenge?

JENNIFER BIRRIEL is an associate professor of physics in the Department of Math, Computer Science, & Physics at Morehead State University in KY. She notes that on the frontiers of science, as in life, “Change is the only constant.”
A Brilliant Observation

Where to explore next in the outer solar system?

Just a couple weeks ago I came across an interesting quote in the signature line of a poster on a paleontological web forum that I frequently:

“There has been an alarming increase in the number of things I know nothing about.” — Ashleigh Brilliant

My immediate reaction was that those words sum up very nicely my feelings of the true value of going through the process of adding three letters after my name. The intellectual journey of learning just about all you can about one little corner of our planetary system quickly instills in you a gut understanding that there is an infinity of other such corners in all areas of human endeavor — each with their own specialists and a depth of detail that can take a lifetime to explore.

It’s a personal analog for the process of exploration in science in general, and a valuable lesson for our strategies for continued exploration of our solar system in particular. Like many, I’ve been following with interest and great joy the continuing stream of stunning discoveries in the Saturn system revealed by the Cassini spacecraft. The team of passionate scientists and talented engineers who are targeting Cassini’s observations of Saturn and its retinue of moons are showing us that there is always something new and surprising to be discovered, even in those places where we might have thought ahead of time little of interest could be found.

One has to step back a bit to understand how a statement like that can apply to a moon like Enceladus, now revealed to be a living, breathing, geologically vibrant little world. In the early days of planning observation sequences for the Voyager flybys of Jupiter and Saturn, there were sensible arguments made that valuable data-gathering resources ought not be overly invested in observations of the moons of these giant planets. Of course we’d take a good look at them as long as we were passing through, but surely these frozen worlds would reveal little more than long-dead surfaces thoroughly and uniformly scarred by the ancient battering of a bygone era.

Instead, Voyager started us down the road of developing a new understanding of the surprisingly complex and dynamic evolutionary pathways followed by the various moons of the outer solar system. Voyager’s Enceladus was a bright little world, perhaps so white because of a fresh dusting of water frost covering its surface. What ongoing processes could supply fresh-water frost on a frozen little world that should have been geologically dead?

Cassini has revealed a spectacular series of plumes of water vapor and frost issuing from cracks in Enceladus’ surface, around the so-called ‘tiger stripe’ terrain in its south polar region. There is salt in the plume water as well, implying that at least some of the water is not just melted surface ice, but liquid that may have at least some connection to a source deeper under the surface where it interacts with rocky minerals. Some as-yet unknown source of internal energy is driving on-going geyser-like geologic activity on a small world that, years ago, many could very reasonably have argued should be a geologically deceased moon.

So, in the context of Brilliant’s subtly profound quote, and with the backdrop of the remarkable discoveries at places like Enceladus, what do you do when faced with the task of prioritizing our next steps in outer solar system exploration? Do you choose to return to worlds we’ve already reconnoitered in order to follow up on remarkable discoveries, to answer the new questions, to add even more depth to our understanding of their history and evolution (a dedicated mission to Titan)? Or do you set sail for the comparatively new worlds, the ones we’ve only glimpsed in flyby, the ones we still, in a comparative sense, know nothing about (a mission to Uranus)?

There are no right or wrong answers here, of course — we do in fact play both options, and there is clearly value in both exploration strategies. But in a world of real budgetary constraints, competing opinions on which are the most important fundamental open questions in planetary science, and the sometimes career-spanning intervals between major mission opportunities — such either/or options for planning future missions are the frustrating quandaries we have to wrestle with.

No matter the strategy, though, we’ll always be in the happy situation of discovering an increasing number of things we know nothing about.

DANIEL D. DURDA is a Principal Scientist in the Department of Space Studies at the Southwest Research Institute in Boulder, Colorado.
Gamma-Ray Burst Engine Finally Revealed

Magnetic fields likely channel the energy.

At first glance, it seemed that a certain gamma-ray burst (GRB) from January 2009 was dominating world news. Just Google “Liverpool,” “RINGO,” and “star,” and you’ll see a half million hits. Alas, add “—The Beatles” to the search and you’re down to only a few, the first being a Nature journal article from December 10, 2009, describing the best detection yet of polarization from a star explosion, captured by the RINGO instrument on the robotic Liverpool Telescope.

Pity the press didn’t pounce on this. The detection of 10% polarization in the afterglow of GRB 090102 is arguably the most significant gamma-ray burst (GRB) result in years. Polarization points to the mechanism behind these mysterious bursts.

GRBs are created in the collapse and death of extremely massive stars or in the merger of two neutron stars. In either scenario, a black hole is born. And in the span of a few seconds to about a minute, out from this tiny region will pour more energy than the Sun will create in its 10-billion-year lifetime.

First detected around 1970, these bursts proved too fleeting to study in detail. Confirmation of GRBs’ origins didn’t come until 2005, after the launch of NASA’s Swift satellite. Swift pinpoints GRBs within seconds, relays the location to telescopes worldwide, and then follows up with its X-ray and UV/optical telescopes.

With the origin question mostly settled, the effort now has turned to understanding the engine. Don’t let the “G” of GRB fool you. GRBs emit energy across the spectrum, and the afterglow in lower energy regimes can be detected for days or weeks — if one knows where to look. The afterglow, much like a car wreck, contains clues to how one fleeting event can momentarily outshine the rest of the universe.

GRB 090102 was an ordinary burst lacking the superlatives of brightest or most distant. The gamma rays lasted for 27 seconds. Swift detected and relayed the location, as usual. About two minutes later astronomers were observing the afterglow with the Liverpool Telescope, situated on La Palma in the Canary Islands.

The automated telescope grabbed 60 seconds of optical afterglow with RINGO, a polarimeter installed in 2006. Polarization is a measure of the preferred direction of electromagnetic wave oscillations. The polarization of most astrophysical sources rarely exceeds a few percent, indicating that such light is largely isotropic. Something big might have channeled GRB 090102 to polarize it on the order of 10%, according to team leader Iain Steele of Liverpool John Moores University.

This cuts to the heart of the GRB engine. One theory holds that GRBs are powered by a fireball, a gas-dynamic phenomenon of pure heat driven by a jet of gases from the explosion’s core.

A competing or sometimes complementary theory holds that magnetic field coupling and reconnection can accelerate particles. That is, large-scale magnetic fields can accelerate electrons to nearly light speed to emit the gamma-ray energy detected, as well as launch and collimate the outflow, similar to the mechanism behind solar flares. The magnetic fields’ handiwork would be imprinted in the robust polarization signal. If, in contrast, small-scale, localized magnetic fields were at work, then the polarization signal from various regions would average out to zero.

Most scientists wouldn’t be too surprised by the presence of magnetic fields, because the fireball mechanism is too inefficient to produce the energies detected, said Stan Woosley of the University of California, Santa Cruz, an expert on nucleosynthesis and the hydrodynamics of star explosions.

“The issue is how coherent the field is across the whole jet and how strong it is,” Woosley said. “The jet [might] start out magnetically but by the time it burrows through the [collapsing] star, its rather ordered magnetic energy has been created into heat by friction with the surrounding star.” All in all, he added, it’s “a rich subject.”

Detecting polarization is difficult, and previously reported detections from GRBs have been controversial. But RINGO’s was the quickest such measurement after a burst, making the GRB 090102 observation “more credible,” Woosley said.

The utility of polarization measurements demonstrated by RINGO supports the need for more polarimeters for the study of all kinds of jets, said Swift lead scientist Neil Gehrels of NASA Goddard. NASA has an X-ray polarimetry mission under development for launch in 2014.

“Optical polarization measurements may be taking us from the realm of theoretical conjecture to understanding how jets work,” said Roger Blandford, director of the Kavli Institute for Particle Astrophysics and Cosmology at Stanford University. Blandford is also half the conjecturing team behind the Blandford-Znajek mechanism, which attempts to explain particle jets around black holes as a result of magnetic fields coupled to gravity, which might apply to GRB jets as well.

And so GRB 090102 has provided nice bookends for 2009, with the burst starting the year with a bang and its analysis closing the year in equally fantastic fashion.
The Internet explosion seems to be catching up with Astro 101 instructors. Finding resources on the Web can appear overwhelming at times, with searches resulting in frustration. Here’s a short compilation of educational sites that should help all Astro 101 instructors.

The journal for and by astronomy educators, Astronomy Education Review (AER), should be on every instructor’s reading list. Long sponsored by the NOAO, the journal is now published by the American Astronomical Society. This should be your first stop for finding out about “best practices” in instruction and what research tells us about how students learn.

A new e-zine called the Classroom Astronomer has been created by Larry Krumenaker primarily to aid high-school instructors. Published quarterly in PDF format, the content is geared toward classroom use rather than education research, with some articles appropriate for K-8 or Astro 101 instructors as well. Access is now by subscription, but the e-zine remains free.

The American Astronomical Society and the American Association of Physics Teachers have cooperatively produced ComPADRE as a physics and astronomy education site. Astro 101 instructors will want to go directly to the Astronomy Center. The center has sections for labs, images, and simulations; topical lists (Sun, stars, planets, pedagogy); and a search mechanism. Because ComPADRE is a collection of author-, user-, and editor-contributed items, the quality and applicability of materials can vary. Searches can also take a little practice to maximize the relevance of the results returned; “survey” returns sky surveys, for example, and not concept inventories or other research instruments.

But one thing I like about ComPADRE is that you can search in “Partner” databases such as MERLOT, other parts of ComPADRE, ADS education, and the National Science Digital Library. If you are specifically looking for education research, PER Central, another part of ComPADRE, has an advanced search engine that permits finely tuned searches.

The ASP has long been a supporter of astronomy education efforts, and I continually find something new and different when I return periodically to the education portion of the Society’s site. You can find podcasts, bibliographies, activities, newsletters, and more. And while we are mentioning the Society: Plan to attend Cosmos in the Classroom, a symposium for Astro 101 instructors to be held during the ASP’s upcoming annual meeting August 2–4 in Boulder, Colorado. You can sign up for the mailing list to receive more information about Cosmos at the ASP’s meeting webpage.

Yahoo alone has more than 12,800 astronomy news groups, but educators mostly need two: AstroLrnr and AstroEd_News. AstroLrnr has 754 members who discuss college-level astronomy teaching and learning (many members are high-school teachers). The group freely shares resources and is a good support group when things go astray in the classroom.

AstroEd_News is more of a newsletter for disseminating information to teachers and learners of all ages. The news group is coordinated by the Association for Astronomy Education, an affiliate of the National Science Teachers Association and has 622 members.

If you are looking for labs and simulations, try CLEA (Contemporary Laboratory Experiences in Astronomy) and the Nebraska Astronomy Applet Project (NAAP).

NASA’s Center for Astronomy Education hosts workshops demonstrating the use of lecture tutorials. But they also have a website that includes other materials on topics such as assessment, teaching strategies, and setting goals. Check out the “summer” reading list.

An important non-astronomical site is Collaborative Learning, Small Group Learning, hosted by the National Institute for Science Education. It shares ideas for selecting groups, first-day icebreakers and group activities (think-pair-share to jigsaws and quickwrites).

The SAO/NASA Astrophysics Data System (ADS) has extended its bibliographic search into the area of astronomy education. A simple search on “education” returns 34,904 entries. ADS provides full text for some articles, links to outside Web sites for others, and abstracts for almost all articles. The Searchable Annotated Bibliography of Astronomy Education Research (SABER) is a complementary tool for use with ADS. It can help narrow down the number of articles you might be interested in. The annotations in SABER try to capture an article’s content more fully than the abstracts often allow.

Even this short list can be rather intimidating to keep up with on a regular basis. My New Year’s resolution is to pick one new site and visit it regularly, and then to incorporate the material into my class.

DAVID BRUNING (david.bruning@uwp.edu) is a Distinguished Lecturer at the University of Wisconsin-Parkside.
Astronomy is renowned for exposing the intrinsic beauty of the universe. What a single Hubble Space Telescope image cannot capture, however, is that astronomy is also kinetic: violent and chaotic, rhythmic and graceful, at turns languid and swift.

This presents an interesting challenge. How can astronomers convey the dynamic nature of the universe to the general public? Animations and computer simulations are one obvious pathway. Less conventional methods, however, have the power to attract new audiences and even to challenge our own minds.

Combining dance and astronomy is clearly a non-traditional approach, but these seemingly disparate realms can be fused successfully to educate and inspire an audience. Dance is defined by motion and is a powerful tool for expressing the character of the ever-changing universe. The profound nature of dance also allows it to connect organically with the audience. Perhaps most importantly, the non-threatening artistry of dance may even attract members of the general public who might otherwise be intimidated by the science of astronomy.

During the last year, I had the pleasure of working with choreographer Kathryn Roszak on a dance/astronomy collaboration inspired by the 2009 International Year of Astronomy. I am not a dancer and have no experience with professional dance other than a sincere appreciation for the performing arts. But this unconventional project has significantly expanded my vision of astronomy public outreach.

Kathryn Roszak is an artist with considerable experience translating novel, scholarly concepts into dance. Her dance company, Danse Lumière, creates dance theater linking arts, sciences, and the humanities. Kathryn and I met at the beginning of 2009 through our teaching at the Osher Lifelong Learning Institute at UC Berkeley. I was a new instructor at the Institute, beginning my first class: "Six Questions for Modern Astronomy." When we met, Kathryn was preparing a dance inspired by astronomy ("Copernicus, Galileo, and Kepler") for Humanities West’s Fall 2009 program. Humanities West is a non-profit organization in San Francisco.

Kathryn was excited about learning more about the universe. I provided her with articles regarding the newest discoveries in astronomy. Kathryn invited me to attend rehearsals of "The Star Dances" to discuss astronomy with the dancers. At the rehearsals, I was impressed by how astronomy was encapsulated into the dance both in apparent and subtle, imaginative ways. "The Star Dances" are accompanied by a piano version of Gustav Holst’s “The Planets,” with additional music by Eric Satie.

Prior to the October 2009 premiere of "The Star Dances," Humanities West invited us to talk about our collaboration at the Mechanics’ Institute Library in San Francisco. I discussed the astronomical science, while Kathryn spoke about her creative process. I was pleased that our audience included more women than is typical for the average astronomy public lecture.

"The Star Dances" was presented at the Lawrence Hall of Science in Berkeley on December 12, 2009, as an interactive family program. We interspersed the dance with a multi-media astronomy presentation. To help the kids connect the dance with the science that I explained, Kathryn and the dancers demonstrated specific dance movements before each section was performed. For example, I showed videos of material streaming from the Sun into space, and talked about how these particles impact Mercury and even cause the aurora on Earth. The dancers then illustrated a part of the "Mercury" dance in which they interact by tossing around an imaginary ball.

This program also involved active audience participation. During the talk, the audience answered questions about astronomy. At the end of the program, a group of kids (and parents) became particles moving around the universe and forming into a solar system. Inflatable models of the planets added to the excitement! We believe we succeeded in our goal of inspiring in our young audience an interest in, and enthusiasm for, both the arts and science.

This exciting combination of astronomy and dance promotes intellectual curiosity and makes both subjects accessible to new audiences. Therefore, we plan to continue our collaboration in the future. "The Star Dances" depict, with form and movement, the universe’s energy, grace, and even playfulness, and we hope our program illustrates that science public outreach can successfully incorporate art and beauty.

Bethany Cobb is a National Science Foundation Astronomy and Astrophysics Postdoctoral Fellow at UC Berkeley, where she studies gamma-ray bursts and engages in public outreach, including teaching at the Berkeley Osher Lifelong Learning Institute.
Creating and delivering a good talk needn't be arduous.

by Tijana Prodanovic
It always amazes me, often in a negative way, how few people know how to create, and deliver, a good presentation. For many scientists, it’s often their Achilles’ heel. Some get so caught up in their work that, when they present it at a scientific meeting or to the general public, their talk is often confusing, boring, or sometimes even scary. The good news is that there are some simple rules that can work magic with presentations.

1. Know Your Audience
This rule may seem so simple, but it is the most crucial point and can make a world of difference. Even before you commit to giving a presentation to a group of people, you need to know their demographics. Is your audience young? Are they old? Well-educated? Sometimes it might also help to know their nationality or religious background.

Of course, you don’t need to know all this every time — decide based on your subject matter. For instance, when I give a public science lecture to a high school audience, I try to be more hip, use slang, and refer to things that the students are interested in. However, when I give the same public science lecture in a local cultural center that will be attended mostly by senior, well-educated people, I use more subtle language and don’t try so hard to make it fun (but still keep it interesting). So, adjust your presentation according to the audience.

Personalizing presentations is also a good idea. When I give a lecture about galaxies and show what the Milky Way looks like, I always point out the location of the Earth by noting the name of the city, or the institution, where I’m giving the lecture. You’d be amazed at how a simple thing like that makes a difference.

2. Be Yourself
However much you change your presentation to accommodate the audience — whatever you do, still be yourself. That’s what makes people trust you. The last thing you want when giving a presentation is for the audience to not believe what you’re telling them.

When does the audience distrust you? When they smell “bad acting.” Trying too hard to be something (or someone) you’re not gives people a sense that they’re listening to a phony, which in turn can lead to failure. Two key things that will help are being comfortable with your presentation, and believing in the content.

3. Be the Audience
Create a talk that you, if you were in the audience, would find interesting, engaging, smooth, fun, and whatever else you’re trying to
achieve. Avoid anything that would put even you to sleep! Remember, if you’re not having fun writing it, making it, practicing it, and delivering it, then your presentation probably needs a bit more work.

4. Practice Makes Perfect
Practice, practice, practice. The worst thing to do is to speak your presentation for the first time in front of the audience. Every time I finish writing a presentation, I’m usually happy with how it looks on paper or in PowerPoint. But when I go over it out loud, I always run into a few bumps and some awkwardness, and I end up rewriting it to make it smoother and clearer.

Then again, don’t overdo it. There is such a thing as too much practice, which results in identical sentences coming out of your mouth each time you run through the presentation. You don’t want to learn it by heart because then it starts sounding fake — like bad acting.

However it is a good idea to memorize a few introductory sentences at the beginning of the presentation, especially if you’re nervous. Knowing the first few lines will help you feel more comfortable and ease you into the rest of your presentation.

5. Setup — Confrontation — Resolution
Throughout your presentation, you want your audience to know where they are, why they are there, and where they are going. This is what a smooth presentation is. Just like a nicely written book, it has a setup, a confrontation or a plot, and a resolution.

First tell your audience why they are there. Give them a reason why the topic is important. Then lay out a plan of action. Tell them what the goal is and how you plan to get there. Next, set some general rules, telling your listeners anything important they need to know in order to understand your presentation. Only then do you lead your audience through the plot — your method, your procedure, and the vital and most difficult part of your presentation.

After that, the plot needs to reach a resolution, a conclusion, and the results of your presentation — the punch line, as it were. Make sure that when delivering the punch line you make a big deal out of it, because after all, that’s why both you and the audience are there. Finally, you want your presentation to end smoothly, and not with a cliffhanger like a season-ending TV show — that just annoys the audience.

6. Keywords
Be sure to know what the keywords of your presentation are. In every presentation many words are spoken, many PowerPoint slides are shown, and many demonstrations are done — and in most cases it’s all just too much information. If you give a good presentation, most of the audience will be able to recount it the next day. A week later, most of them will only remember bits and pieces but should recall what the point of the talk was. A year later — well, if they can reproduce a three-word summary of your presentation, then you were successful!

Those three words are your keywords — they are what people will take away from your talk and (hopefully) stick in their minds. So break up your presentation into keywords. The easiest way to do that is to summarize your presentation into three or four words. Once you know your keywords, make sure that you repeat them as often as you can (without sounding too strange or awkward) during your presentation, because repetition makes people remember.

7. Not Too Much
There is such thing as too much information — especially when you’re presenting your own work. You’ll have a desire to tell the audience everything and fill them with details, but they don’t need it all. They only need to understand the presentation and get the punch line. Anything that is not essential for your talk, but that you want to tell your audience — have ready as a backup in case someone asks about it.

If you’re giving a PowerPoint presentation (or using older technology such as an overhead projector with transparencies), do not
include too many visuals/slides. A good guide is one slide per minute. And don't put too much text on your slides. It's difficult for your audience to read and listen to you at the same time. The text you do use must be readable from the back of the room. So if you use a nice, but dark, image as a background for text, make sure the text is large, white, and in a font that's easy to read.

Finally, if you're a scientist, please try to avoid using equations — show only those that are absolutely essential.

8. What is the Center, not How
With all the nice things that software such as PowerPoint can do, it can sometimes happen that the what gets hijacked by the how during your presentation. In other words, presentation style overwhelms content.

Using too many animations, fancy slide transitions, titles, and words, may result in your audience becoming sidetracked from what you are saying to how you are presenting it. Don't overdo it when trying to make your presentation look fancy and shiny — you never want the design of your presentation to get in the way of the content.

9. Eye Contact
This is very simple, but makes a world of difference. Establishing regular eye contact with your audience makes you look friendly, believable, and trustworthy, which is essential for a successful presentation.

10. Stick to the Time
Finally, nothing annoys people more than a presenter who talks over the time limit. You may deliver a brilliant presentation, but if it drags on too long, people will get fidgety and become annoyed — not what you want to have as a final impression.

Conclusion
There you have it: my 10 commandments for presentations. They probably look intuitive and obvious, but sticking to them can be a different story. Hopefully they will be useful, and trust me when I say that they will make a world of difference.

(This article first appeared in the Cosmic Diary, a Cornerstone project of the 2009 International Year of Astronomy.)

Tijana Prodanovic is a Serbian astrophysicist. Her interest in astronomy began at the tender age of 10. Since then she has pursued science as a career, obtaining a PhD in astrophysics. Finding new ways of communicating science to the public ranks highly in her list of interests.
The Dudley Observatory Dedication, 1857, by Tompkins H. Matteson. More than 160 portraits are combined in this painting, including Maria Mitchell, Benjamin Pierce, Joseph Henry, Louis Agassiz, Millard Fillmore, and, of course, Edward Everett. The image in its entirety can be seen here. Courtesy Albany Institute of History and Art.

Astronomy has moved from applied to fundamental research, but its usefulness has not dimmed.

by Mary Crone Odekon

The Dudley Observatory Dedication, 1857, by Tompkins H. Matteson. More than 160 portraits are combined in this painting, including Maria Mitchell, Benjamin Pierce, Joseph Henry, Louis Agassiz, Millard Fillmore, and, of course, Edward Everett. The image in its entirety can be seen here. Courtesy Albany Institute of History and Art.
How do you explain the uses of astronomy? On a summer day in 1856 in Albany, New York, the answer was a two-hour manifesto by famed orator Edward Everett. Everett was not an astronomer. He had recently served as both President of Harvard University and US Secretary of State, and was the main oratorical heavyweight to mark the opening of a new observatory funded by heiress Blandina Bleecker Dudley.

He also delivered the Gettysburg Address — not the succinct version of Abraham Lincoln, which was scheduled for the same day at the last minute, but the full-blown, two-hour main event.

The dedication of the Dudley Observatory, along with a new Geological Hall (inaugurated the previous day with a speech by Louis Agassiz that lasted only one hour), was part of an eight-day extravaganza of lectures linked to the tenth annual meeting of the American Association for the Advancement of Science. Most prominent American scientists were in attendance, joined by political leaders, donors, and thousands of local citizens.

**A Summation of History**

How well do Everett's ideas and style survive the test of time? The full 25-page text, which is available through Dudley Observatory’s website, is a mine of inspirational language, history, philosophical reflection, and cultural prejudice.

Everett begins by summarizing the history of astronomy, the history of the United States, and the history of astronomy within the United States. A clear implication is the importance of national pride.

Besides the institution at Washington [the National Observatory, now the US Naval Observatory], fifteen or twenty observatories have within the last few years, been established in different parts of the country, some of them on a modest scale, for the gratification of the scientific taste and zeal of individuals, others on a broad foundation of expense and usefulness.... There is already in the country an amount of instrumental power (to which addition is constantly making), and of mathematical skill on the part of our men of science, adequate to a manly competition with their European contemporaries.

While the sexist language sounds dated, the nationalistic concept lives on. Arguments for education in science and math are typically phrased in terms of global competition even today. Nonetheless, some of the most poetic — and in my mind, convincing — passages appear in these opening sections of Everett’s speech:

*There is, perhaps, no branch of science which to the same extent as astronomy exhibits phenomena which, while they task the highest powers of philosophical research, are also well adapted to arrest the attention of minds barely tinctured with scientific culture.... But the unspeakable glories of the rising and the setting sun; the serene majesty of the moon, as she walks in full-orbed brightness through the heavens; the soft witchery of the morning and the evening star; the imperial splendors of the firmament on a bright, unclouded night; the comet, whose streaming banner floats over the half the sky, — these are objects which charm and astonish alike the philosopher and the peasant, the mathematician who weighs the masses and defines the orbits of the heavenly bodies, and the untutored observer who sees nothing beyond the images painted upon the eye.*

**The Usefulness of Astronomy**

Arguments for usefulness begin in earnest with three related examples of the “direct connection of astronomical science with the
uses of life and the service of man” — timekeeping, geography, and commerce/navigation. Inconveniently for modern astronomy, we can no longer claim these practical or commercial uses; we have shifted almost entirely out of applied research and into fundamental research. Perhaps the most direct argument we can make today for this kind of practical value is that of technological spin-offs. Everett comes close to the spin-off concept, but focuses on the effect of technology on astronomical progress, rather than the other way around. Consider this description of mechanical computers. 

In the wonderful versatility of the human mind, the improvement, when made, will very probably be made by paths where it is least expected. The great inducement to Mr. Babbage to attempt the construction of an engine by which astronomical tables could be calculated, and even printed, by mechanical means and with entire accuracy, was the errors in the requisite tables. [The tables referred to are Taylor’s Logarithms of 1796, which were used for navigation].

Everett’s cultural prejudices make appearances throughout the speech. The revolution of the year, with its various incidents of summer and winter, and seed-time and harvest, is not less involved in our social, material, and moral progress. It true that at the poles, and on the equator, the effects of these revolutions are variously modified or wholly disappear; but as the necessary consequence, human life is extinguished at the poles, and on the equator attains only a languid or feverish development.

A long, melodramatic ode to Galileo feels especially relevant, having just celebrated the 400th year of the telescope.

Yes, noble, Galileo, thou art right, E pur si muove. “It does move.”… Close now, venerable sage, that sightless, tearful eye; it has seen what man never before saw—it has seen enough. Hang up that poor little spy-glass — it has done its work… the time will come when, from two hundred observatories in Europe and America, the glorious artillery of science shall nightly assault the skies, but they shall gain no conquests in those glittering fields before which thine shall be forgotten.

Seeking Knowledge and the Greater Glory

After the practical values, Everett shifts into more general arguments about the pursuit of truth and knowledge — arguments that are perhaps more relevant for us today.

The different sciences contemplate as their immediate object the different departments of animate and inanimate nature; but this great system itself is but one, and its parts are so interwoven with each other, that the most extraordinary relations and unexpected analogies are constantly presenting themselves; and arts and sci-
ences seemingly the least connected, render to each other the most effective assistance.

Despite not being an astronomer, Everett expresses personal interest and opinions about astronomical controversies of the time, describing the “glow of satisfaction” he felt when notified that “Herschell’s nebular theory” (the theory that nebulae are not stars, but “rudimental material of worlds not yet condensed”) was proved wrong when stars were resolved in the Orion nebula. This was of course, only partially correct; we now know that some of the nebulousness is indeed in the form of unresolved stars.

The planet Neptune was discovered only ten years before Everett’s speech. As a measure of the vastness of space available to Dudley observers, Everett points out “…the extraordinary, not to say fantastic, shapes discerned in some of the nebulous systems — whirls and spirals radiating through spaces as vast as the orbit of Neptune.” (The ‘spiral nebulae’ are actually about 10 million times larger.) He goes on to point out that “…outside of Neptune, between our sun and the nearest fixed star, supposing the attraction of the sun to prevail through half the distance, there is room for ten more primary planets succeeding each other at distances increasing in a geometrical ratio.”

Everett’s final, five-page appeal, is to a sense of glory, which for him included belief in the Christian God:

But the great object of all knowledge is to enlarge and purify the soul, to fill the mind with noble contemplations, to furnish a refined pleasure, and to lead our feeble reason from the works of nature up to its great Author and Sustainer….How grand the conception of the ages on ages required for several of the secular equations of the solar system; of distances from which the light of a fixed star would not reach us in twenty millions of years, of magnitudes compared with which the earth is but a foot-ball; of starry hosts — suns like our own — numberless as the sands on the shore; of worlds and systems shooting through the infinite spaces, with a velocity compared with which the cannon-ball is a way-worn, heavy-paced traveler!

Understanding the Universe
With these words, the Dudley Observatory was officially launched. But it was an empty building. Benjamin Gould, the Observatory’s first director, never succeeded in getting the observatory up and running, despite (or perhaps partly caused by) his high standards. Most critically, he dealt poorly with trustees and donors, leading to his dramatic dismissal as Director and his equally dramatic refusal to vacate the Observatory. As Bartky et al. conclude in an article about the Dudley dedication: “this unhappy episode serves as a reminder of the absolute need for mutual respect between those who would use a scientific facility, and those who would fund it.” It was not until the 1870s, under Dudley’s fourth director, Lewis Boss, that a significant program of research was finally sustained.

The coincidence of the International Year of Astronomy with a worldwide financial crisis might provoke soul-searching among those of us who support disciplines that are not obviously “useful.” And astronomy is more firmly in the non-useful category today than it was during the nineteenth century, when it really was used for commerce and navigation. But even in Everett’s time, and even in a speech titled “The

Johann Gabriel Doppelmayr’s 1742 *Atlas Coelestis* conveys celestial glory in its astronomical diagrams, which includes paths of comets as well as illustrated depictions of the constellations.
Uses of Astronomy, there was an emphasis on the excitement and dignity of understanding the universe — as well as a hint of the idea that curiosity-driven research leads to useful technologies.

Nonetheless, it seems to me that two important points are left out. One is the survival of humanity, which might plausibly depend on understanding how to avoid catastrophic impacts from space. The other is astronomy’s role in education, a role that is probably in the minds of those reading this article (and magazine).

I will end with my favorite nineteenth-century description of this role — not to be found in Everett’s speech, but in a classic 1889 high school textbook by Charles A. Young.

By the precise and mathematical character of many of its discussions it [astronomy] enforces exactness of thought and expression, and corrects that vague indefiniteness which is apt to be the result of pure literary training. On the other hand, by the beauty and grandeur of the subjects it presents, it stimulates the imagination and gratifies the poetic sense. In every way it well deserves the place which has long been assigned to it in education.

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After 150 years of reinventing itself, the Dudley Observatory is now devoted to astronomy education and history, with an emphasis on its extensive collections. Director Janie Schwab looks through Dudley’s collections with Guy Consolmagno.
Serious observing at low elevations near large cities is challenging, but possible.

by Brian Oetiker
Intrigued at the prospect of an exciting discovery being made right in the “backyard” of a large city, you suddenly remember that old telescope sitting in the attic and wonder if you should dig it out and turn it skyward. But then you think: “I live in a larger city than Tucson and at a much lower elevation. I can’t even see the stars from my driveway. There’s no point trying to do serious astronomy where I live.”

Well, don’t give up, because you can observe interesting celestial sights near low-elevation big cities. In fact, astronomical finds are being made at sites other than remote, high-elevation observatories. Still skeptical? Check this out — “Sea Level Stargazing: Astronomers make key sighting with Florida telescope” — and then read on.

Where the Observatories Are

Large, modern observatories are built at isolated locations for good reasons. Long ago, astronomers learned that observing through Earth’s atmosphere is a challenge. Cloudy weather, rain, humidity, and pollution — common at low elevations — are bad for observing. Light pollution caused by our nightly activities also hampers astronomical observations. These reasons drive astronomers to remote locations far from lowlands and big cities. While the clear, dry, dark skies found at high elevations are needed for most astronomical research, some interesting and scientifically useful astronomy can be done at lower elevations, often within a two-hour drive of even the largest cities.

The United Nations estimates that half of humanity now lives in cities. In developed countries, nearly three-quarters of us dwell in urban areas. A 1998 study revealed that one-third of us live at an elevation of less than 300 feet above sea level, while more than three-quarters of us live below 1,600 feet. Since the majority of us
live in light-polluted cities at low elevations, we are at risk of losing our natural interest in the skies.

Fortunately, in the United States we have a network of small observatories located near large cities — some operated by professional astronomers, many run by dedicated amateurs. These telescopes are a valuable educational and scientific resource that provide us with the opportunity to do hands-on astronomy and spark the imaginations of young and old alike. Astronomers are even doing research, such as searching for extrasolar planets, at some of these unlikely locations. Astronomy near low-lying cities is not without challenges, but it also has its rewards.

Getting Started Near Your City

The original telescope is the human eye. It was the only instrument we had for observing the night sky until Hans Lipperhey (among others) invented the refracting telescope in 1608. While naked-eye astronomy is the least expensive and easiest observing to do, you’re limited to spotting the brightest night-sky sights, particularly if your observing site is within a city. A good star chart is handy — the ones made available to ASP members via Sky & Telescope (see page 38) are useful for city observers.

The next step that most enthusiasts take is to use binoculars or a small portable telescope to explore the night sky. This kind of astronomy does not require a fixed-site observatory and can be done within a city — from your balcony, your backyard, or a nearby park. Of course, celestial views are still hindered by light pollution, so often a follow-up step is to find a dark site, unobstructed by trees or buildings. Most cities have state or county parks located on their outskirts.

During the summer months, driving roughly an hour beyond the edge of your city or town will take you to a sky dark enough to reveal a faint, “cloudy” band of light stretching across the heavens. This dim band is our galaxy, the Milky Way — a sight that is literally eye opening when seen for the first time from a dark-sky site. Binoculars or a telescope will reveal an amazing universe of celestial sights. If you’re nervous about observing by yourself outside the city, consider joining your local astronomy club and venturing out with other like-minded folks. Most cities have one; you can search for the one near you on Sky & Telescope’s Clubs and Organizations page.

Astrophotography

The next level of sophistication in astronomy is attaching a camera to the telescope. Ten years ago, this meant buying a camera with a removable lens and an adapter to connect the camera body to the telescope. Special film was needed, along with access to a good photo lab and a lot of patience while waiting for the film to be developed.

With the explosion of cheap, high quality digital cameras, we no longer have to deal with film or developing. (Instead, we now spend hours in front of our computers “processing” our own images!)

Two bright emission nebulas, nicknamed Heart (IC 1805, right) and Soul (IC 1848, left), shine brightly in the red light of energized hydrogen. Both are found in the constellation of Cassiopeia, the Queen. All the deep-sky images in this article were taken by Don Taylor at the Sam Houston State University observatory, located approximately 70 miles north of downtown Houston, Texas.
Because of the availability of digital cameras, astrophotography has become very popular, and many amateur astronomers at local observatories can be found working on astrophotography projects. What does it take to do astrophotography? That question goes beyond the range of this article, but key elements include a good quality telescope on a stable mount and plenty of patience.

Some fine examples of astrophotography, acquired at a low-elevation site near a large city, are included in this article. The images, by Don Taylor, were taken at the Sam Houston State University observatory, located approximately 70 miles north of downtown Houston, Texas. Taylor used a high-quality CCD camera mounted on a number of different telescopes. The vibrant colors are a result of shooting through narrow optical filters and combining the results using image-processing software. The exposure times vary in length from 10 minutes to more than one hour, depending on the brightness of the object and the amount of light passing through the filter.

The Challenges of Low-Elevation Observing

Observatories not located on mountaintops definitely face some observational challenges. Three of the major ones are scintillation, extinction, and light pollution.

Twinkling, or scintillation, is an atmospheric effect that causes rapid variations in the apparent brightness or color of a celestial object. It plagues all observatories but is more noticeable at low elevations. While it makes the stars pretty to look at, scintillation reduces image quality, especially at very high resolution.

Since most small observatories don't image at high resolutions, scintillation is not a major problem. For low-elevation astronomers interested in getting the clearest, sharpest images possible, the best cure for scintillation is to install "adaptive optics," a system that helps correct atmospheric distortion. Major observatories began using it some 20 years ago, but these days adaptive-optics systems are affordable by even small observatories.

Extinction is a term normally associated with dinosaurs and irreversible loss of plant and animal life. But in astronomy, extinction refers to the scattering of light by matter lying between a celestial object and an observer. In our case, Earth's atmosphere is the cause, and extinction is most noticeable when an object (such as the Sun or Moon) is observed near the horizon. Atmospheric extinction causes a celestial object to appear dimmer and redder than it actually is.

While extinction is an issue even when observing from a mountaintop, it's worse at low elevations because you're looking through more atmosphere for a longer period of time. The only cure for this problem is to wait, if possible, for your object to rise higher above the horizon, where the effects of extinction are less. By the time the object is 30° above the horizon, you might see a slight improvement in image quality.
horizon, amateurs and small observatories can pretty much ignore the problem.

One of the major reasons research telescopes are remote is that astronomers are trying to escape light pollution. All astronomers want to get away from light pollution, but for city-dwelling amateurs, convenience must also be considered. The question is: How far do you need to travel from your front door to escape most of the effects of light pollution and view the heavens from a reasonably dark sky?

The answer depends on what kind of astronomy you want to do. If you’re interested in observing the planets, stars, or star clusters, you need not go very far. A park located a few miles from a small town, or 10 to 20 miles from the outskirts of a city, will probably do the trick. But if you’re interested in making precise brightness measurements, or observing galaxies or dim nebula, then you need to roam farther afield. To see these deep-sky sights, or to view the glorious summertime Milky Way, you’ll likely need to be 50 to 60 miles from home — a good hour’s drive.

**Astronomical Research Near Cities**

While more common in the past, astronomical research near large cities is still possible. In fact, there are many exciting, ongoing observing projects near some of the largest cities in the United States. Here are three kinds of research techniques that can be employed almost anywhere.

*Photometry* is the measurement of the brightness of an object (star, planet, comet, or asteroid) over a long period of time. Photometry is useful for studying variable stars and searching for planets. Conveniently, photometry can be done anywhere the sky is reasonably dark and can easily deal with many of the problems mentioned previously. In fact, I’m currently conducting a search for extrasolar planets using a photometer on one of the telescopes at the Sam Houston State University campus observatory.

The very precise measurement of an object’s position in the sky over a period of time is called *astrometry*. Pluto was found via astrometry, and many objects such as comets, asteroids, and Kuiper Belt Objects are discovered using this method. As with photometry, ideal observing conditions are not necessary for astrometry, because the only thing of interest is changes in the location of bright points on the images. Professional and amateur astronomers all around the world employ astrometry with telescopes of all sizes to search for new asteroids and comets.

*Spectroscopy* is used to measure the spectrum of light from a star, planet, or galaxy. While more sophisticated than photometry and astrometry, it’s another kind of astronomical research that can be done near large, low-elevation cities. Spectroscopy is used to determine the chemical composition, the speed, and/or the rotation of an object. The Harvard-Smithsonian Center for Astrophysics operates a “digital speedometer” at the Oak Ridge Observatory not far from the city of Boston, Massachusetts, which is used for a variety of applications such as measuring the motions of stars, asteroids and comets.

**Head Out and Observe**

It’s definitely possible to perform both simple observing and cutting-edge astronomical research right in your own backyard — even if it happens to be in or near a large city at a low elevation. While research can require expensive and sophisticated technology, basic observing needs nothing more than a good set of eyes and a dark observing location. Find a local astronomy club, or check with your local university. Some of this activity might be happening in your neighborhood.

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BRIAN OETIKER is an assistant professor in the physics department at Sam Houston State University. When he’s not teaching or hunting for planets, he spends his time with his wife fixing up their old house.
2010: Year of the Baffling Eclipse
AAVSO

In August 2009, amateur and professional astronomers reported that the bright star Epsilon Aurigae had begun to lose brightness for the first time in 27 years. It is believed that the dimming of the star’s light is caused by an eclipsing object of an unknown nature.

The first phase of the eclipse involved a dramatic drop in brightness over the course of a few months beginning in August. Professional and amateur astronomers teamed up to monitor the eclipse and have announced that this critical phase ended around New Year’s Day 2010.

“We have increasing evidence that a dark disk of material has moved in front of our view of Epsilon Aurigae,” said Dr. Robert Stencel, scientific advisor for the project. “But the exact shape and make up of the disk has been unknown, but will be better defined soon.”

Even during the eclipse, the star is so bright that sensitive equipment in professional observatories can have trouble monitoring its brightness in the optical wavelengths. Furthermore, large telescopes cannot afford to monitor one star continuously. This is where amateurs and citizen scientists step in.

“Amateurs are the ideal astronomers for this project. Either with their naked eyes or with digital cameras, they have proven that they can record professional quality data,” said Dr. Arne Henden, director of the American Association of Variable Star Observers (AAVSO) and principal investigator of the project.

If past eclipses are any guide, this dark stage will last nearly 18 months, followed by a rapid return to its normal brightness in the first half of 2011.

Earthlike Exoplanet Started Out as Gas Giant
NASA / Goddard Space Flight Center

The most earthlike planet yet found around another star may be the rocky remains of a Saturn-sized gas giant.

“The first planets detected outside our solar system 15 years ago turned out to be enormous gas-giants in very tight orbits around their stars. We call them ‘hot Jupiters,’ and they weren’t what astronomers expected to find,” said Brian Jackson at NASA’s Goddard Space Flight Center in Greenbelt, Md. “Now, we’re beginning to see Earth-sized objects in similar orbits. Could there be a connection?”

Jackson and his colleagues turned to CoRoT-7b, the smallest planet and the most like Earth that astronomers have found to date. Discovered in February 2009 by the Convection, Rotation and Planetary Transits (CoRoT) satellite, CoRoT-7b takes just 20.4 hours to circle its sunlike star.

“CoRoT-7b is almost 60 times closer to its star than Earth, so the star appears almost 360 times larger than the sun does in our sky,” Jackson said. As a consequence, the planet’s surface experiences extreme heating that may reach 3,600 degrees Fahrenheit on the daylight side.

CoRoT-7b’s size (70 percent larger than Earth) and mass (4.8 times Earth’s) indicate that the world is probably made of rocky materials.

“But with such a high dayside temperature, any rocky surface facing the star must be molten, and the planet cannot retain anything more than a tenuous atmosphere, even one of vaporized rock,” Jackson said. He estimates that solar heating may have already cooked off several Earth masses of material from CoRoT-7b.

“There’s a complex interplay between the mass the planet loses and its gravitational pull, which raises tides on the star,” Jackson explained. Those tides gradually change the planet’s orbit, drawing it inward in a process called tidal migration. But closer proximity to the star then increases the mass loss, which in turn slows the rate of orbital change.
Kepler Space Telescope
Discovers its First Exoplanets

NASA

NASA’s Kepler Space Telescope, designed to find Earth-size planets in the habitable zone of sun-like stars, has discovered its first five new exoplanets, or planets beyond our solar system. Kepler’s high sensitivity to both small and large planets enabled the discovery of the exoplanets, named Kepler 4b, 5b, 6b, 7b, and 8b.

“These observations contribute to our understanding of how planetary systems form and evolve from the gas and dust disks that give rise to both the stars and their planets,” said William Borucki of NASA’s Ames Research Center in Moffett Field, Calif. “The discoveries also show that our science instrument is working well. Indications are that Kepler will meet all its science goals.”

Known as “hot Jupiters” because of their high masses and extreme temperatures, the new exoplanets range in size from similar to Neptune to larger than Jupiter. They have orbits ranging from 3.3 to 4.9 days. Estimated temperatures of the planets range from 2,200 to 3,000 degrees Fahrenheit, hotter than molten lava and much too hot for life as we know it. All five of the exoplanets orbit stars hotter and larger than Earth’s sun.

“It’s gratifying to see the first Kepler discoveries rolling off the assembly line,” said Jon Morse, director of the Astrophysics Division at NASA Headquarters in Washington. “We expected Jupiter-size planets in short orbits to be the first planets Kepler could detect. It’s only a matter of time before more Kepler observations lead to smaller planets with longer period orbits, coming closer and closer to the discovery of the first Earth analog.”

Massive Stars: Good Targets for Planet Hunts, Bad Targets for SETI

Harvard-Smithsonian CfA

Most searches for planets around other stars, also known as exoplanets, focus on Sun-like stars. Those searches have proven successful, turning up more than 400 alien worlds. However, Sun-like stars aren’t the only potential homes for planets. New research by astronomers at the Harvard-Smithsonian Center for Astrophysics (CfA) and the National Optical Astronomy Observatory (NOAO) confirms that planet formation is a natural by-product of star formation, even around stars much hotter than the Sun.

“We see evidence of planet formation on fast forward,” said Xavier Koenig of the CfA. Koenig and his colleagues examined the star-forming region named W5, which lies about 6,500 light-years away in the constellation Cassiopeia. They employed NASA’s Spitzer Space Telescope and the ground-based Two Micron All-Sky Survey (2MASS) to look for infrared evidence of dusty planet-forming disks. They targeted over 500 type A and B stars, which are about two to 15 times as massive as the Sun. Sirius and Vega, not included in this study, are two type A stars easily visible to backyard skygazers.

The team found that about one-tenth of the stars examined appear to possess dusty disks. Of those, 15 showed signs of central clearing, which suggests that newborn Jupiter-sized planets are sucking up material. “The gravity of a Jupiter-sized object could easily clear the inner disk out to a radius of 10 to 20 astronomical units, which is what we see,” said Lori Allen of NOAO.

The stars in W5 are only about two to five million years old, yet most have already lost the raw materials needed to form planets. This indicates that, at least for type A and B stars, planets must form quickly or not at all.

This artist’s conception shows a Jupiter-sized planet forming from a disk of dust and gas surrounding a young, massive star. The planet’s gravity has cleared a gap in the disk.

More information
Alien Dust Nothing to Sneeze At
Gemini Observatory

Using the Gemini South telescope in Chile, astronomers at UCLA have found dusty evidence for the formation of young, rocky planets around a star some 500 light years distant. But these potential extrasolar worlds are alien in an even more intriguing way…. In the aftermath of collisions between planetary embryos around this star, the researchers discovered that the dusty debris bears no resemblance to the planetary building blocks of our own Solar System.

“Until now, warm dust found around other stars has been very similar in composition to asteroidal or cometary material in our Solar System,” said Dr. Carl Melis, who led the research while a graduate student at UCLA. “This newly discovered dusty star is a compelling exception.”

The star, known as HD 131488, appears to be surrounded by warm dust in a region called the terrestrial planet zone, where the star heats the dust to temperatures similar to those found on Earth. “What makes HD 131488 truly unique is the unidentified dust species released from the colliding bodies as well as the presence of cold dust far away from the star,” said UCLA professor of physics and astronomy Dr. Benjamin Zuckerman, who is a co-author of the research.

“Typically, dust debris around other stars, or our own Sun, is of the olivine, pyroxene, or silica variety, minerals commonly found on Earth,” said Melis. “The material orbiting HD 131488 is not one of these dust types. We have yet to identify what species it is — it really appears to be a completely alien type of dust.”

Peering Into the Heart of Darkness
NASA / CXC

Astronomers have long known that the supermassive black hole at the center of the Milky Way Galaxy, known as Sagittarius A* (or Sgr A* for short), is a particularly poor eater. The fuel for this black hole comes from powerful winds blown off dozens of massive young stars that are concentrated nearby.

These stars are located a relatively large distance away from Sgr A*, where the gravity of the black hole is weak, and so their high-velocity winds are difficult for the black hole to capture and swallow. Scientists have previously calculated that Sgr A* should consume only about one percent of the fuel carried in the winds.

However, it now appears that Sgr A* consumes even less than expected — ingesting only about one percent of that one percent. Why does it consume so little? The answer may be found in a new theoretical model developed using data from a very deep exposure made by NASA’s Chandra X-ray Observatory.

This model considers the flow of energy between two regions around the black hole: an inner region that is close to the so-called event horizon (the boundary beyond which even light cannot escape), and an outer region that includes the black hole’s fuel source — the young stars — extending up to a million times farther out. Collisions between particles in the hot inner region transfer energy to particles in the cooler outer region via a process called conduction. This, in turn, provides additional outward pressure that makes nearly all of the gas in the outer region flow away from the black hole. The model appears to explain well the extended shape of hot gas detected around Sgr A* in X-rays as well as features seen in other wavelengths.
### Intergalactic Gas Stream Longer than Thought

**NRAO**

A giant stream of gas flowing from neighbor galaxies around our own Milky Way is much longer and older than previously thought, astronomers have discovered.

The first evidence of such a flow, named the Magellanic Stream, was discovered more than 30 years ago. However, the earlier picture showed gaps that left unanswered whether other gas was part of the same system. “We now have answered that question. The stream is continuous,” said David Nidever, of the University of Virginia.

The Magellanic Clouds are the Milky Way’s two nearest neighbor galaxies, about 150,000 to 200,000 light-years distant. They are much smaller than our Galaxy and may have been distorted by its gravity.

Nidever and his colleagues observed the Magellanic Stream for more than 100 hours with the Green Bank Telescope (GBT). They then combined their GBT data with that from earlier studies with other radio telescopes, including the Arecibo telescope in Puerto Rico, the Parkes telescope in Australia, and the Westerbork telescope in the Netherlands. The result shows that the stream is more than 40 percent longer than previously known with certainty.

One consequence of the added length of the gas stream is that it must be older, the astronomers say. They now estimate the age of the stream at 2.5 billion years. “The new age of the stream puts its beginning at about the time when the two Magellanic Clouds may have passed close to each other, triggering massive bursts of star formation,” Nidever explained.

More information

### Astronomers Map Shape of Galactic Dark Matter

**UCLA**

The halo of dark matter surrounding our Milky Way Galaxy is shaped something like a gigantic flattened cosmic beach ball, astronomers announced. This result is important because it is the first time that the three-dimensional shape of an individual dark-matter halo has been conclusively measured.

Dark-matter haloes account for over 70% of the mass in galaxies such as the Milky Way, but this dark matter is invisible; all we see when we look up in the sky is the small amount of stars and gas sitting in the centers of these haloes. So how do astronomers ‘see’ invisible dark matter? It might not be possible to detect it through normal means, but dark matter obeys the laws of gravity and tugs on small dwarf galaxies as they orbit around the Milky Way. By observing the orbits that these dwarf galaxies follow, astronomers can deduce where the dark matter must be using Newton’s law of gravity.

While it would take roughly a billion years to watch a typical dwarf galaxy orbit just once around our home galaxy, dwarf galaxies get shredded by tidal forces as they orbit the much more massive Milky Way and leave stars like bread-crumbs along their path. These stellar breadcrumbs can be traced in huge astronomical surveys such as the Two-Micron All Sky Survey and the Sloan Digital Sky Survey and can therefore be used to infer the orbits of their parent dwarf galaxies.

Using observations of such tidal debris from a dwarf known as the Sagittarius Dwarf Galaxy, astronomers have been able to reconstruct the orbit of Sagittarius and derive models for the Milky Way and its dark-matter halo. These models had met an impasse, however. Different parts of the orbit suggested wildly different solutions. “Until recently,” says Law, “we simply didn’t understand why the Sagittarius stream of stars behaves as it does.”

More information
Astronomers Discover Waltzing Black Holes

Astronomical observations have shown that 1) nearly every galaxy has a central supermassive black hole (with a mass of a million to a billion times the mass of the Sun), and 2) galaxies commonly collide and merge to form new, more massive galaxies. As a consequence of these two observations, a merger between two galaxies should bring two supermassive black holes to the new, more massive galaxy formed from the merger. The two black holes gradually in-spiral toward the center of this galaxy, engaging in a gravitational tug-of-war with the surrounding stars. The result is a black hole dance, choreographed by Newton himself.

Astronomers expect there to be many such waltzing supermassive black holes in the Universe, but until recently only a handful had been found. Dr. Comerford and her colleagues announce the discoveries of 33 new pairs of waltzing supermassive black holes, which help alleviate the discrepancy between the expected and observed numbers of black hole pairs.

By searching for the redshifted and blue-shifted light that is a signature of black hole dances, Dr. Comerford and her colleagues discovered 32 waltzing supermassive black hole pairs in the DEEP2 Galaxy Redshift Survey. The team clocked each black-hole dance at a velocity of a few hundred kilometers per second and in each case measured the distance between the two black hole dancers to be 3,000 light-years. The waltzing black holes are located in galaxies at distances 4 to 7 billion light-years away from Earth (corresponding to redshifts z=0.3 to z=0.8; when the universe was 7 to 10 billion years old).

Team Shines Light on Missing Ordinary Matter

An international team of scientists, led by University of Maryland astronomer Stacy McGaugh, has found that individual galactic objects have less ordinary matter, relative to dark matter, than does the Universe as a whole.

Scientists believe that all ordinary matter, the protons and neutrons that make up people, planets, stars and all that we can see, are a mere fraction — some 17 percent — of the total matter in the Universe. The protons and neutrons of ordinary matter are referred to as baryons in particle physics and cosmology.

The remaining 83 percent apparently is the mysterious “dark matter,” the existence of which is inferred largely from its gravitational pull on visible matter. “Dark matter,” explains McGaugh “is presumed to be some new form of non-baryonic particle — the stuff scientists hope the Large Hadron Collider in CERN will create in high energy collisions between protons.”

McGaugh and his colleagues posed the question of whether the “universal” ratio of baryonic matter to dark matter holds on the scales of individual structures like galaxies.

“One would expect galaxies and clusters of galaxies to be made of the same stuff as the universe as a whole, so if you make an accounting of the normal matter in each object, and its total mass, you ought to get the same 17 percent fraction,” he says. However, our work shows that individual objects have less ordinary matter, relative to dark matter, than you would expect from the cosmic mix; sometimes a lot less!”

Just how much less depends systematically on scale, according to the researchers. The smaller an object the further its ratio of ordinary matter to dark matter is from the cosmic mix. “By the time we reach the smallest dwarf satellite galaxies, the content of normal matter is only ~one percent of what it should be.”
Astronomers Detect Earliest Galaxies
Carnegie Institution for Science

Astronomers, using NASA's Hubble Space Telescope, have broken the distance limit for galaxies by uncovering a primordial population of compact and ultra-blue galaxies that have never been seen before. They are from 13 billion years ago, just 600 to 800 million years after the Big Bang.

The Hubble Ultra Deep Field 2009 team combined the new Hubble data with observations from NASA's Spitzer Space Telescope to estimate the ages and masses of these primordial galaxies. “The masses are just one percent of those of the Milky Way,” explains team member Ivo Labbé of the Carnegie Observatories. He further noted that “to our surprise, the results show that these galaxies existed at 700 million years after the Big Bang and must have started forming stars hundreds of millions of years earlier, pushing back the time of the earliest star formation in the universe.”

Team member Rychard Bouwens of the University of California, Santa Cruz says “the faintest galaxies are now showing signs of linkage to the origin of the first stars. They are so blue that they must be extremely deficient in heavy elements, thus representing a population that has nearly primordial characteristics.”

The results are gleaned from [Hubble] observations, which are deep enough to reveal galaxies at redshifts from z=7 to beyond redshift z=8. (The redshift value “z” is a measure of the stretching of the wavelength or “reddening” of starlight due to the expansion of space.) The clear detection of galaxies between z=7 and z=8.5 corresponds to “look-back times” of approximately 12.9 billion years to 13.1 billion years ago.

More information

Galaxy History Revealed in This Colorful Hubble View
NASA / ESA

More than 12 billion years of cosmic history are shown in an unprecedented, panoramic, full-color view of thousands of galaxies in various stages of assembly. The image, taken by NASA's Hubble Space Telescope, was made from mosaics taken in 2009 with the newly installed Wide Field Camera 3 and in 2004 with the Advanced Camera for Surveys. The view covers a portion of the southern field of a large galaxy census called the Great Observatories Origins Deep Survey, a deep-sky study by several observatories to trace the formation and evolution of galaxies.

Hubble's sharp resolution and new color versatility are allowing astronomers to sort out the various stages of galaxy formation. The image reveals galaxy shapes that appear increasingly chaotic at each earlier epoch, as galaxies grew through accretion, collisions, and mergers. The galaxies range from the mature spirals and ellipticals in the foreground, to smaller, fainter, irregularly shaped galaxies, most of which are farther away, and therefore existed farther back in time. These smaller galaxies are considered the building blocks of the larger galaxies we see today.

The image shows a rich tapestry of 7,500 galaxies stretching back through most of the universe's history. The closest galaxies seen in the foreground emitted their observed light about a billion years ago. The farthest galaxies, a few of the very faint red specks, are seen as they appeared more than 13 billion years ago, or roughly 650 million years after the Big Bang.

The new Hubble view highlights a wide variety of stages in the galaxy assembly process.

More information

A segment of Hubble's panoramic view of thousands of old and young galaxies.
NASA Flight-Tests Unique Jumbo Jet
The Astronomical Society of the Pacific, in partnership with the SETI Institute, will be conducting the Education and Public Outreach Program for SOFIA — the Stratospheric Observatory for Infrared Astronomy.

SOFIA is a modified NASA jumbo jet that will help scientists unlock the origins of the universe with infrared observations. The project reached a milestone when doors covering the plane’s telescope were fully opened in flight. The jet flew for 79 minutes, which included two minutes with the telescope’s doors fully opened. The goal was to allow engineers to understand how air flows in and around the telescope. It was the first time outside air has interacted with the part of the plane that carries the 98-inch infrared telescope.

“[On December 18th] we opened the telescope cavity door, the first time we have fully exposed the telescope and the largest cavity ever flown while in flight,” said Bob Meyer, SOFIA program manager at NASA’s Dryden Flight Research Center in Edwards, Calif. “This is a significant step toward certifying NASA’s next great observatory for future study of the universe.”

Besides these test flights of the airplane, two flights to operate and verify the scientific capabilities of the telescope assembly are planned for spring 2010. Telescope systems such as the vibration isolation system, the inertial stabilization system, and the pointing control system will be tested during daytime flights.

These flights will prepare the telescope assembly for the first flight with the telescope operating. That first flight will be the initial opportunity scientists have to use the telescope and begin the process of quantifying its performance to prepare for SOFIA’s planned 20-year science program.

Travel with the ASP
In conjunction with MWT Associates, the ASP offers two trips to the July 11, 2010, total eclipse of the Sun. The Grand Patagonia Sunset Total Eclipse presents a unique opportunity to see totality in the mountains of Patagonia, the southernmost Argentine continental province. The eclipsed Sun will hover a few degrees above the horizon and holds the promise of a dramatic sunset as totality ends. In the South Pacific, the Expedition to the Marquesas Islands and Tuamotus offers a chance to explore these extraordinary islands. After visiting the Marquesas, our expedition ship, Aramis III, heads to the centerline for eclipse viewing from the Pacific Ocean.

All tours feature an astronomical enrichment program. Revenue from these tours helps support the ASP’s mission and education programs.

2010 ASP Annual Meeting
The 122nd Annual Meeting of the Astronomical Society of the Pacific will be held from July 31 to August 4, 2010, at the University of Colorado at Boulder.

The meeting will include “Cosmos in the Classroom 2010: A Hands-on Symposium on Teaching Introductory Astronomy” and “Making Connections in Education and Public Outreach: A Symposium for Those Working in EPO.”

We will gather for three days (August 2–4) to consider how we can do a better job with the introductory astronomy course and learn from some of the outstanding astronomy professors and instructors in the country. At the same time, everyone working in EPO is invited to a meeting (August 2–4) to consider how best to share the results of their work and improve their practice, to make connections with each other across science disciplines — and with the Astro 101 instructors also in attendance. A set of weekend workshops (July 31 to August 1) for educators will precede the meeting.

Please save the date for a double hands-on meeting for everyone involved in astronomy and space science education! You can sign up to receive more information as it becomes available on the ASP’s meeting webpage.

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NEW MEMBERS — The ASP welcomes new members who joined between October 16 and December 31, 2009.

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The Skies of February

The brightest star in the night skies of Earth is **Sirius**. It’s impossible to miss this month — it is the brilliant, madly twinkling star sweeping low in the south during the evening. Sirius is the brightest star in **Canis Major, the Greater Dog**. In a reasonably dark sky, it is possible to imagine a stick-figure dog outlined by the nearby stars (see the star chart below).

Just below Sirius is the open star cluster **M41**. It’s often overlooked but is easily found in binoculars if you aim first at Sirius, and then slowly drop your gaze southward. Even in light-polluted skies, the half dozen brightest stars in this cluster shine through.

Pure-white Sirius has been the focus of stories and legends for more than 5,000 years. Three thousand years ago the Egyptians called it the Dog Star and blamed it for joining with the Sun in August to produce excessive heat and the “dog days of summer.”

Bright, red **Mars** is up in the east after sunset. It’s reasonably close to the bright stars Castor and Pollux (in Gemini, the Twins), but its fiery red color makes it easy to identify. The red planet begins the month almost as bright as Sirius, which is near the southern horizon (to the far lower-right of Mars). But by month’s end, Mars has definitely faded. On the 25th, the Moon sits below the red planet.

Giant **Jupiter** begins the month very low in the west-southwest after sunset and sets about 90 minutes later. By month’s end, it’s too close to the Sun to be seen.

But if you’re up for a challenge of Jovian proportions, head outside at sunset on the 16th. Find a spot with a clear and low western horizon. Roughly 15 minutes after sunset, use binoculars to look for Jupiter next to bright **Venus** in the twilight sky. At this time the planetary pair is a mere 5° above the horizon! A two-day-old crescent Moon sits 20° (that’s the width of two fists stacked one on top of the other and held out at arm’s length) directly above them. Good luck! Venus remains a challenge to find during the rest of the month, rising low in the west after sunset.

**Saturn** rises during mid-evening. In 2010 Saturn’s rings slowly close (as seen from Earth) until late May, when they’re inclined a mere 1.67° to our line of sight. After that, their inclination opens rapidly until by year’s end, they’re tipped by slightly more than 10°. The Moon is to Saturn’s upper right as they both rise on the 1st; to Saturn’s lower right on the 2nd.

**Mercury** begins the month low in the southeast as dawn brightens, but it disappears as the month progresses. You’ll need binoculars to spot Mercury, and the thin crescent Moon to its upper right, on the morning of the 11th.

The Skies of March

High in the south these March evenings is a well-named constellation. **Gemini, the Twins**, contains a pair of bright stars that, at first glance, appear twin-like. **Pollux** (the leftmost) is slightly brighter and a bit more colorful; **Castor** (the rightmost) is marginally dimmer and a bit whiter.

The difference in color is obvious in binoculars. In even a small telescope, an additional difference is revealed: Castor is a superb double star. In her book *Double Stars for Small Telescopes* (Sky Publishing), Sissy Haas describes Castor seen through a small (60-mm) telescope as: “A stunning pair of brilliant stars, lemon white in color, that are just kissing at 65x.” Castor is actually a triple star, but the third component is quite faint.

But if you look at a star atlas, you’ll note that Castor is designated as the Alpha star and Pollux the Beta. Some 400 years ago, when astronomer Johannes Bayer used Greek letters to name the brightest stars, Castor was designated Alpha Geminorum, despite being the (slightly) fainter of the two. The designation stuck.

Castor and Pollux are the names of twin brothers in Greek and Roman mythology, and the stars mark their heads. If you look at the chart on the next page, you’ll see their stick-figure bodies extend down toward Orion.

Just above the tip of Castor’s elongated western foot is **M35**, an open cluster that’s a nice sight in binoculars. If you gaze at it with a small telescope in a moderately dark sky, you may spot **NGC 2158**, a distant open cluster that looks like a dim, small, hazy glow attached to the southwestern edge of M35.

**Venus** is gradually climbing higher into the western sky after sunset, but its progress is slow. At mid-month, it’s less than 10° high
30 minutes after sunset, so to easily see it you’ll need a flat, low, and clear western horizon. On the 16th, a thin crescent Moon hovers some 10° above this brilliant planet.

**Mercury** is hidden in the solar glare for most of March, but it emerges right at month’s end. During the final few days of March, it’ll appear to Venus’s lower right after sunset.

The red planet **Mars** is blazing away in Cancer, the Crab — a region of the sky full of dim stars. This makes it easy to spot high in the south after sunset. See April’s star chart for the path of Mars through Cancer and past the open cluster M44, the Beehive star cluster. The Moon passes well beneath the red planet on the 24th and 25th.

In the east, **Saturn** is now rising as the Sun sets. The nearly full Moon is to Saturn’s right on the 1st and again on the 28th. Don’t mistake Saturn for Spica, the brightest star in Virgo, the Maiden. Although both look to be about the same brightness, Spica is to Saturn’s east. The Moon can help confirm which is which — this month it’s above Spica on the 2nd and beside it on the 30th.

**Jupiter** is lost in the Sun’s glare this month.

### The Skies of April

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

If you can never find the faint springtime constellation of **Cancer, the Crab**, this April is as good a time as any. That’s because Cancer has a visitor — the red planet **Mars**.

All month long, Mars slides through the constellation, slowly shifting position, night-by-night, from west to east. During the nights of April 15, 16, and 17, use binoculars to see ruddy Mars pass slightly more than 1° north of the center of the Beehive star cluster, also known as the Praesepe or M44.

Once you’ve used Mars to find Cancer, take a wider view of the sky and look for signpost stars to help you find this little constellation in future. Cancer lies roughly half way between Gemini, the Twins, and Leo, the Lion. So if you find the bright stellar pair **Castor** and **Pollux** (in Gemini) in the southwest, and brilliant **Regulus** (in Leo) high in the south, you’ll note that Cancer is nicely positioned between them. Use the chart above to help you locate all these celestial sights.

Mars moves rapidly, and as you contemplate the nearby bright stars, realize that Mars will pass Regulus in early June.

**Mercury** puts on a lovely show during the first two weeks of the month. At the start of April it pops out from the sunset glow just to the lower right of brilliant **Venus**. (Both are low in the west.) After the 8th, Mercury slowly sinks back toward the horizon while Venus slowly climbs higher. On the 15th a very thin crescent Moon some 18 hours old will hover just above Mercury — but you’ll need a clear, flat, and low western horizon to catch the sight. The next evening the Moon is near Venus.

As mentioned earlier, Mars is in Cancer this month. Although it’s dimmer than it was in March, its ruddy glow in a region devoid of bright stars makes it easy to spot. The first quarter Moon hangs below the red planet on the 21st.

**Saturn** shines high in the southeast after sunset. The Moon is nearly on the 24th and 25th. **Jupiter** emerges in the east before dawn as the lone planet in the morning sky. The crescent Moon stands nicely above the giant planet before sunrise on the 11th.

The **Lyrid meteor shower** peaks during the morning hours of the 22nd. It’s not a strong shower, and you’ll have to wait until after midnight on the 21st/22nd (after the Moon sets) to spot the meteors. If you have a reasonably dark observing site, you’ll see roughly 15 to 20 meteors per hour in the predawn sky. This is one meteor shower that’s best seen in the Southern Hemisphere.

For more information about meteor showers and the dates of upcoming showers, see Sky & Telescope’s webpage “**Meteor Showers in 2010**.”

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**Sky sights**

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### Sky Map

- **Canis Minor**
- **Cancer**
- **Gemini**
- **Procyon**
- **Regulus**
- **Leo**
- **Mars**
- **Castor**
- **Pollux**
- **Voyager / Carina Software**
- **Sky & Telescope’s April 2010 Sky Chart**
- **How to use S&T’s Interactive Sky Chart**
Using Sky & Telescope's Interactive Sky Chart

Thanks to Sky & Telescope magazine, Mercury readers have direct access to S&T's online Interactive Sky Chart. While anyone can go to it on Sky's website, registration is required to load and use the charts. Registration is free and has some advantages, but it's not necessary for ASP members who just want to retrieve the monthly star chart.

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

Using the Chart: The Basics

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

For instance, when you click on the link for the February Sky Chart, you should see, in a new window, a screen that looks like the image above. Each of the monthly links in Sky Sights will take you to a chart set for 40° north latitude and 100° west longitude (so it's useful throughout the continental US) at 9 pm local time at mid-month in February and March, and 10 pm in April. The chart can be used one hour later at the start of each month and one hour earlier at month-end.

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

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

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

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

Changing the Chart

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

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

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

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

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

Tech Talk

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

If you have trouble getting the Sky Chart to open on your computer, please review Sky's detailed system requirements to check whether you're using a supported operating system. And don't forget to also review the Help page.
In the recent blockbuster *Avatar*, humans visit the habitable — and inhabited — alien moon called Pandora. Life-bearing moons like Pandora or the *Star Wars* forest moon of Endor are a staple of science fiction. With NASA's Kepler mission showing the potential to detect Earth-sized objects, habitable moons may soon become science fact. If we find them nearby, a new paper by Smithsonian astronomer Lisa Kaltenegger shows that the James Webb Space Telescope (JWST) will be able to study their atmospheres and detect key gases like carbon dioxide, oxygen, and water vapor.

"If Pandora existed, we potentially could detect it and study its atmosphere in the next decade," said Lisa Kaltenegger of the Harvard-Smithsonian Center for Astrophysics (CfA).

So far, planet searches have spotted hundreds of Jupiter-sized objects in a range of orbits. Gas giants, while easier to detect, could not serve as homes for life as we know it. However, scientists have speculated whether a rocky moon orbiting a gas giant could be life-friendly, if that planet orbited within the star's habitable zone (the region warm enough for liquid water to exist). "All of the gas giant planets in our solar system have rocky and icy moons," said Kaltenegger. "That raises the possibility that alien Jupiters will also have moons. Some of those may be Earth-sized and able to hold onto an atmosphere."

Kepler looks for planets that cross in front of their host stars, which creates a mini-eclipse and dims the star by a small but detectable amount. Such a transit lasts only hours and requires exact alignment of star and planet along our line of sight. Kepler will examine thousands of stars to find a few with transiting worlds.

Once they have found an alien Jupiter, astronomers can look for orbiting moons, or exomoons. A moon's gravity would tug on the planet and either speed or slow its transit, depending on whether the moon leads or trails the planet. The resulting transit duration variations would indicate the moon's existence.

Once a moon is found, the next obvious question would be: Does it have an atmosphere? If it does, those gases will absorb a fraction of the star's light during the transit, leaving a tiny, telltale fingerprint to the atmosphere's composition. The signal is strongest for large worlds with hot, puffy atmospheres, but an Earth-sized moon could be studied if conditions are just right. For example, the separation of moon and planet needs to be large enough that we could catch just the moon in transit, while its planet is off to one side of the star.

Kaltenegger calculated what conditions are best for examining the atmospheres of alien moons. She found that Alpha Centauri A, the system featured in *Avatar*, would be an excellent target. "Alpha Centauri A is a bright, nearby star very similar to our Sun, so it gives us a strong signal," Kaltenegger explained. "You would only need a handful of transits to find water, oxygen, carbon dioxide, and methane on an Earth-like moon such as Pandora."

While Alpha Centauri A offers tantalizing possibilities, small, dim, red dwarf stars are better targets in the hunt for habitable planets or moons. The habitable zone for a red dwarf is closer to the star, which increases the probability of a transit.

Astronomers have debated whether tidal locking could be a problem for red dwarfs. A planet close enough to be in the habitable zone would also be close enough for the star's gravity to slow it until one side always faces the star. (The same process keeps one side of the Moon always facing Earth.) One side of the planet then would be baked in constant sunlight, while the other side would freeze in constant darkness.

An exomoon in the habitable zone wouldn't face this dilemma. The moon would be tidally locked to its planet, not to the star, and therefore would have regular day-night cycles just like Earth. Its atmosphere would moderate temperatures, and plant life would have a source of energy moon-wide.

"Alien moons orbiting gas giant planets may be more likely to be habitable than tidally locked Earth-sized planets or super-Earths," said Kaltenegger. "We should certainly keep them in mind as we work toward the ultimate goal of finding alien life."