Join Us for the ASP’s New 2016 Awards Gala
October 22, 2016,
Embassy Suites, Burlingame, CA

This year, we’re establishing a new tradition, replacing our annual February dinner with a brand new event that will showcase our exciting projects and celebrate the distinguished recipients of our Annual Awards.

Join us for a gourmet reception and sit-down dinner as we honor eight incredible individuals who have made significant contributions to amateur and professional astronomy research, instrumentation, education, and outreach.

Among the evening’s highlights will be the presentation of the Catherine Wolfe Bruce Gold Medal. Awarded since 1898 to a professional astronomer in appreciation of lifetime achievement, the Bruce Medal is recognized as one of the most prestigious awards in astronomy.

Watch for an announcement with more details coming this summer.
ASP’s Statement on Harassment and Commitment to Diversity and Inclusion

New Horizons and the Exploration of the Pluto System
ALAN STERN
For all of us who worked on New Horizons, the flyby of Pluto was an unbelievable experience of scientific discovery.

Mars in 2016: A Close Approach
PAUL DEANS
Don’t miss bright Mars, now appearing in our spring and early summer sky.

Touring to Totality in 2017
PAUL DEANS
Even if the eclipse is in your own back yard, joining a tour to totality in 2017 has certain benefits.

Astronomy in the News
Explaining the sustained eruptions on Enceladus, longest-lasting stellar eclipse discovered, and the first discovery of a binary companion for a Type Ia supernova. These are some of the discoveries that recently made news in the astronomical community.

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on the cover

Front: While residents of islands and nations in the Western Pacific looked up in the early morning hours to observe a total eclipse of the Sun, the Deep Space Climate Observatory (DSCOVR) looked down from space and captured the shadow of the Moon marching across Earth’s sunlit face. An explanation, animation, and series of stills are here. Courtesy the DSCOVR EPIC team.

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A Fool for Planets

Decades ago, when I first started observing (from my suburban backyard with my little 60-mm refractor), the Moon and the bright planets were all I could easily see. But it was just my luck that the exploration of the planets by spacecraft was kicking into high gear at the same time. I devoured the images snapped by the Mariners and Vikings at Mars and later the Voyager probes to the outer planets.

So I’ve always had a “thing” for planets. Perhaps this is why I was so taken by the results, discussed at the recent Lunar and Planetary Science Conference (LPSC), from New Horizons at Pluto and Dawn at Ceres. And I’m delighted to be able to provide an edited excerpt of Alan Stern’s LPSC Masursky lecture (page 20) about Pluto and Charon for Mercury readers. (Stern is the Principal Investigator for New Horizons.)

Then there are times when I simply parse through the incredible data banks of planetary images now available — Mercury, Mars, Saturn, now Ceres and Pluto. Occasionally I stumble across a gem that I’ve not seen before. This image of Helene, one of two Trojan moons of Saturn’s large moon Dione, is one such find.

The leading hemisphere of Helene (21 miles/33 km across) is lit; north is up. This high-res view of Dione’s leading Trojan moon reveals gullies and apparent dust flows but few craters. There are more images of this unusual moon here. [NASA/JPL-Caltech/Space Science Institute]

And once again I’m struck by how, in a mere 50 years, the planets and their satellites have gone from points of light to distinct worlds, each with a unique identity.
Harassment, Diversity, and Inclusion at the ASP

The ASP’s Statement on Harassment and Commitment to Diversity and Inclusion.

Over the last several months, the astronomy community has been rocked by the revelations of very serious cases of sexual harassment against women at several institutions. Equally disturbing was the discovery that these behaviors had gone unchecked at universities for decades. Serious questions were raised concerning who knew about it, how and why this behavior was tolerated for so long, and whether the profession has the right mechanisms in place to address sexual harassment swiftly and meaningfully.

Horrendous emotional damage has been done to women directly affected by sexual harassment and scores of female astronomers have left the field because of what they experienced or witnessed. Internationally respected science and news outlets such as Nature, The New York Times, and The Washington Post have pronounced: “Astronomy’s Snowballing Sexual Harassment Scandal Picks Up Even More Cases,” “Stories Spill Out as Spotlight Is Shined on Sexism in Astronomy,” and “Astronomy Roiled Again By Sexual-Harassment Allegations.” These are hardly headlines that encourage girls and young women to pursue astronomy as a career.

Formal statements have been made by professional societies such as the American Astronomical Society, Royal Astronomical Society, and others strongly denouncing sexual harassment and reaffirming institutional commitments to create safe and inclusive work and learning environments. The ASP now adds its voice to condemn harassment, support victims, and promote a culture of inclusion.

The ASP Board of Directors and staff continues to strongly condemn harassment based on gender, gender identity, sexual preference, race, ethnicity, age, religious beliefs, or disability. We affirm our commitment to diversity, inclusion, and equity, and commit ourselves to promoting change through education.

The ASP also announces several proactive initiatives designed to promote equity and inclusion. More than any other organization, the ASP is uniquely positioned, holds the reputation, and possesses the skills needed to educate the astronomy community. Ending sexual harassment requires a multipronged approach focusing on the beliefs and behavior of individuals, organizations, and systems. We are the trusted organization that the entire astronomy community looks to when it needs to access the very best in educational materials, resources, and training. Through existing ASP programs and initiatives — Astronomy Ambassadors, My Sky Tonight, ASP Teacher Learning Center — we can do a great deal to promote equity and inclusion.

On behalf of the ASP Board, Staff, and all the astronomy enthusiasts our programs serve, thank you for your continued support of our work. Together we will ensure that the excitement of astronomy is available to all.

LINDA SHORE is the Executive Director of the Astronomical Society of the Pacific.
Villum Lange is a name sunk in obscurity for more than 300 years, but research published this year has ‘resurrected’ his work. I use that word deliberately as his only book deals with certain dates on the Christian calendar that immediately precede the Resurrection.

From 1647 to 1651 Georgius Frommius (1605–51) was professor of astronomy at Copenhagen University. He succeeded Christen Longomontanus, the first director of the Round Tower observatory in Copenhagen, who is most famous as the assistant of Tycho Brahe. Thus, when Lange took over from Frommius in 1651, he was the standard bearer of the most important astronomical tradition in Europe at the time. He held the top astronomy post in Copenhagen for 31 years.

His Latinized name was Gulielmus Langius, and he lived from 1624 to 1682. From 1646 to 1650 he went on a study tour that took him to the main centers of learning including Oxford, Paris, and Leiden, which is where he published a book in 1649 (more on that later). In 1650 he was appointed professor of mathematics at Copenhagen University but almost immediately left for Vienna. He then continued his grand intellectual tour of Europe, visiting Leipzig (1650), Padua (1651), and Florence (1652).

After his studies in Italy, Lange traveled through the Low Countries, and he wrote Johannes Hevelius on October 3, 1652: “As I was in Leiden I borrowed your book [Selenographia] from a young Danziger and read it through in 4 days.” Lange was impressed with the book, imploiring Hevelius to “continue to make your hometown famous.” Selenographia, published in 1647, has earned Hevelius the title of the founder of lunar topography. It was in 1652, the year Lange wrote to him, that Hevelius discovered the first of his four comets.

Back in Copenhagen at last, Lange presided over the first recorded observation from the Round Tower — a lunar eclipse, on March 13, 1653. It seems he did little observational work, as his career took another path. By 1661 he was a High Court judge in Jutland, far from the capital of Copenhagen.

It was actually before he took over in Copenhagen in 1651 that Lange made his mark in astronomy. A theory of the first lunar
visibility is at the heart of the Jewish calendar, so it is by its very nature an astronomical problem. In 1649, Lange wrote a book titled *De Annis Christi* which came to the attention of Isaac Newton. By dint of this book, Lange became Newton's first mentor on the subject of the Jewish calendar, but this was unknown until a discovery published in 2008 by Ari Belenkiy and Eduardo Vila Echague, two historians of mathematical astronomy.

Lange's 1649 book attempted to establish a date for the Passion. He rejected dates given by two other scholars who had neglected the issue of lunar visibility. Lange relied on a book about the Jewish calendar that had been published in 1644 by John Selden, which gave texts from two Jewish religious movements. Lange incorrectly identified one of these, the Karaites, with the first-century Sadducees. The Karaites ruled that new Moon visibility occasionally allowed for the month to start a day earlier, so Lange identified the date on the Last Supper as Thursday April 2, 33 AD, one day earlier than officially announced by the Jewish authorities of the time.

Newton became interested in all this as a young man and it stayed with him his whole life. Initially, Newton agreed with Lange on two basic elements. They both believed the Last Supper happened on the eve of the official Jewish lunar month known as Nisan, and Newton accepted Lange's belief the Sadducees were guilty of a double standard as they celebrated Passover a day earlier than mainstream Judaism. But ultimately he rejected Lange's conclusions and formulated his own insight into the question of first lunar visibility.

CLIFFORD J. CUNNINGHAM'S latest book, *Early Investigations of Ceres, and the Discovery of Pallas*, will be published by Springer in May. It is the second of four books in a series on early asteroid studies.

**Type Ia Supernovae: Progenitors and Host Galaxies**

Two recent studies try to close some gaps in our knowledge of these important standard candles.

The accelerating universe phenomenon, and concomitantly dark energy theory, rely on the use of Type Ia supernovae (SNe Ia) as cosmological standard candles. However, we do not yet have a good grasp on the nature of their progenitor systems.

It is generally agreed that SNe Ia progenitors are binary systems containing at least one white dwarf star. In the single degenerate (SD) scenario, the companion is a non-degenerate star (e.g. a main sequence or red giant star) that “dumps” excess mass onto the white dwarf, pushing it over the 1.4 solar mass Chandrasekhar limit resulting in a massive explosion. In this scenario, the non-degenerate companion is expected to survive. In the double degenerate (DD) scenario, the companion is another white dwarf star, and the explosion occurs when the two stars merge.

Since both progenitor components are too faint for direct imaging with current optical telescopes, it is not surprising that no surviving companion stars have been detected in any SNe Ia remnant to
date. One proposed way to distinguish between the two models is to examine the interaction of the ejected mass from the explosion with the circumstellar matter from the progenitor system. In a recent paper, a team at Harvard developed a model for circumstellar interactions and found that the SD scenario would produce decreasing x-ray and radio flux over time, while the opposite is true in the DD scenario.

The Harvard team examined x-ray and radio data from G1.9+0.3, the youngest known SNe Ia remnant in the Milky Way (page 46) and found that its decades-long rise in flux and increase in size is consistent with a DD progenitor system. They proposed a new diagnostic called the “surface brightness index” that can be computed from theory and compared with observed flux and size evolution with time. Recent upgrades to major radio observatories should allow astronomers to examine nearby historical Type Ia supernova and finally determine the nature of their progenitor systems.

Another unresolved question is the evolution of SNe Ia over cosmological timescales. The SNe Ia standard candle method was calibrated using supernovae in the local universe, in galaxies with chemical compositions very similar to our Sun. But Type Ia supernovae in distant (older) galaxies would have very different chemical compositions. In astrophysics, elements other than hydrogen and helium are “metals” and the “metallicity” of the universe has increased over time due to stellar nucleosynthesis. According to theory, the peak luminosity of a supernovae directly depends on progenitor metallicity. So it is expected that SNe Ia located in higher redshift galaxies might be dimmer than those with lower redshift.

An international group examined the dependence of SNe Ia luminosities as a function of host galaxy metallicity. Their study examined 28 SNe Ia host galaxies in the local universe. They selected host galaxies that are not in the Hubble flow and with known distances determined by a method other than Type Ia supernovae data. Using optical spectra obtained with the William Herschel Telescope, the group obtained oxygen abundances in regions near the individual Type Ia supernovae.

Using apparent magnitudes of the SNe Ia in the maximum of their light curves from literature and known distances to host galaxies, they computed the absolute magnitude of each SNe Ia. Plotting SNe Ia absolute magnitude as a function of oxygen abundance, the group found that metal-rich galaxies host fainter SNe Ia. The Type Ia supernovae distance method was calibrated assuming that all SNe Ia in the local sample have the same peak luminosity, which appears not to be the case. The group compared distances to their sample galaxies using different methods and determined that the SNe Ia technique in its current form results in higher maximum luminosities and, therefore, higher distances than those derived using Cepheid variables or the Tully-Fisher method. If their results hold, then there is likely a systematic error in the SNe Ia standard candle method used for cosmological distance determination.

JENNIFER BIRRIEL is Professor of Physics in the Department of Mathematics and Physics at Morehead State University in KY.
This March, NASA’s Dawn mission celebrated one year in orbit around Ceres, one of the solar system’s dwarf planets (along with Pluto, Eris, Makemake, and Haumea) and the largest object in the asteroid belt. Dawn has been a mission of many firsts. It is the first spacecraft to ever orbit two different solar system objects, a feat made possible by its first-of-a-kind ion engine. Dawn’s first stop was Vesta, an asteroid that it reached in 2011. After 14 months in orbit, it departed for its two-year journey to Ceres.

Since reaching the dwarf planet, the probe has completed more than 300 orbits, orbits that grew progressively tighter as it spiraled down toward the surface. Initially it took Dawn weeks to complete one trip around Ceres. But at its current 240-mile altitude (which it reached December 7, 2015), an orbit now takes only 5.5 hours, which means Dawn has been able to photograph 99.6% of the surface of Ceres from closer than the International Space Station is to Earth.

There have been many discoveries made during this past year, but two highlights have been Ahuna Mons and Occator Crater.

Ahuna Mons was a surprise. The three-mile-high mountain was first observed before Dawn entered orbit, showing up as a bump on the dwarf planet’s limb from 29,000 miles away. It is by far the largest peak on Ceres, with sides streaked in some areas by bright material (we don’t know yet if this material is the same as the bright spots in Occator). The big mystery of Ahuna Mons is that common mountain-forming processes are not found on Ceres — there are no volcanoes to generate peaks from eruptions or lava flows (though cryovolcanism — eruptions of water or ammonia — is a possibility) or tectonic plates to force the crust upward. We have yet to figure out what created the peak.

Occator was visible from the Hubble Space Telescope as a bright
area on the surface of Ceres. As Dawn approached, the “area” was resolved into at least 10 individual spots of material that are much more reflective than the rest of the terrain. There are other splotches of brightness located on the dwarf planet, but Occator is home to the brightest of them. Currently, evidence suggests that the bright spots are composed of hexahydrate, a type of magnesium salt. One possibility is that the impact that created the crater exposed a subsurface layer of water ice, which then evaporated, leaving the salt behind.

In the eight years since Dawn left Earth, it has fulfilled all of its planned objectives and more. The primary mission is scheduled to end on June 30, 2016, and while there is a possibility of an extension, even that extra funding can’t replenish the spacecraft’s diminishing supplies of hydrazine. Hydrazine is the fuel used by Dawn’s attitude control thrusters, which have seen more use than expected due to the failure of two of the spacecraft’s four reaction wheels. Without the wheels to stabilize the probe, Dawn’s team has been using tiny thruster firings to control its orbit. This creative approach will allow it to complete its planned primary mission. But even the most optimistic estimates have fuel running dry in early 2017.

After that, Dawn is expected to remain in perpetual orbit around Ceres, traveling with the dwarf planet as it circles the Sun. Even after the probe goes dark, however, there will be years of work for us on Earth, learning all we can from the remarkable data it has sent home.

EMILY JOSEPH is a Research Assistant (with an emphasis on Mars studies) at the Planetary Science Institute, and is part-time on the VIMS operations team for the Cassini mission at the University of Arizona Lunar and Planetary Lab. You can find her on Twitter @EmExAstris.
The Aliens Are Silent Because They Are Extinct

This possibility goes to the question of why we haven’t been contacted by aliens.

Life on other planets would likely be brief and become extinct very quickly, say astrobiologists from ANU Research School of Earth Sciences. In research aiming to understand how life might develop, the scientists realized new life would commonly die out due to runaway heating or cooling on their fledgling planets.

“The universe is probably filled with habitable planets, so many scientists think it should be teeming with aliens,” said Dr. Aditya Chopra, lead author on the paper, which is published in Astrobiology. “Early life is fragile, so we believe it rarely evolves quickly enough to survive.”

“Most early planetary environments are unstable. To produce a habitable planet, life forms need to regulate greenhouse gases such as water and carbon dioxide to keep surface temperatures stable.”

About four billion years ago Earth, Venus, and Mars may have all been habitable. However, a billion years or so after formation, Venus turned into a hothouse and Mars froze into an icebox. Early microbial life on Venus and Mars, if there was any, failed to stabilise the rapidly changing environment, said co-author Associate Professor Charley Lineweaver from the ANU Planetary Science Institute. “Life on Earth probably played a leading role in stabilising the planet’s climate,” he said.

Dr. Chopra said their theory solved a puzzle. “The mystery of why we haven’t yet found signs of aliens may have less to do with the likelihood of the origin of life or intelligence and have more to do with the rarity of the rapid emergence of biological regulation of feedback cycles on planetary surfaces,” he said.

Wet, rocky planets, with the ingredients and energy sources required for life, seem to be ubiquitous. However, as physicist Enrico Fermi pointed out in 1950, no signs of surviving extraterrestrial life have been found. A plausible solution to Fermi’s paradox, say the researchers, is near universal early extinction, which they have named the Gaian Bottleneck.

“One intriguing prediction of the Gaian Bottleneck model is that the vast majority of fossils in the universe will be from extinct microbial life, not from multicellular species such as dinosaurs or humanoids that take billions of years to evolve,” said Lineweaver. A PDF copy of the paper can be downloaded here.
Catch a (Gravitational) Wave and You’re Sitting on Top of the World

The improbable history and propitious future of gravitational wave astronomy.

It was a ripple in spacetime tinier than a picometer. But it shook the world nonetheless.

I’m writing, of course, about the gravitational waves detected by researchers using the Laser Interferometer Gravitational-Wave Observatory (LIGO), announced in February 2016 at the headquarters of the National Science Foundation near Washington, DC. (In case you missed it, here is a NSF LIGO special report page.)

These were the faint, passing signals of two colliding black holes more than one billion light-years away: the first direct detection of gravitational waves; the first direct proof of stellar-mass black holes greater than 25 solar masses; and the first proof that black holes can merge within a timescale we can observe.

As such, the LIGO observation may go down as the astronomy achievement of the decade — a classic tale of crazy theory, crazy experimentation, budgetary intrigue, and well-deserved satisfaction.

Crazy Theory?

That’s Albert Einstein’s general relativity, published in 1915. By 1916, coincidentally almost exactly 100 years before the LIGO detection, Einstein conjectured that all of our movements create a tiny ripple in the fabric of space and time, distorting space like a pebble thrown into a pond. Yet these fantastical ripples, he said, would be far too subtle to detect.

The waves move at light speed and stretch and compress all that they pass through. The more massive the object, the bigger the
waves. There are, in fact, equations courtesy of Einstein predicting the frequency and intensity of these waves. So, with an instrument capable of sensing a distortion of about the width of an atomic nuclei — above all the background noise on a seismically active Earth! — one could, in theory, detect the waves produced by merging black holes or pulsars. And that’s just what LIGO did.

Crazy Experimentation?
In the early 1960s, Russian physicists M.E. Gertsenshtein and V.I. Pustovoit sketched out an optical experiment to detect the waves, but the constraints were so extreme that their paper was greeted as science fiction. American physicist Joseph Weber began working on detection by the mid-1960s with his now-infamous “Weber bars,” aluminum cylinders “tuned” to the gravitational wave frequency expected from pulsars. Weber claimed detection in the early 1970s and maintained that stance till his death in 2000. But the community vigorously rejected these claims, pointing to numerous errors in instrument design and data analysis.

Based loosely on the Gertsenshtein and Pustovoit concept, LIGO is an L-shaped interferometer using lasers to precisely measure the distance of objects placed at the end of perpendicular tunnels. A passing gravitational wave, stretching and contracting the Earth, alters the distance from the center of the “L” to one object and then the other. But the devil is in the details, and LIGO took decades to conceive. At issue was how to control background noise — seismic activity, or even a passing truck — that would jostle the objects far more than a gravitational wave ever could. LIGO would need to be the most sensitive experiment ever built.

Budgetary Intrigue?
Not surprising, the US Congress didn’t buy the idea, and LIGO lingered...
for years without prospect of funding. But LIGO’s scientific leaders may have fudged the numbers a bit to pitch LIGO as an experiment that would likely detect gravitational waves, knowing quite well it wouldn’t, according to several scientists who spoke to me off the record. Their goal was to build LIGO as a steppingstone to a more advanced system, using knowledge gained from the de facto prototype to petition for more funds to the “real” experiment.

And that’s just what happened. The first version of LIGO, with interferometers in Livingston, Louisiana, and Hanford, Washington, ran from 2002 to 2010 and detected nothing (to no one’s surprise). LIGO shut down for a few years while enhanced detectors were built, funded by the NSF for an additional $200 million. LIGO opened for business in September 2015 and, bang, almost instantly detected its first gravitational wave. The exact pattern of waves passed through the Louisiana detectors and then the Washington detectors 0.007 seconds later, at light-speed.

Well-deserved Satisfaction?
Someone will be getting the Nobel Prize for this, but who? Note that Russell Hulse and Joseph Taylor already won a 1993 Nobel Prize in Physics for their 1974 discovery of the orbital decay of binary pulsars, which was solid, indirect evidence of gravitational waves.

Most scientists feel that, if anyone gets the Prize, it would be Rainer Weiss, the MIT physicist who conceived the LIGO experiment. Also on the shortlist is Kip Thorne, the Caltech theorist and experimentalist who championed the project. Ronald Drever, also of Caltech and a LIGO co-founder, is a third. Weiss and Thorne, quite elated, led the NSF press conference on the discovery. Drever would have been there, they said, but he suffers from dementia. It’s worth noting that Thorne called the much-maligned Joseph Weber the father of gravitational wave experimentation.

Now What?
Well, the figurative window is wide open. Scientists now have an entirely new way of observing the universe that complements information gleaned from electromagnetic radiation. LIGO is expecting several detections per year. Sources include supernovae, merging neutron stars, and stellar-mass black holes. More detectors are planned for India and Europe, which would enable scientists to pinpoint the detection for follow-up observations with “traditional” telescopes.

LISA, the Laser Interferometer Space Antenna, once a crazy idea, is back on the drawing board as eLISA, with the “e” standing for “evolved.” This observatory comprises three free-falling test masses in space, arranged in an equilateral triangle separated by million-kilometer-long arms. eLISA would be sensitive to the frequencies of very distant supermassive black hole mergers and binary stars in the Milky Way galaxy. LISA Pathfinder launched in December 2015 and, with a version of eLISA truncated to about 40 centimeters, is testing the technology as of March 2016.

So, this is just the beginning. With the necessary sensitivity, scientists could detect the primordial gravitational waves from the big bang itself, the creation of the universe, hundreds of thousands of years before observable light. Indeed, they have their sights set on that with an advanced version of LISA.

All this excitement stemming from a picometer-size wave first detected in rural Louisiana. Talk about a ripple effect! ☮

CHRISTOPHER WANJEK is a Baltimore-based science writer convinced he felt the wave 0.0001 second before LIGO.
Thinking About Space

The WorldWide Telescope helps create a virtual environment for learners.

The advent of the personal computer and the World Wide Web revolutionized the way we interact with each other and information about, well…about everything. A cliché, without a doubt. From an educational standpoint, these virtual interactions have yet to fulfill their promise, with many of them little more than novelties and games. Computers have provided innovative means to collect and analyze data in the classroom, access data online, and change the parameters in simulations to better understand the relationships between variables.

A common limitation of these activities is the learner remains passive, observing what is taking place, or simply acquiring information. It is the rare program or website that truly provides a dynamic environment for learners to actively engage in manipulating a scenario and making sense out of phenomena. Desktop planetarium software does provide the ability to navigate through space and time with relative ease. However, in many ways it is more suited to acquiring data for historic or future astronomical events.

The folks at the Harvard-Smithsonian Center for Astrophysics (CfA) are out to change this. They’re creating a virtual environment for learners to engage in inquiry about a variety of astronomical phenomena through the WorldWide Telescope (WWT), an astronomy visualization program created by Microsoft Research and now an open source program hosted by the American Astronomical Society.

For a number of years, the WWT Ambassadors team, led by Alyssa Goodman and Patricia Udomprasert, has tested the efficacy of WWT as a platform for inquiry. An NSF EAGER grant allowed them to collect data to demonstrate its potential, resulting in a larger DRK-12 development grant to produce a series of modules utilizing guided inquiry to teach about astronomical phenomena and spatial thinking.

One finding from their initial research is how the WWT as a learning tool is particularly effective when combined with activities where learners physically manipulate objects to model the phenomena they are investigating in the WWT. It turns out the learners develop a more accurate and durable mental model of the phenomena when using both tools together than with either in isolation.

This has some profound implications for education in general, particularly when it comes to providing opportunities for learners to develop their spatial thinking. Co-Principal Investigator Julia Plummer (Pennsylvania State University) of the DRK-12 project says: “One of the main issues in spatial thinking in astronomy is learning to visualize both static and dynamic objects and systems, and then imagine how those objects or systems would look from different perspectives.”

In traditional astronomy teaching, static images are frequently used to represent dynamic phenomena, without providing learners enough support to allow them to construct a mental model.
of the phenomena. The WWT-based labs, designed by the WWT Ambassadors team, allow learners to move around within the visualization, observing the phenomena from a variety of perspectives. Combined with physical manipulation of objects through modeling of the phenomena, learners are able to undertake spatial transformations, shifting their perspective in real time, thus providing a greater amount of information for their construction of a mental model to explain the actual phenomena.

In general, astronomy has been hampered with an inability to run direct investigations on distant phenomena. We can only observe, and infer through modeling what is occurring. Translated into a learning environment, astronomy does not fit into the neat sequence of the “scientific method” as taught in the majority of classrooms.

However, astronomy provides a rich milieu for incorporating modeling into the learning environment, with the opportunity to develop spatial thinking skills with wider application for learners — not only in the study of science, but for life skills in general. Platforms and dynamic visualization environments, such as those under development at the CfA, will hopefully serve to move the use of computers and online resources away from mere information gathering tools for passive learners, towards model-building simulators where learners actively investigate phenomena to build their own mental models of how the universe operates.

You can learn more about the WorldWide Telescope here.

BRIAN KRUSE manages the formal education programs at the ASP and is the Director for Region F of the National Science Education Leadership Association. He is also serving on the advisory board for the WWT ThinkSpace Labs program.

Gravitational Waves Detected and Explained

I was genuinely delighted by the overwhelmingly excellent media coverage of the event.

On Monday, February 8, 2016, the LIGO Scientific Collaboration invited journalists and the general public (via online streaming) to a press conference to be held three days later to “provide an update on the search for gravitational waves.” Of course, astronomers and physicists all around the world immediately suspected that LIGO would announce a revolutionary “first” in science: the first direct detection of gravitational waves.

Predicted by Einstein exactly 100 years ago, gravitational waves were indirectly proven to exist in the 1970s thanks to the “Hulse-Taylor” binary pulsar system, whose orbit is slowly decaying thanks to the energy being radiated away in the form of gravitational waves. For more than a decade, LIGO has been hunting for these waves, and on social media rumors had been circulating during the last few months about possible detections. So while the LIGO detection was highly anticipated by the scientific community, it was basically a foregone conclusion that it would happen soon thanks to recent
upgrades in the LIGO detectors. Despite the fact that everyone in the scientific community knew exactly what was going to be announced at that LIGO press conference, the excitement was not diminished.

I, of course, was personally thrilled by the detection and its potential to advance astronomy and physics. But beyond my excitement about the discovery itself, I was genuinely delighted by the overwhelmingly excellent media coverage of the event. None of the related topics — black holes, general relativity, spacetime! — are simple concepts, yet every article made a real effort to provide appropriate background and context for the reader so that they could understand why this detection was so important. I suspect that some science reporters were well aware that this detection would take place soon and, to their credit, had prepared ahead of time.

We often malign the depiction of science in the media. I can’t tell you the number of times I’ve literally yelled “correlation isn’t causation” at a newspaper article, or let out an exasperated sigh at a stereotypical depiction of a scientist in a movie. Therefore, it was encouraging to see the media embrace gravitational waves, especially since they are a really “tough sell” for the general public. Since they are detected by an interferometer, there are no pretty pictures to accompany an article about gravitational waves — and such images are the lifeblood of astronomy (think Voyager, HST, rovers on Mars).

How can you make astronomy cool and sexy without pictures? This is a real challenge, but fortunately one made easier thanks to the digital platform of modern media. In particular, video and audio (e.g. the “chirp”) simulations were used extensively to help tell the story of this discovery. People also seem to have a soft spot in general for Einstein, so the media played up the idea that this proved him right (even though this had really happened decades ago).

The positive reaction of the media to the detection of gravitational waves, and their willingness to take on the task of telling complex scientific stories, is particularly important in this day and age when “pure” science is struggling to prove its worth when compared with more “practical” science that has clear and immediate benefits to society. There are many examples of practical outcomes that eventually result from basic science (e.g. relativity and GPS, quantum mechanics and transistors), but — at least for now — gravitational waves have no such practical benefits. Therefore, the media has a huge role to play in communicating to the public why this kind of science is important and necessary despite its billion-dollar price tag.

To me, the detection of gravitational waves is like Galileo using his first telescope to observe the heavens — it was an incredibly important first step. This LIGO detection is an equally important step, and it is heartening to be reminded that the media is still capable of recognizing and responding to these kinds of monumental moments in science. I look forward to the next one, whatever it might be — dark energy or dark matter, perhaps?

BETHANY COBB is an Assistant Professor of Honors and Physics at The George Washington University, where she studies gamma-ray bursts and teaches physics/astronomy to non-science majors.
ASP Board Statement on Harrassment

Recently, multiple serious cases of sexual harassment in astronomy occurring at several major universities have been exposed and reported. The Astronomical Society of the Pacific, the oldest astronomical society in the US, strongly condemns sexual harassment, as well as any form of harassment or discrimination in the astronomical community. We also unequivocally support the victims of abuse who bravely speak out against such behavior, often at the risk of their own professional careers.

The mission of the ASP is to increase the understanding and appreciation of astronomy, by engaging scientists, educators, communicators, amateur astronomers and the public, to advance science and science literacy. We strive to engage people of all backgrounds, gender, sexual orientation, or disability status. As such, we will not tolerate harassment of any kind in our programs and activities. We encourage all astronomy educators at every level, K–12, college or university, museum, or informal educational setting, to maintain a similar strong stance against harassment of any kind in their educational institution or setting.

Sexual harassment weakens our field by driving out members of our community and hampering their professional development, thereby costing us their contributions, on top of the personal and professional suffering caused. All members of our community must step up and take responsibility for these events, even if committed by a few.

The creation of a truly respectful astronomical community requires the participation of us all; more senior members of the community, especially those from more privileged groups, must speak out and play an active role. If we all work together to develop and maintain an environment that does not tolerate harassment, then the field of astronomy will be better off.
ASP’s Commitment to Diversity and Inclusion

The Astronomical Society of the Pacific (ASP) is an international organization whose mission is to increase public science literacy through the study of and participation in astronomy. To fulfill this mission, the ASP provides astronomy enthusiasts of every kind — regardless of age, level of education, or professional training — with the resources, programs, and materials needed to improve their own understanding of astronomy and their abilities to share their knowledge with others.

The ASP is committed to actively promoting diversity and will engage in astronomy initiatives expanding participation among underrepresented groups. These efforts include the development of educational materials and programs specifically designed to increase participation among groups underrepresented in STEM fields, including women and girls, African Americans, Hispanics, Native Americans, Pacific Islanders, the LGBTQ community, and the disabled. Additionally, the ASP commits to involving itself in international efforts supporting the teaching and learning of astronomy in the developing regions of the world (including Central and South America, Asia, and Africa).

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The ASP is committed to expanding and diversifying its membership. The ASP has been a membership organization since 1889, first serving the needs of professional researchers and amateur astronomers and then expanding to serve casual enthusiasts and science educators. The ASP is committed to diversifying the membership, and we will actively recruit and provide support to professional researchers, amateur astronomers, astronomy educators, and casual enthusiasts from traditionally underrepresented groups in STEM, including but not limited to women, people of color, the disabled, and members of the LGBTQ communities.

The ASP is committed to celebrating contributions to astronomy made by people across a variety of cultures and from diverse backgrounds. The ASP Annual Awards honors the achievements made by professional astronomers, amateur astronomers, and astronomy educators. The ASP will diversify the pool of nominees in all categories and create new awards that celebrate individuals who have made significant strides in promoting diversity and equity. The ASP’s educational resources, books, popular magazines, and other materials will be culturally sensitive and inclusive.

The ASP is committed to creating professional learning communities within which participants feel safe, respected, and free to express their views regardless of gender, sexual orientation, race, ethnicity, religious belief, or disability. The ASP will act to ensure that all of our programs and events are places where participants are free from harassment or discrimination based on gender, sexual orientation, race, ethnicity, religious beliefs, or disability.
New Horizons and the Exploration of the Pluto System

For all of us who worked on New Horizons, the flyby of Pluto was an unbelievable experience of scientific discovery.

By Alan Stern

A composite of enhanced color images of Pluto (lower right) and Charon (upper left), taken by NASA’s New Horizons spacecraft. This image highlights the striking differences between Pluto and Charon. They are shown with approximately correct relative sizes, but their true separation is not to scale. Unless otherwise noted, all images in this article are courtesy NASA/JHUAPL/SwRI.
Let’s start with last year. This was Pluto before the New Horizons flyby. We’ve come a long way, and we’ve turned a point of light that Hubble could barely distinguish as a disk into a real system of worlds. I think it shows the power of exploration, and I’ll say a little more about that later.

In this presentation I’ll use names of surface features on Pluto. As you know, these are all informal names that our team uses. We have not submitted them to USGS or the IAU, but we need to be able to refer to surface features, so you’ll see some of those names used here.

**Pluto’s Small Satellites**

For those of you who don’t know, Pluto’s satellite system has five objects in it. Four of them are small, orbiting beyond the [Pluto-Charon] binary. They are shown here, from left to right, in order of their Pluto-centric distance: Styx is closest to the binary and Hydra is farthest out. All of these objects were discovered by the Hubble Space Telescope between 2005 and 2012, but they were never resolved prior to the flyby by New Horizons. The two larger ones are about 50-70 kilometers across, and more like 10-15 kilometers across for the two smaller ones.

They all turn out to have very high albedos — as high as Pluto’s bright surfaces and much higher than Charon. They seem to come in two pairs: small and large, and then small and large. That may be telling us something about the disk out of which these satellites formed, but I think it’s too early to know for sure.

One of the discoveries that we made from doing photometry on the satellites is that unlike the Pluto-Charon binary, they are in excited rotation states. That is, they are not synchronously rotating. Even though the damping times for these objects are short compared to the age of the solar system, they are being rotationally excited. In fact, Hydra turns about 90 times on its axis for every time it travels around Pluto. It’s truly an amazing system and a dynamicist’s delight.

**Charon**

Next I’d like to say a few words about Pluto’s big satellite, Charon. Charon is a mid-sized icy satellite about 1,214 kilometers across with primarily a water-ice surface. We knew a little about it prior to the flyby, but during the flyby we learned many new things. You can tell just by looking at this beautiful mosaic of Charon that
it’s a fascinating object. We have determined that unlike Pluto, it has no atmosphere down to picobar levels — that upper limit is a million times lower than the atmospheric pressure on Pluto. We’ve discovered that it has a very heavily cratered surface, that there are vast extensional tectonics, and that its pole has an oddly red-colored stain that we think may be related to atmospheric transfer from Pluto onto Charon with cold trapping at the pole.

Kelsei Singer and Stuart Robbins [both at SwRI] and others have been age-dating the surface by counting craters. Of course we can only count the craters on the encounter hemisphere, which we see at high resolution. They’ve counted hundreds and hundreds of craters [below] and derived a surface age that’s very old — four billion years. In addition, they’ve been counting craters on the two larger of Pluto’s small satellites, Nix and Hydra. And they also turn out to be about four billion years old.

So for the first time we think we can age date the formation of Pluto’s satellite system. We always had circumstantial evidence that the Pluto-Charon binary and its satellites were created in the distant past, but we never had data to support that. And now we can show it, thanks to New Horizons.
Pluto
Let’s turn to Pluto. Pluto is a slow rotator \([\text{right}]\). It turns on its axis in 6.4 days, so on approach we wanted to take imagery of all of the visible terrains that were presented to us...and that’s what we did. The close approach hemisphere is shown at the bottom, at the six o’clock position, in color.

This is the close approach hemisphere in all of its glory \([\text{left}]\). It is a spectacular object, and there is a little bit of something for everyone — whether you like atmospheres, or glaciology, or tectonics, or surface composition and color variations, or something else.

This perspective view \([\text{lower right}]\) is as if you were several hundred kilometers above Pluto, looking down on the most prominent feature on the surface, which is the western half of the “heart” that we informally call Tombaugh Regio. This western lobe is what we call Sputnik Planum. It is a 1,000-kilometer-scale nitrogen ice plain — a cold trap to the volatiles on Pluto’s surface. It is such a prominent feature that we even saw evidence of it from Earth in Earth-based data. [With New Horizons] we could see this feature from more than an astronomical unit away — it’s spectacular.

We believe that although the ices there are young — we can’t find any craters on the surface of Sputnik Planum at any resolution down to 70 meters per pixel in high-resolution strips — the actual structure itself is an ancient impact basin. Notice that it’s ringed by mountain ranges that tower three to five kilometers above the plain.

But there’s a lot more in Sputnik Planum than just an impact basin with ice. We see evidence of sublimation — thousands and thousands of sublimation pits with characteristic scales of one to several kilometers [in length] and evidence for flows in the ice that you can see where there are distortions in the patterns.

On approach in July 2015, the cameras on NASA’s New Horizons spacecraft captured Pluto rotating over the course of a full “Pluto day.” The best available images of each side of Pluto taken during approach have been combined to create this view of a full rotation. The red arrow marks a fixed point on the planet’s surface, offering a frame of reference in each time-stepped rotation.
In this annotated image of the northern region of Pluto's Sputnik Planum, swirl-shaped patterns of light and dark suggest that a surface layer of ices has flowed around obstacles and into depressions, much as glaciers do on Earth.

Up in the north we see flow patterns [above] that are different, and here I want to point out a number of things. First, even upon casual inspection, you don't see any craters. Second, you’ll notice that where there are obstacles to the ice, which appears to be flowing toward the shoreline — for example, those islands that are protruding upward — we can actually see the flow lines, the dynamics of the ice… the ice is moving. If you look a little more closely you’ll see ovoids or polygonal patterns in the ice, with horizontal scales of tens of kilometers. We believe this is due to convection in the ice, and it’s this convection that is erasing the craters that are forming on the surface and keeping the crater retention age low.

We also see evidence of flow into Sputnik Planum [right] from the highlands down chutes where massive, 50-kilometer-scale flows have taken place in the recent past. Pluto is just an amazingly dynamic place.

We also see evidence for what may be large cryovolcanos on the surface of Pluto. These are clearly constructional features with scales of 100 or 150 kilometers and very large central pits that are, potentially, caldera at their summits.

And for those of you who think that all of the terrain on Pluto is young like Sputnik Planum, that’s not the case at all. There are ancient terrains as well, including at the interface [next page, top] between Sputnik Planum and a broad expanse we call Cthulhu Regio, the darker region, which is very heavily cratered and is as old as the late heavy bombardment — four-plus billion years old.

Just like Charon and the small satellites, we’ve been age-dating on Pluto as well. I think the most interesting result is that we have

Unambiguous evidence of massive, recent downsloping glacial flow in Pluto’s Sputnik Planum region.
found a wide variety of surface ages. Sputnik itself has an upper-limit crater retention age of only about 10 million years; Cthulhu more than four billion years old. What is particularly interesting is that we find intermediate-age terrains as well. And that tells us that Pluto has been active throughout its history and Sputnik is not a recent anomaly on a dead world. Pluto has been active, and that’s certainly something I never expected, and I don’t think very many people did, because it’s such a small planet.

**Pluto’s Atmosphere**

I’d also like to say a little about Pluto’s atmosphere, which was discovered back in the 1980s with the Kuiper Airborne Observatory. Before New Horizons arrived, we had atmospheric occultations that were observed from Earth and from airplanes flying high above Earth, and there was a controversy about whether or not some of the vertical structure [in Pluto’s atmosphere] might have been caused by hazes. We could never really tell, but New Horizons solved this problem in 15 minutes flat. It took this image [bottom] showing almost two dozen concentric haze layers stretching 200-plus kilometers into Pluto’s sky.

Our atmospheric team has been thinking a lot about how these hazes get produced. They’re very much reminiscent of the detached haze layers high in Titan’s atmosphere, and of course Titan also has a nitrogen-methane atmosphere like Pluto’s. But there’s now a growing consensus on our team that the structure we see — that horizontal banding or layering — is organized by gravity waves... not cosmological gravity waves but atmospheric buoyancy waves created by the flow of the atmosphere over the steep topography of mountain ranges.
Here’s another interesting atmospheric science result. One of our objectives was to measure the atmospheric escape rate. It was thought, because Pluto is such a small planet, that its atmosphere would be very large, like a cometary coma, and that it would be escaping at rates of $10^{28}$ molecules per second, give or take. That turned out to be completely wrong. What our atmospheric occultation with Alice, our UV spectrometer, showed us is that in fact, the upper atmosphere is about 40º kelvin colder than Earth-based models had indicated. That means the atmosphere is more compact, the scale heights are smaller, and so the atmosphere is held more closely to the planet, deeper in Pluto’s gravitational potential well. In addition, because it’s colder, the individual molecules in the atmosphere have less energy, and those two things combine in an exponential term in the escape equation.

The end result is that our understanding of the escape of Pluto’s atmosphere has completely changed from before the flyby to after. In fact, our best estimate of the escape rate today is a few $10^{25}$ molecules per second, five hundred or one thousand times less than we thought before we went there. It’s really quite an amazing change from our pre-flyby understanding.

**Extended Mission: 2016 to 2021**
We built the Pluto mission to explore the Kuiper Belt. In fact, NASA’s Announcement of Opportunity called this the “Kuiper Belt Pluto Mission” to emphasize the context. So we were required to build the spacecraft to be capable of flying on for years — to have the communications range, the sensitivity in the instruments, the fuel on board, etc. — to take advantage of having a spacecraft in the Kuiper Belt. And that’s what we’ve proposed to [NASA’s] senior review.

The centerpiece of our extended mission proposal is a close flyby, a much closer flyby than the flyby of Pluto, of a small Kuiper Belt Object [KBO] discovered by the Hubble Space Telescope for New Horizons.
Horizons — actually our team lead that observing campaign. The object is called 2014 MU69. We don't know its precise size, but we can make good guesses about its albedo and therefore derive a size estimate from its brightness. It's somewhere between 20 and 40 kilometers across, so it's on the scale of the large near Earth asteroid Eros.

This diagram [above] shows a little cartoon depiction of MU69 against the state of Massachusetts and Rosetta's comet 67P/C-G. MU69 is known from its orbit to have an extremely high probability of being a cold classical KBO, meaning its origin was not somewhere dramatically closer to the Sun but actually out in the Kuiper Belt. This is the one portion of the Kuiper Belt population that we know was formed in the Kuiper Belt. So it is an anchor point to understanding the composition of things in the [solar-system-forming] nebula at very large distances, and it's an object that has always been cold.

Unlike the comets and all the other small bodies we've flown by, this is probably our opportunity to view the most pristine object that anyone has ever been able to study. The flyby, which we've already targeted by making engine burns with NASA's permission, will take place on January 1, 2019, a billion miles beyond Pluto.

An Unbelievable Experience
For all of us who got to work on New Horizons, the flyby of Pluto was an unbelievable experience of scientific discovery. And I think that for most people on the team, it was actually emotional. We worked very hard for 15 years to build that spacecraft, get it launched, get it across the solar system, and plan the flyby itself. Pluto turned out to be spectacular, and so did its satellite system.

This was the scene at the Johns Hopkins University Applied Physics Laboratory on the morning of the flyby (July 14, 2015), when the spacecraft was making closest approach. [NASA/Bill Ingalls]
But it wasn’t just our science team that was interested. The public turned out in droves, and I think this is a very important lesson for our entire community. People really love exploration. They love what we do in planetary science. And we worked very hard before the flyby — for four years — to try and drive public interest in Pluto, to drive interest in New Horizons, to show what exploration is all about.

I want to give you a couple of other metrics. We got the Google Doodle — you can’t beat that! New Horizons was on the cover of 450-plus newspapers above the fold on the same day, in countless magazines, and the response on our website was unparalleled — we had 10 times as many visitors on flyby day as MSL [Mars Curiosity] had on landing day.

These are great metrics, but I’ve been giving public talks on New Horizons and so has our team, every single week since the flyby. We get asked to give a lot of talks, we give a lot of talks, and after the talks people line up, sometimes for more than an hour, to ask questions or to have their picture taken with us. It’s really a very emotional response from the public.

Last August [2015] I gave a talk at a convention of telescope makers — it’s kind of a maker fair for those people who build telescopes themselves, and it’s up in [Stellafane] Vermont. The talk was at 9:00 at night, it was 10:45 by the time the questions ended, and then a line formed until almost midnight. In the middle of that line was a young woman in college. When she got to the front of the line, she said: “People say that our generation doesn’t have the same chance that our parent’s generation did to do great things. Thank you, we do. New Horizons is the best thing that has ever happened in my lifetime.”

ALAN STERN is an Associate Vice President of the Space Science and Engineering Division at Southwest Research Institute (SwRI) and the Principal Investigator of NASA’s New Horizons mission to Pluto and the Kuiper Belt. His research has focused on studies of our solar system’s Kuiper Belt and Oort cloud, Pluto, the satellites of the outer planets, comets, and the search for evidence of solar systems around other stars. He has been involved in 27 space missions; New Horizons is his favourite.
Mars in 2016: A Close Approach

Don’t miss bright Mars, now appearing in our spring and early summer sky.

By Paul Deans

The path of Mars through Libra and Scorpius — from February 1st to September 6th during its 2016 apparition. (Starry Night Pro Plus 7)
Mars is back. Well, okay, it never really went away. But for most of the past decade, it has been glowing dimly as it made its way through the heavens. If you turned a telescope toward it — even a reasonably large amateur instrument — the red planet looked small and almost featureless. But this year Mars is putting on its best show in a decade, and it’s a prelude to 2018 when Mars will be the closest (and brightest) it has been since 2003.

Some Disclaimers
What can you expect to see this spring? First, Mars will not appear as large as the full Moon. That canard shows up on the Internet every August, but it might well put in an early appearance this year. Second, you will not see anything like the image at right, no matter what size of telescope you use. We have been spoiled by views of Mars from the Hubble Space Telescope and all the spacecraft currently in orbit around the red planet. So please — temper your expectations as to what you will see when you look through a telescope’s eyepiece.

Third, you will need a telescope to see anything. Binoculars will only make Mars look brighter and perhaps redder than it appears to the naked eye. And the bigger the telescope the better. You really won’t see much of anything with a little 60-mm refractor; a 4-inch refractor or 6-inch reflector are minimum telescope sizes that will let you glimpse a few of the Martian surface markings — especially from within a city. (See the end of the article for suggestions if you don’t own a telescope.)

Finally, for Northern Hemisphere observers, Mars will remain quite low in the sky as it passes through the constellations of Libra and Scorpius. That means you’ll be looking through a lot of Earth’s atmosphere and Mars will appear to bounce and bubble in the eyepiece. Occasionally the turbulence will settle and you’ll suddenly have an amazing view with plenty of detail…and then it will be gone.

What’s the Big Deal About Mars in 2016?
Every 26 months Mars and Earth are close, and Mars is at opposition. This means Mars and the Sun are on directly opposite sides of Earth, so Mars rises as the Sun sets. But because Mars’ orbit is much more elliptical than Earth’s, opposition and closest approach usually occur when the two planets are some distant from each other.

At opposition in April 2014, Mars was reasonably nearby, shining at magnitude -1.5 (which made it roughly as bright as Sirius, the brightest star in the nighttime sky). Even though it was bright, the...
red planet’s disk was only 15.2” (15.2 arcseconds) in diameter when closest to Earth. (By comparison, Jupiter’s disk is more than 40” when it’s closest to us.) During the remainder of 2014 Mars faded rapidly, and stayed dim throughout much of 2015.

Now it’s 2016 and Mars is again bright in our sky. It’s at opposition on May 22nd and at closest approach on May 30 — reaching magnitude -2.0 with an apparent diameter of 18.6”. That may not sound like much, but it’s some 20% larger than two years ago, and every arcsecond increase in size counts when you’re straining to see surface details through your telescope. Why does it appear 20% larger than in 2014? Because this May, Mars is 17 million miles (27 million km) closer than it was at opposition two years ago. When it comes to observing Mars, closer is definitely better.

**Where and When to Look**

During spring and summer, you’ll find Mars in the constellations of Libra, the Scales, and Scorpius, the Scorpion. Unfortunately, they (and Mars) are low in the sky, even at the best of times (unless you’re in the Southern Hemisphere). Until the end of May, Mars rises (in the southeast) after sunset; thereafter it rises before the Sun goes down. In June and July, it’s in the south at sunset; in August and September, it’s sinking into the southwest as dusk falls.

You should have no problem finding Mars — it blazes a brilliant orange-red in the sky, outshining any star in its vicinity. But to confirm Mars’ location in the sky, the Moon is a handy guide, albeit only once a month. On May 21, the red planet is to the right of the full Moon as both rise in the southeast. Note that full Moon is a terrible time to try to see any detail on Mars; wait a day or two until Mars rises before the Moon. On June 16 about an hour after sunset Mars is below the Moon; on the 17th it’s to the Moon’s lower right. On July 14, the red planet is again beneath the Moon after sunset; both are due south at this time. Mars is again below the Moon after sunset on August 11 and September 9. But in reality, once you’ve confirmed that you’re seeing Mars, you will never mistake it for anything else this summer.
Observing Mars

And what might you see? Ah, that is the $64-million-dollar question, because it’s not possible to provide a definitive answer. It depends on when you observe (date and time of night), what instrument you use, and what side of Mars is facing Earth. Note that a day on Mars is roughly 40 minutes longer than a day on Earth. This means if you observe at about the same time each evening, you’ll see roughly the same features on Mars for several consecutive observing sessions. So here are a few general comments about what you might see.

Mars is currently enjoying equinox, with its north pole tilted only very slightly toward us. This means you might be able to spot whitish caps at each Martian pole, though the white at the south pole may be more cloud than ice.

It’s possible to see surface features even in a small telescope, but obviously the bigger the scope, the more you’ll see. Syrtis Major is the most prominent (and hence obvious) dark feature. Here is a nice B&W map with the classical names of numerous features; a whole webpage of Mars maps is here.

There are several “tricks” to Mars observing. First, make sure your telescope is well adapted to the outside temperature; don’t take it outside and expect good views 10 minutes later. Try observing during evening twilight. Earth’s atmosphere is often steadier at this times. On the other hand, if the sky looks at all hazy, or the stars are twinkling even more than usual, you might be wasting your time trying to see much on the red planet.

Use high magnification. Cranking up the “power” on a 60-mm refractor won’t help, but it will on larger instruments. Try higher and higher magnifications until the planet looks terrible, and then back it off until details swim into view. Also remember that conditions change nightly and even hourly. One night it may be possible to push the power to 300x; an hour or a night later, only 150x will do.

Take your time and be patient. Because of Earth’s turbulent atmosphere and the low altitude of the red planet, most of the time Mars will look like a bubbling, boiling blob of red. But a sudden moment of stillness may reveal rich detail, and you have to be alert to catch it.

Don’t be satisfied with one or two nights of viewing. Experience counts. If you observe regularly, you’ll soon be able to immediately identify prominent features during those moments of good viewing, giving you time to go looking for less obvious details.

Try color filters if you have them. An orange filter increases the contrast between light and dark features. A light red filter provides maximum contrast of surface features, enhancing fine surface details.

Don’t Have a Telescope?

Astronomy Day is on May 14. Planetariums, science centers, and local amateur astronomy clubs will have telescopes out that evening. Visit them. Sure, the first quarter Moon is nice to look at, Jupiter will be
beside the Moon, and Saturn will be up as well, but I guarantee that Mars will attract its fair share of telescopes. But consider going to an Astronomy Day event a bit later in the evening, since Mars doesn’t even rise until about an hour after sunset.

Beyond Astronomy Day, Mars will remain reasonably bright (and close to Earth) into early August. So again, check with your science center to see if they’ll have any special summer observing sessions. Another option is to ask about star parties, where amateur astronomers meet for several days under dark skies to observe the heavens — sometimes with impressively large telescopes. (Try the ASP’s Night Sky Network to see if there’s a star party near you.) Even into the summer months, Mars is sure to be a high-priority target.

Mars Apps
There really is only one (at least that I could find prior to publication) that will help you identify what you’re seeing on Mars. Sky & Telescope’s Mars Profiler, Which Side is Visible is free, but you have to sign into the S&T website (and join if you haven’t). You’ll find it under Observing – Interactive Tools, and you’ll need to have pop-ups enabled on your computer. For any specified date and time, and for the three most common optical configurations, this JavaScript routine displays basic data about the planet as well as a map of the hemisphere currently facing Earth — complete with the names of the major Martian features. I used it in 2003 and found it very helpful.

Most planetarium software programs (on computers or tablets) let you zoom all the way down to the planet’s surface, but beware. There is no guarantee that the global view of Mars it shows for any given date or time is accurate. (Try checking it against what the Mars Profiler shows.) Also, most (if not all) of these programs don’t name many (or any) of the features that might be visible through your scope.

If it’s cloudy or rainy and you simply want to explore Mars from the comfort of your home, here are two apps you might enjoy.

- **Mars Globe** by Midnight Martian (free for iPhone & iPad on the Apple App Store). This virtual globe combines a high-resolution satellite map with laser altimeter data and topographic lighting to show Mars as it appears from above.

- **Mars Atlas** by Julian James ($5.99, for iPhone & iPad on the Apple App Store). This app lets you use pinch and finger gestures to manipulate a 3D globe of Mars; double tap on the labels to get more information about a particular feature. Mars Atlas displays the approximate phase, axial tilt and central meridian of Mars from your chosen location and time, and renders these on the globe.

If you’re suffering through a streak of really bad weather, you can always watch The Martian and try to identify the science errors in the movie…or read the book and perform the same exercise! Or read The Planet Mars: A History of Observation and Discovery by William Sheehan. Although published in 1996, it’s available online and recounts exactly what its title says.

While writing the Spring edition of “Sky Sights,” Mercury editor PAUL DEANS realized he needed to ‘go long’ on Mars; this is the result. He really enjoyed the close approach of Mars in 2003.
Touring to Totality in 2017

Even if the eclipse is in your own back yard, joining a tour to totality in 2017 has certain benefits.

By Paul Deans

Joining a tour to witness totality in the US in 2017 may seem strange, but there is more to an eclipse tour than first meets the eye. Unless otherwise noted, all images are courtesy Paul Deans/TravelQuest.

**Take a Tour?**

Join an eclipse tour in 2017? OMG, why? you're likely thinking. I can hear that opinion being muttered from sea to shining sea in the United States. Why join a tour to see the total solar eclipse of August 21, 2017, when it's possible to drive to the path of totality? Well, I can think of several reasons.

- Perhaps the eclipse tour goes to a part of the United States you've never visited — a part that’s not particularly close to home — and offers to show you sights you never even knew existed. The eclipse is a good excuse to get out and see more of the US.
- Perhaps the idea of being trapped in a car for several days with assorted family members (and/or supposed friends) gives you the heebie-jeebies.
- Perhaps you can already feel the knot building in your stomach as you contemplate trying to find the best site with the best weather — with expectations at an all-time high that you’ll pull it off (you are the family’s astro-geek, after all).
- Or perhaps you’d prefer — to adapt a line from the classic Greyhound bus commercial — to leave the driving to someone else.

**A Guided Tour About Group Travel to Totality**

During the past decade, I've led numerous tours to various parts of the world to see eclipses (both total and annular) and to watch for displays of the northern lights. I have also traveled extensively by myself and with my spouse, so I come at this topic from both sides: self-guided travel and organized tours. (Full disclosure: While I work for the ASP as *Mercury’s* editor, I am not associated with MWT Travel, nor am I part of their 2017 eclipse trips.)

So, why would you want to join a 2017 eclipse tour? I can suggest a few possibilities. Actually, these ideas apply to any tour going to any total solar eclipse, whether it's in the US next year or some remote locale in the more distant future such as Chile/Argentina in 2019 and 2020. And even if you don’t think joining a tour in 2017 is for you, bear with me. I might change your mind, or you might discover something applicable to a future trip to totality.
1) If you’re going to join an eclipse tour, travel with an operator/tour company who has previously organized eclipse trips. **This is absolutely critical.** You need to go with an experienced operator. I fear that some travel companies may jump on the 2017 eclipse-tour bandwagon, and many unsuspecting tour travelers will end up frustrated and/or disappointed. Google “2017 eclipse tours” or something similar, click on the links, and check out each tour’s website. Is it obvious that the company has offered at least several previous eclipse tours? If not, try another. (Discovering whether a particular operator successfully observed totality on those tours is another matter.)

2) Yes, you’ll likely spend more on an eclipse tour than you would taking a trip yourself, but keep in mind that the tour company has already done all the legwork. Their representative (often the owner) has likely made several trips into the path of totality to book transportation, hotels, and restaurants; arrange for group entry to museums and regional sights (sometimes with behind-the-scenes tours);
scout locations; and select and perhaps reserve a great viewing site.

3) Speaking of hotels and such, tour companies usually lock in prices as much as two to three years in advance of totality. Sadly, local amenities have been known to hike prices for everything from hotel rooms to meals to car rentals once it is realized that being in (or near) the path of totality means a sudden influx of eclipse chasers. Participating in a tour should protect you from such gouging.

4) The weather on eclipse day is always an issue. Tour operators can’t part the clouds, and sometimes success involves just plain luck. But they can (and should) be in touch with experienced meteorologists who can help determine the weather prospects for a particular site on eclipse day. Certainly there’s plenty of local and countrywide weather coverage available to anyone in the US, but if you are the one looking at weather maps, charts, and forecasts, can you correctly interpret all the data?

5) Once you’ve found a tour operator and a tour you like, ask a lot of questions. Call the company and talk to the trip organizer. And the one question you absolutely have to ask is: “Are you prepared to move the group to another location on eclipse-day morning if, the night before, you learn that the weather forecast for your prime viewing site isn’t favorable?” If the answer is no, or the response is full of “ifs,” “maybes,” and “it depends,” then I suggest you keep looking.

Please bear in mind there are no guarantees when it comes to the weather. “Climate is what you expect; weather is what you get” is a saying commonly heard on eclipse-day morning. It’s unrealistic to expect a tour company to move a large group more than 100 miles.
(about two hours by bus) on eclipse day in the hope of finding clear skies. If that’s your level of commitment, then do the trip yourself.

6) If you’re serious about photographing the eclipse, there are two more questions to ask. First, will the tour reach the selected viewing site at least an hour before first contact — the start of the eclipse? This will give you plenty of time to set up all your gear. Of course this doesn’t apply if the group is moving to try to find clear skies.

Second, will the tour remain in place until fourth contact (the end of the partial phase)? Soon after third contact — the end of totality — many (now former) eclipse virgins and those easily bored will want to leave…especially if there’s no wireless availability at the site! But if you want to photograph the entire event, you need to know that the tour will remain in place until the very end — roughly 80 minutes after third contact.

7) Finally, if you’re trying to choose between two or three different tours, perhaps delving into the details of eclipse day will help you decide. So in addition to asking about moving due to bad weather, and staying in place for the duration of the eclipse, inquire about the simple necessities of the day such as the availability of restrooms at the viewing site, whether water is provided, and if a snack (or a meal if totality falls near noon or around dinner time) is included.

Camaraderie

I can think of two more good reasons for joining an eclipse tour in 2017 — guest speakers/experts and the participants. All (good) eclipse tours include an experienced eclipse chaser, one who can explain what to expect and how to safely view and photograph the eclipse. If you’ve never see totality before, this is a critical expert to have along. Sometimes there is also guest speaker on the trip, someone knowledgeable about astronomy in general or the area through which you’re traveling. These guest experts are a bonus you don’t get when you go it alone.

As for the participants in the tour — yes, I know. Group travel can have its annoyances, such as the individual who is always late (my pet peeve as a tour leader). But participating in an eclipse tour brings you in contact with like-minded folks with whom you have at least one thing in common — solar eclipses.

I’ve repeatedly found that by the end of a tour, many new friendships have been struck, and because of common interests, those friendships endure even though the new friends may live thousands of miles apart. In fact, a significant number of travelers on the eclipse tours I’ve led join another tour (often with the same company), because they either enjoy the idea of making new friends with a common interest, or they know their friends from a previous tour are on the next one — and they physically reconnect by again journeying into the shadow of the Moon.

So don’t immediately dismiss the notion of joining a group tour

On solar eclipse tours you will definitely meet some interesting characters! [Michel Tournay]
to totality in 2017. Consider what you want to accomplish, and how much stress you’re willing to put up with to succeed. You may well discover that an eclipse tour in 2017 is an appealing prospect. If so, start your research now. Don’t wait until this time next year, because by then you may find that the tours of interest are sold out.

I Want to be Alone
You remain unconvinced. My arguments have not swayed you. You’re going to skip the tours and travel, by yourself or with family and/or friends, to totality in 2017. Fine. You’ll need to do your research. There’s plenty of general information online, including the Great American Eclipse site (once there, click on “More” to find an extensive resource page), meteorologist Jay Anderson’s weather site, and Fred “Mr. Eclipse” Espenak’s EclipseWise.com, the essential source for eclipse predictions.

But contrary to what you might have heard, everything good is not exclusively on the Internet. There are these old-fashioned things called books, and I’d suggest one or two of them if you’re planning to drive the roads of America in search of totality.

Eclipse Bulletin: Total Solar Eclipse of 2017 August 21 is written by Fred Espenak (Mr. Eclipse) and Jay Anderson (a meteorologist well known for his eclipse-related weather and climatology work). The book includes details about the Moon’s shadow path, maps plotting the umbral path across the US, and a cross-country look at the climate and possible weather along the path of totality. And Road Atlas for the Total Solar Eclipse of 2017 by Fred Espenak is a comprehensive series of 37 large-scale maps (1:700,000 or 1 inch = 11 miles) of the path of totality. Both are available at AstroPixels.com.

There are times when group travel provides some unexpected (and delightful) surprises. After the second diamond ring signaled the end of totality in November 2012, a third diamond ring put in an appearance. The engagement ring was created in the shape of a solar eclipse diamond ring. (BTW, she said yes.) [Michel Girardin/TravelQuest]

Mercury editor PAUL DEANS has led 19 astronomy tours, primarily solar eclipse trips, during the past 14 years. He has reached the point where he enjoys helping people successfully view totality almost as much as seeing the spectacle itself.
Unexpected Changes of Bright Spots on Ceres Discovered

European Southern Observatory

Ceres is the largest body in the asteroid belt between Mars and Jupiter and the only such object classed as a dwarf planet. NASA’s Dawn spacecraft has been in orbit around Ceres for more than a year and has mapped its surface in great detail. One of the biggest surprises has been the discovery of very bright spots, which reflect far more light than their much darker surroundings. The most prominent of these spots lie inside the crater Occator and suggest that Ceres may be a much more active world than most of its asteroid neighbors.

New and very precise observations using the HARPS spectrograph at the ESO 3.6-metre telescope at La Silla, Chile, have now not only detected the motion of the spots due to the rotation of Ceres about its axis, but also found unexpected additional variations suggesting that the material of the spots is volatile and evaporates in sunlight.

The lead author of the new study, Paolo Molaro, at the INAF–Trieste Astronomical Observatory, takes up the story. “As soon as the Dawn spacecraft revealed the mysterious bright spots on the surface of Ceres, I immediately thought of the possible measurable effects from Earth. As Ceres rotates the spots approach the Earth and then recede again, which affects the spectrum of the reflected sunlight arriving at Earth.”

Ceres spins every nine hours and calculations showed that the effects due to the motion of the spots towards and away from the Earth caused by this rotation would be very small, of order 20 kilometers per hour. But this motion is big enough to be measurable via the Doppler effect with high-precision instruments such as HARPS.

The team observed Ceres with HARPS for a little over two nights in July and August 2015. “The result was a surprise,” adds Antonino Lanza, at the INAF–Catania Astrophysical Observatory and co-author of the study. “We did find the expected changes to the spectrum from the rotation of Ceres, but with considerable other variations from night to night.”

This image of Ceres is part of a sequence taken by NASA’s Dawn spacecraft on May 7, 2015, from a distance of 8,400 miles (13,600 kilometers). [NASA/JPL-Caltech/UCLA/MPS/DLR/IDA]
Computer Model Explains Sustained Eruptions on Enceladus

University of Chicago

The Cassini spacecraft has observed geysers erupting on Saturn’s moon Enceladus since 2005, but the process that drives and sustains these eruptions has remained a mystery. Now scientists at the University of Chicago and Princeton University have pinpointed a mechanism by which cyclical tidal stresses exerted by Saturn can drive Enceladus’ long-lived eruptions.

“On Earth, eruptions don’t tend to continue for long,” said Edwin Kite, assistant professor of geophysical sciences at UChicago. “When you see eruptions that continue for a long time, they’ll be localized into a few pipelike eruptions with wide spacing between them.”

But Enceladus, which probably has an ocean underlying its icy surface, has somehow managed to sprout multiple fissures along its south pole. These “tiger stripes” have been erupting vapor and tiny frost particles continuously along their entire length for decades and probably much longer.

“It’s a puzzle to explain why the fissure system doesn’t clog up with its own frost,” Kite said. “And it’s a puzzle to explain why the energy removed from the water table by evaporative cooling doesn’t just ice things over.”

What’s needed is an energy source to balance the evaporative cooling. “We think the energy source is a new mechanism of tidal dissipation that had not been previously considered,” Kite said.

Enceladus, which Kite calls “an opportunity for the best astrobiology experiment in the solar system,” serves as a leading candidate for extraterrestrial life. Cassini data have strongly indicated that the cryovolcanic plumes of Enceladus probably originate in a biomolecule-friendly oceanic environment.

One of the problems that attracted Kite and Rubin was the anomalous tidal response of the Enceladus eruptions. The eruptions reach their peak approximately five hours later than expected — even when taking into account the 40 minutes needed for the erupted particles to reach the altitude at which Cassini can detect them.
The Frozen Canyons of Pluto’s North Pole

This ethereal scene captured by the New Horizons spacecraft tells yet another story of Pluto’s diversity of geological and compositional features, this time in an enhanced color image of the north polar area. Long canyons run vertically across the polar area — part of the informally named Lowell Regio, named for Percival Lowell, who initiated the search that led to Pluto’s discovery. The widest of the canyons (yellow in the image at right) — is about 45 miles (75 kilometers) wide and runs close to the north pole. Roughly parallel subsidiary canyons to the east and west (in green) are approximately 6 miles (10 km) wide. The degraded walls of these canyons appear to be much older than the more sharply defined canyon systems elsewhere on Pluto, perhaps because the polar canyons are older and made of weaker material. These canyons also appear to represent evidence for an ancient period of tectonics.

A shallow, winding valley (in blue) runs the entire length of the canyon floor. To the east of these canyons, another valley (pink) winds toward the bottom-right corner of the image. The nearby terrain, at bottom right, appears to have been blanketed by material that obscures small-scale topographic features, creating a ‘softened’ appearance for the landscape.

Large, irregularly-shaped pits (in red), reach 45 miles (70 km) across and 2.5 miles (4 km) deep, scarring the region. These pits may indicate locations where subsurface ice has melted or sublimated from below, causing the ground to collapse.

MORE INFORMATION
ALMA’s Best Image Yet of a Protoplanetary Disk

National Radio Astronomy Observatory

The disks of dust and gas that surround young stars are the formation sites of planets. New images from the Atacama Large Millimeter/submillimeter Array (ALMA) reveal never-before-seen details in the planet-forming disk around a nearby Sun-like star, including a tantalizing gap at the same distance from the star as the Earth is from the Sun.

This structure may mean that an infant version of our home planet, or possibly a more massive “super-Earth,” is beginning to form there.

The star, TW Hydrae, is a popular target of study for astronomers because of its proximity to Earth (approximately 175 light-years away) and its status as a veritable newborn (about 10 million years old). It also has a face-on orientation as seen from Earth. This affords astronomers a rare, undistorted view of the complete disk.

“Previous studies with optical and radio telescopes confirm that this star hosts a prominent disk with features that strongly suggest planets are beginning to coalesce,” said Sean Andrews with the Harvard-Smithsonian Center for Astrophysics in Cambridge, Mass., and lead author on a paper published in Astrophysical Journal Letters. “The new ALMA images show the disk in unprecedented detail, revealing a series of concentric dusty bright rings and dark gaps, including intriguing features that suggest a planet with an Earth-like orbit is forming there.”

Other pronounced gap features are located 3 billion and 6 billion kilometers from the central star, similar to the distances from the Sun to Uranus and Pluto in our own solar system. They too are likely the result of particles that came together to form planets, which then swept their orbits clear of dust and gas and shepherded the remaining material into well-defined bands.

Earlier ALMA observations of another system, HL Tau, show that even younger protoplanetary disks can display similar signatures of planet formation.

MORE INFORMATION

ALMA image of the planet-forming disk around the young, Sun-like star TW Hydrae. The inset image (upper right) zooms in on the gap nearest to the star, which is at the same distance as the Earth is from the Sun. The additional concentric light and dark features represent other planet-forming regions farther out in the disk. [S. Andrews (Harvard-Smithsonian CFA)/ALMA (ESO/NAOJ/NRAO)]
An Oasis in the Brown Dwarf Desert
Sloan Digital Sky Survey

Most stars in our galaxy have a traveling companion. Often, these companions are stars of similar mass, as is the case for our nearest stellar neighbors, the triple star system Alpha Centauri.

Our Sun, of course, has companions of its own — the planets of our solar system. Planetary companions are vastly different from stellar companions: they are much smaller, and they do not shine with their own light created through nuclear fusion. Even the largest planet in our solar system, Jupiter, would need to be 80 times more massive to even begin to shine this way.

Stuck in the middle are “brown dwarfs,” much bigger than Jupiter but still too small to be shining stars. These brown dwarfs give off merely a dim glow as they slowly cool. The universe is full of stars, and now we know that it is full of planets too. Astronomers expected that the universe would also be teeming with brown dwarfs.

But strangely, that’s not what they had been finding. Although astronomers have found plenty of brown dwarfs floating through space on their own, they found very few as stellar companions. Even in recent years, as new and sensitive detection techniques have allowed them to discover thousands of extrasolar planets, brown dwarfs have remained elusive — in spite of the fact that they should be easier to find than planets.

In fact, until recently, so few brown dwarfs have been found orbiting close to other stars that astronomers refer to the phenomenon as the “brown dwarf desert.” This in turn created a problem for theorists, who have been scrambling to explain why astronomers have found so few. Therefore when SDSS astronomers started sifting through their data looking for brown dwarf companions to stars, they were hoping not to come up completely dry.

“We were shocked to find that so many of the stars in our sample have close-orbiting brown dwarf companions,” says Nick Troup of the University of Virginia, lead author of the paper.

For each of the 41 close-in brown dwarf companions detected previously, the left panel shows the distance to its host star. The right panel shows the 112 brown dwarfs discovered in the new study. In both panels, the sizes of the brown dwarfs indicate their masses, and the circle shows the distance to Earth’s orbit. The larger dot (yellow or red) in the center of each panel represents the host star (not to scale). All the companions were discovered in different systems; they are shown together for comparison only. (SDSS)
Longest-lasting Stellar Eclipse Discovered

Vanderbilt University

Imagine living on a world where, every 69 years, the sun disappears in a near-total eclipse that lasts for three and a half years.

That is just what happens in an unnamed binary star system nearly 10,000 light-years from Earth. The newly discovered system, known only by its astronomical catalog number TYC 2505-672-1, sets a new record for both the longest duration stellar eclipse and the longest period between eclipses in a binary system.

Discovery of the system’s extraordinary properties was made by a team of astronomers from Vanderbilt and Harvard with the assistance of colleagues at Lehigh, Ohio State and Pennsylvania State universities, Las Cumbres Observatory Global Telescope Network and the American Association of Variable Star Observers.

“It’s the longest duration stellar eclipse and the longest orbit for an eclipsing binary ever found...by far,” said the paper’s first author, Vanderbilt doctoral student Joey Rodriguez. The previous record holder is Epsilon Aurigae, a giant star that is eclipsed by its companion every 27 years for periods ranging from 640 to 730 days.

“Epsilon Aurigae is much closer — about 2,200 light-years from Earth — and brighter, which has allowed astronomers to study it extensively,” said Rodriguez. The leading explanation is that Epsilon Aurigae consists of a yellow giant star orbited by a normal star slightly bigger than the Sun embedded in a thick disk of dust and gas oriented nearly edge on when viewed from Earth.

“One of the great challenges in astronomy is that some of the most important phenomena occur on astronomical timescales, yet astronomers are generally limited to much shorter human timescales,” said co-author Keivan Stassun, professor of physics and astronomy at Vanderbilt. “Here we have a rare opportunity to study a phenomenon that plays out over many decades and provides a window into the types of environments around stars that could represent planetary building blocks at the very end of a star system’s life.”

MORE INFORMATION
**Trigger for Milky Way’s Youngest Supernova Identified**

*Chandra X-ray Observatory*

Scientists have used data from NASA’s Chandra X-ray Observatory and the NSF’s Jansky Very Large Array to determine the likely trigger for the most recent supernova in the Milky Way.

G1.9+0.3 belongs to the Type Ia category, an important class of supernovas exhibiting reliable patterns in their brightness that make them valuable tools for measuring the rate at which the universe is expanding.

“Astronomers use Type Ia supernovas as distance markers across the universe, which helped us discover that its expansion was accelerating,” said Sayan Chakraborti, who led the study at Harvard University. “If there are any differences in how these supernovas explode and the amount of light they produce, that could have an impact on our understanding of this expansion.”

Most scientists agree that Type Ia supernovas occur when white dwarfs, the dense remnants of Sun-like stars that have run out of fuel, explode. However, there has been a debate over what triggers these white dwarf explosions. Two primary ideas are the accumulation of material onto a white dwarf from a companion star or the violent merger of two white dwarfs.

The new research with archival Chandra and VLA data examines how the expanding supernova remnant G1.0+0.3 interacts with the gas and dust surrounding the explosion. The resulting radio and X-ray emission provide clues as to the cause of the explosion. In particular, an increase in X-ray and radio brightness of the supernova remnant with time, according to theoretical work by Chakraborti’s team, is expected only if a white dwarf merger took place.

“We observed that the X-ray and radio brightness increased with time, so the data point strongly to a collision between two white dwarfs as being the trigger for the supernova explosion in G1.9+0.3,” said co-author Francesca Childs, also of Harvard. The result implies that Type Ia supernovas are either all caused by white dwarf collisions, or are caused by a mixture of white dwarf collisions and the mechanism where the white dwarf pulls material from a companion star.

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**MORE INFORMATION**

Astronomers had previously identified G1.9+0.3 as the remnant of the most recent supernova in our galaxy. It is estimated to have occurred about 110 years ago in a dusty region of the galaxy that blocked visible light from reaching Earth. ([X-ray: NASA/CXC/CfA/S.Chakraborti et al.])
First Discovery of a Binary Companion for a Type Ia Supernova

Harvard-Smithsonian Center for Astrophysics

A team of astronomers has detected a flash of light from the companion to an exploding star. This is the first time astronomers have witnessed the impact of an exploding star on its neighbor. It provides the best evidence on the type of binary star system that leads to Type Ia supernovae. This study reveals the circumstances for the violent death of some white dwarf stars and provides deeper understanding for their use as tools to trace the history of the expansion of the universe. These types of stellar explosions enabled the discovery of dark energy, the universe's accelerating expansion that is one of the top problems in science today.

The subject of how Type Ia supernovae arise has long been a topic of debate among astronomers. “We think that Type Ia supernovae come from exploding white dwarfs with a binary companion,” said Howie Marion of The University of Texas at Austin (UT Austin), the study’s lead author. “The theory goes back 50 years or so, but there hasn’t been any concrete evidence for a companion star before now.”

Astronomers have battled over competing ideas, debating whether the companion was a normal star or another white dwarf. “This is the first time a normal Type Ia has been associated with a binary companion star,” said team member and professor of astronomy J. Craig Wheeler (UT Austin). “This is a big deal.”

For a long time, the leading theory was that the companion was an old red giant star that swelled up and lost matter to the dwarf, but recent observations have virtually ruled out that notion.

According to team member Robert P. Kirshner of the Harvard-Smithsonian Center for Astrophysics, “If a white dwarf explodes next to an ordinary star, you ought to see a pulse of blue light that results from heating that companion. That’s what theorists predicted and that’s what we saw. Supernova 2012cg is the smoking — actually glowing — gun: some Type Ia supernovae come from white dwarfs doing a do-si-do with ordinary stars.”

MORE INFORMATION
ASP Awarded More Than $2 Million in NASA Education Contracts

The ASP is receiving five years of funding to support three new NASA STEM education projects. In addition, ASP has been awarded a separate NASA Infrastructure Award to continue our work with nearly 500 amateur astronomy clubs comprising the Night Sky Network (NSN). The ASP’s four new NASA contracts are:

- **Reaching for the Stars: NASA Science for Girl Scouts**
  
  “Reaching for the Stars,” led by the SETI Institute in Mountain View, CA, will support the Girl Scout’s efforts to increase STEM interest and engagement among girls.…The ASP will assist in the development of astronomy activities and help train Girl Scout leaders and volunteers and, since we oversee the NASA Night Sky Network, we’ll be partnering amateur astronomy clubs across the country with Girl Scout troops in their towns.

- **NASA Space and Earth Informal Science Education (SEISE)**
  
  The goal of this ambitious and visionary project is to bring NASA science, people, and missions to an existing network of 500 science museums across the country.…The ASP will provide training in science content and pedagogy to the thousands of museum educators across the country responsible for bringing NASA science to their visitors.

CosmoQuest: Engaging Students & the Public through a Virtual Research Facility

This project brings NASA data directly to the people through a series of citizen science projects using mission data.…The ASP’s role...
in this project is to develop these engaging hands-on investigations for the Educator Zone, building on our over 10 years of experience in doing just that for museum educators and amateur astronomers.

The NASA Night Sky Network (NSN)

The ASP will receive funding to support and expand the NASA Night Sky Network (NSN), a dynamic community of more than 470 amateur astronomy clubs across the nation whose members share their time and telescopes to engage the public in observational astronomy. The ASP will also help the 27 newly-funded NASA projects connect with and disseminate to this vibrant and growing amateur astronomy community.

More details are available in the ASP’s February Newsletter.

NEW MEMBERS — The ASP thanks all those who recently renewed their membership, and welcomes new members who joined between January 1 and March 31, 2016.

**Individual**
- Daniel Angerhausen, NASA GFSC, Greenbelt, MD
- Felipe Ardila, Princeton, NJ
- Alan Bako, Orlando, FL
- Danielle Bardenilli, San Francisco, CA
- Lauren Bittle, Charlottesville, VA
- Dr. Kenneth Chambers, Honolulu, Hi
- Sang-Lim Chang, Chicago, IL
- Holly Christenson, Bellingham, WA
- Erin Cox, Urbana-Champaign, IL
- Ryan Cybulski, Amherst, MA
- Bill DeJager, Castro Valley, CA
- Tiara Diamond, NASA GFSC Greenbelt, MD
- Andrew Fagan, Gig Harbor, WA
- Michelle Ferrara Peterson, Claremont, CA
- Patrick Fleming, FPO, AP
- Alexander Gagliano, Blacksburg, VA
- Joel Goodman, Columbia, MD
- Dan Grzenia, San Francisco, CA
- Emily Hardegree-Ullman, Urbana-Champaign, IL
- John Hewitt, Jacksonville, FL
- Timothy Howard, Albuquerque, NM
- Nathan Jean-Louis, Fort Lauderdale, FL
- Regina Jorgenson, Nantucket, MA
- Tanveer Karim, Rochester, NY
- Dhanesh Krishnarao, Madison, WI
- Meagan Lang, Urbana-Champaign, IL
- Jingzhe Ma, Gainesville, FL
- Avinash Marajh, Chaguanaus, Trinidad
- Jennifer Miller, Saint Louis, MO
- Wenli Mo, Gainesville, FL
- Emily Moravec, Gainesville, FL
- Gregory Mosby, Madison, WI
- Robert Palmer, Willmar, MN
- Riwij Pokhrel, Amherst, MA
- Dominique Segura-Cox, Urbana-Champaign, IL
- Darryl Seligman, New Haven, CT
- Joseph Simon, Milwaukee, WI
- Theresa Summer, San Francisco, CA
- Nicholas Troup, Charlottesville, VA
- Sormeh Yazdi, Wellesley, MA
- Jinmi Yoon, South Bend, IN

**Senior**
- Robert Anderson, Olympia, WA
- William Baker, New York, NY
- Darwin Bohnet, Honolulu, HI
- Henry Bouchelle, Newark, DE
- Randolph Byrd, Meridian, ID
- Steve Gay, Paso Robles, CA
- Edward Grastorf, Pacific Palisades, CA
- Gary Hitz, Cottage Grove, MN
- Peter Noerdlinger, Boulder, CO

**Student**
- Elizabeth Apala, Wilburton, OK
- Violeta Czarnecki, Abbotsford, BC, Canada
- Jackson Goldberg, San Mateo, CA
- Adrian Kositanont, Santa Clara, CA

**Family**
- Scott Landry, Yorba Linda, CA

**Technical**
- Dr. Matthew Craig, Moorhead, MN
- Frank Schiffel, Ellensburg, WA
- Geoffrey Stone, Auberry, CA
The Skies of May

The start of the month sees a rare event: a transit of Mercury. As described in the Winter 2016 issue of Mercury, page 27 (go [here](#) to download the issue if you haven’t already done so). The transit occurs on the 9th and is widely visible from most of Earth including the Americas, the Atlantic and Pacific Oceans, Europe, Africa, and much of Asia. For North American observers, PDFs containing predicted contact times and the corresponding altitude of the Sun are available for a number of cities in the US and Canada. Also, Xavier Jubier has a [local circumstances calculator](#) and an [interactive transit map](#) on his website.

The transit of Mercury turns out to be the only time this month you’ll be able to spot the tiny planet, because it’s otherwise lost in the solar glare — as is Venus.

Throughout May Jupiter is high in the south at sunset — on the 14th the planet will sit to the Moon’s upper left. If you’re frustrated trying to see details on the disk of Mars, have a look at this giant planet with its retinue of four large, easy-to-find moons. At least two of Jupiter’s major belts (the dark bands) and zones (the bright bands) will be easily visible. Surprisingly, the Great Red Spot (GRS) may be harder to see. Although large, the GRS is often of low contrast, which can make it hard to find (though recent reports indicate that it’s currently quite a striking orange-pink). Still, you’ll probably need at least a 6-inch scope to spot the Spot. A [Sky & Telescope app](#) is available (you have to sign in to use it and join if you haven’t) that tells you when the center of the GRS should cross the center of the Jovian disk.

As described in the article “Mars in 2016: A Close Approach” (see [page 29](#)), this spring is the time to get out and observe Mars. The red planet is a bright magnitude -2.0 (brighter than Sirius, the brightest star in the night sky), rising just after sunset for most of the month. On the 21st, the red planet is to the right of the full Moon as both rise in the southeast; once you realize how bright Mars is, you’ll have no trouble finding it during the upcoming months. The next evening it’s at opposition, which means it rises as the Sun sets. Closest approach to Earth occurs on the 30th, when it has an apparent diameter of 18.6’.

Saturn follows Mars into the sky, rising roughly an hour after the red planet. On the 22nd the ringed planet sits to the right of the
Moon as both rise in the southeast.

Don’t forget Astronomy Day — Saturday May 14. Your local planetarium and/or science center will have telescopes set up, and if you have a local astronomy club, it’s likely they’ll also have telescopes set up somewhere on that evening.

The Skies of June

Jupiter graces the evening sky, sitting high in the southwest as darkness falls. But it is slowly sliding toward the Sun, and by the end of September, it will be gone. On the 11th, the giant planet will sit to the right of the first quarter Moon.

The red planet Mars continues to glow fiercely in the southeast as dusk fades. Its apparent diameter begins to shrink as it slowly recedes from Earth. But it will remain a good sight in telescopes; see the article on page 29 for more details about observing the red planet. Don’t miss it — July 2018 is the next time Mars will be this close and bright. Although the apparent size of Mars is shrinking, it’s at its highest altitude in the southern sky (for Northern Hemisphere observers) during the late evening, so get out your telescope and have a peek. The Moon is well above the red planet on the 16th and to the left of Mars on the 17th.

On the 18th Saturn is less than 4° to the lower right of the Moon. To the lower right of the pair is pale-red star Antares. Its name means, basically, “the rival of Mars,” so-called because of the star’s reddish hue. But when Mars is brilliant, as it is now, Antares literally pales by comparison. Although the ringed planet is low, its rings are tilted open almost at their maximum of 27°. That will occur next year, but by 2025 the rings will be edge on. Saturn reaches opposition on the 3rd, so it rises at, or shortly before, sunset all month long. It’s also shining at its brightest for 2016. So if you’re having trouble seeing detail on Mars, point your telescope about 20° farther east and enjoy Saturn and its magnificent ring system.

Venus is invisible as it’s right beside the Sun all month. During the first two weeks of the month, Mercury peeks above the eastern horizon about an hour before the Sun. But thanks to the early arrival of twilight in June, this dim little planet remains invisible in dawn’s glow.

Finally, the Solstice occurs at 6:34 pm Eastern Time (3:34 pm Pacific Time) on June 20, which means summer officially begins in the Northern Hemisphere, and winter in the Southern.

The Skies of July

Both Mercury and Venus spend the first half of July completely buried in the Sun’s glow. But they start to emerge at the end of the month. You might try looking for them very, very low in the west shortly after sunset…or you could wait until next month, when the crescent Moon will be your guide to both worlds on August 4.

Giant Jupiter is now an early evening sight, setting more than three hours after the Sun at the start of the month but less than two hours after sunset by month’s end. On the 8th Jupiter will be about 4° to the upper left of the 4-day-old Moon; the pair will make a pretty sight as twilight slowly fades.

Although nicely placed for viewing in the south after sunset, Mars
is beginning to seriously shrink in size and fade in brightness. The red planet remains nicely placed for viewing, low in the south after sunset all month, but surface features are now more challenging to spot than just two months ago. If you’re simply watching Mars, note that it has ceased its retrograde motion and is now heading east against the stars. This month it’ll start to close the gap on Saturn and the reddish star Antares. Mars ends July about 10° west of both objects and passes between them in late August. On the 14th, the red planet is to the lower right of the 10-day-old Moon.

The next evening Saturn is almost directly below the Moon as dusk fades. The ringed world is also nicely placed for viewing and is a fine sight in even small telescopes.

Since our planet’s orbit is slightly elliptical, Earth reaches aphelion, the farthest point in its orbit around our star, on the 4th. If you do the calculation, it means the Sun appears about 3% smaller in our sky at aphelion than it does during perihelion in December, when Earth is closest to the Sun. Practically speaking, you’ll not notice a difference.

Save the Date
Looking ahead, plan to be away from city lights on the night of August 11/12 (Thursday night/Friday morning). That’s the peak evening for the Perseid meteor shower. The Moon will be just past first quarter and setting around midnight, so the darkest skies will be during the early morning hours of the 12th. Usually upwards of 60 meteors per hour grace sky during the peak of this shower, but there seems to be a chance that the rates may be a little higher this year.

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

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

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

Apps For Tablets and Smart Phones. SkySafari 4 ($2.99 for the basic version; available for iPhone, iPad, and iPod touch; now available for Android) is a very well done star chart app and is the one I use consistently. TheSky by Software Bisque is one of the most popular planetarium programs out there, and is now available for the iPad and iPhone. If ASP stargazers have a favorite night sky app, regardless of the device, I’d like to hear about it.

— P.D.
The Origins of a Coma

This March 2016 image of comet 67P/Churyumov-Gerasimenko was taken at a phase angle of about 159°, meaning the comet lay almost directly between Rosetta and the Sun. In this configuration, the nucleus appears back-lit, with only a portion of the illuminated nucleus visible from this angle. The image reveals the bright environment surrounding the comet, displaying beautiful outflows of gas and dust streaming away from the nucleus to eventually form the coma. Courtesy ESA/Rosetta/NAVCAM – CC BY-SA IGO 3.0