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Diversifying the Ranks

I ENCOURAGE YOU to read Dara Norman's Focal Point on page 86. She discusses how the future progress of professional astronomical discovery will benefit by broadening the participation of underrepresented minorities. Much of this also applies to amateur astronomy. Given demographic trends, U.S. amateur astronomy will continue to flourish only if we expand the diversity of its practitioners. It's also incumbent on us amateurs to spread the word about astronomy, because it enriches peoples' lives and broadens their horizons.

This reminds me of a conversation in September, when I attended a large public star party outside Detroit, Michigan. I was introduced to Chuck Jones, an African-American who serves as Vice President of the Ford Amateur Astronomy Club (whose membership is almost entirely white). He asked me why *S&T* hasn't done more to promote racial diversity in amateur astronomy, and that led to a more general discussion with Chuck and several attendees.

I thank Chuck for raising the issue, and I sympathize with the gist of his question. I would love to see more African-Americans and underrepresented minorities participate in amateur astronomy, and I have thought about how *S&T* can play a proactive role.

S&T: GREGG DINDERMAN

The lack of ethnic diversity in amateur astronomy stems from deep-rooted societal and cultural trends. *S&T,* and even a million well-intentioned amateur astronomers, can only make small inroads in addressing the wider problems. But we *can* help. Amateurs can do more outreach in predominantly minority schools and neighborhoods. Some African-Americans might feel discomfort in joining an astronomy club that is 95% white, so members need to be sensitive to these feelings, and provide a welcoming environment (based on my experiences, clubs perform admirably in this area). African-American amateurs can play an important role in outreach, but anyone can serve as a mentor.

I don't have all the answers, but I hope this Spectrum column and Dara's Focal Point at least stimulate more people to think and talk about these important issues. Please share your ideas and success stories with me.

Due to an error at the printing company in Kentucky, pages 87 to 94 were missing from the January issue. These pages included the Market Place ads and Focal Point. As a result, the Northern Hemisphere Sky Chart was not printed on the thick paper. We apologize to our readers and advertisers for any inconvenience caused by the printing error. We'll reprint the Focal Point in the March issue. Pages 87 to 94 can be found at SkyandTelescope.com/missingpages.

Robert Naeye
Editor in Chief

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2012 Hysteria

The 2012 article in your November issue ("The Great 2012 Scare," by E. C. Krupp, page 22) is outstanding! As a member of four astronomy clubs, I can attest to the questions coming in from the public about the supposed December 2012 doomsday. I'm sure your readers are familiar with the "Mars as big as the Moon" hoax we have to deal with every year. Unfortunately, that's nothing compared to what we will have to deal with for the next three years regarding this latest exercise in junk science.

S&T has provided us with a lot of ammunition to fight the junk science and the hysteria it most likely will foster. Thanks for providing a very timely and useful article!

Bob Berta
Macomb Township, Michigan
biker123@att.net

Editor's note: NASA liked Dr. Krupp's article so much that it posted the text on its official website at www.nasa.gov/topics/earth/features/2012-guest.html. The full magazine pages, including the pictures and captions, are available (as a .pdf download) at SkyandTelescope.com/2012.

Attracting Young Amateurs

I am very pleased you've written on a subject many of us in the telescope industry have been concerned about for years: how do we attract new people into astronomy? ("Missing Young Astronomers," December issue, page 8). In my opinion, we need to do a better job of promoting how entertaining observing can be for groups of people. I believe we have all the tools to make our hobby exciting and interesting, but we continue to promote it in the same manner we have for the past 30 years.

Young people have many entertainment choices that require minimal effort to get into, but once in, they are willing to spend hours at a time perfecting their skills. We have to find a "hook" to attract the youth; if we do, a reasonable percentage will remain interested in our hobby.

Write to Letters to the Editor, *Sky & Telescope*, 90 Sherman St., Cambridge, MA 02140-3264, or send e-mail to letters@SkyandTelescope.com. Please limit your comments to 250 words.

Thanks again for beginning a dialog about this subject. I intend to introduce the concept of forming an industry council or trade association to promote the hobby of astronomy.

Joseph A. Lupica, Jr.
Celestron President & CEO

Baby boomers like me grew up with the excitement of the race to the Moon. My little group of high-school friends had the idea that we might hold a get-together on the Moon in 2001. In our first books on astronomy, we read that life on Mars seemed like a near certainty and swamps teeming with life on Venus seemed a definite possibility. If the current crop of 15–25 year olds aren't as interested in astronomy, maybe their low likelihood of ever going to the Moon or seeing Martians has something to do with it.

At some point, space travel may become easier. We may yet find primitive life on Mars or Europa and Earthlike planets in extrasolar habitable zones. We could revive widespread interest in astronomy if space travel and astrobiology start making great strides again.

I volunteer at a small observatory and help with public star parties. I've taught volunteer astronomy classes for my local school district. A lot of younger people become enthusiastic about astronomy when they are exposed to it. But sadly, I have seen a lot of very intelligent and hard-working people put a lot of effort into trying to build a career in science and getting a poor return on their investment. The problem isn't a lack of potential public interest in astronomy and space; it's a lack of funding, hiring, and big exciting action to stimulate that interest.

Frank Grober
garlock57@yahoo.com

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The inspiration for a new generation can be found in the very issue where you bemoan the loss of interest among the young: build planetariums!

Put them in schools, put them in communities, and watch the crowds come in. I recently accompanied my son to the Einstein Planetarium at the Smithsonian Air and Space Museum in DC. I was shocked that the Zeiss projector never made an appearance from its sub-floor cradle. Let us not forget the simple thrills that can captivate people even in the modern age!

Robert Dorsky
Basking Ridge, New Jersey

Editor's note: We're receiving so many thoughtful letters on this subject that we'll use them as a basis for a feature-length article in an upcoming issue. Thank you to everyone who has written to us!

Credit Where Due

Our article on the Wide-field Infrared Survey Explorer (December issue, page 26) might give the misimpression that the authors built WISE. Like all satellites, constructing WISE required many skilled people. The Space Dynamics Laboratory designed, assembled, and tested the WISE instrument, including megapixel detectors from Teledyne Imaging Sensors. Ball Aerospace & Technologies Corporation built the spacecraft bus using electronics from the Southwest Research Institute, integrated the instrument to the bus, and tested the completed satellite.

Peter Eisenhardt and Ned Wright
Pasadena, California

For the Record

- *Pages 87 to 94 were missing from the January 2010 issue (see page 6 of this issue for more details).*
- *On page 34 of the January issue, the small box for the Easter Island Tour should have said "flight" instead of "cruise."*
- *In the December issue, page 59, the December minima-of-Algol times are off. The December times listed in the January issue are correct.*

50 & 25 Years Ago

Leif J. Robinson

February 1960

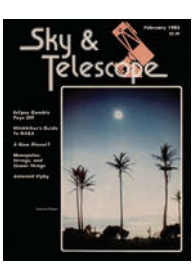
Polaris as Pole Star "As the north celestial pole describes its giant circle of precession in the sky, requiring 25,800 years for one revolution, when will it pass nearest to the North Star, Polaris, and how close? . . .

"[Charles Smiley and Abdul Khan] find the mean polar distance of Polaris will be least in the year 2102 [with a] value then of 0° 27′ 31″.50. . . ."

From more accurate positional data, Jean Meeus has refined the calculation. He finds closest approach will take place in March 2100, with Polaris 27′ 09″ from the pole.

February 1985

Famous Telescope Neglected "I was startled to read . . . that the 36-inch Clark objective of the Lick Observatory was not successfully refigured and should be stopped down to 22 inches. In October, 1964 . . . I had the opportunity to make a quick evaluation of this lens. Not only did the front surface show an appreciable diffusion due to devitrification of the glass, but . . . I was able to obtain a rough sketch of the wavefront showing roughly a quarter-wave overcorrection of the original Clark figuring. . . .



"It is a pity that the Lick objective has not received better treatment."

The writer, Jean Texereau, was one of the giants of 20th-century astronomical optics.

A Dim Outlook "Two German astronomers have compiled the first comprehensive catalogue of the dark nebulae and globules found in the southern skies. . . . Recording all dark clouds greater than 0.01 square degree between galactic longitudes 240° and 360°, they found that only 1.92 percent of the southern sky is obscured, compared with 4.98 percent of the northern sky."

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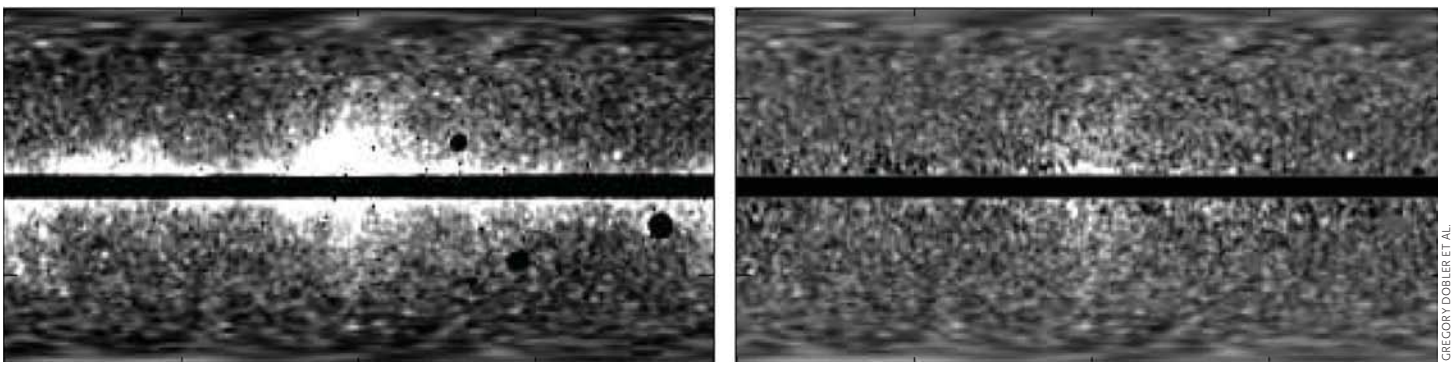
Closing In on Dark Matter?



GREGORY DOBLER ET AL.

Left: **This all-sky map, aligned on the Milky Way, shows gamma-ray emission seen by Fermi.** ***Right:*** **When all known types of sources are eliminated, a mysterious central haze remains.**

We know it's out there, but what is it? The universe has about six times as much "nonbaryonic dark matter" as all ordinary matter combined. Its gravitation is obvious, but its nature remains one of the greatest mysteries in science — even as various experiments attempt to capture bits of it (*S&T:* April 2009 cover story).

Now the Fermi Gamma-ray Space Telescope has confirmed a much-anticipated clue. A haze of very hard gamma radiation (2 to 50 GeV) indicates that very-high-energy electrons fill the central portion of our galaxy, where dark matter ought to be densest. The speedy electrons seem to originate not from known types of events such as supernova shock waves, but from some widespread process that gives them an even greater kick.

The most popular theory for dark matter is that it's made of the invisible particles predicted by the "supersymmetry" model of physics. The lowest-mass supersymmetric particles, called neutralinos, would annihilate when they encounter each other, producing high-energy electrons and positrons that would seem to pop out of nothing. Is this the source of Fermi's mystery haze?

"It's very easy to produce this kind of a signal with dark matter," says Doug Finkbeiner (Harvard-Smithsonian Center for Astrophysics), who analyzed Fermi's data with Greg Dobler and others. "It's not so easy to do it with other things."

Other scientists urge caution. "While this work is certainly interesting, it's premature to draw any conclusions, especially if it requires exotic physics," says Fermi science-team member Simona Murgia. "The gamma-ray sky is very complex."

One catch: the expected rate of neutralino annihilations is much too low to create the observed gamma-ray haze. So theorists have proposed a new force between dark-matter particles that makes them attract — a so-called "dark force." But scientists take a dim view of theories that keep needing arbitrary add-ons.

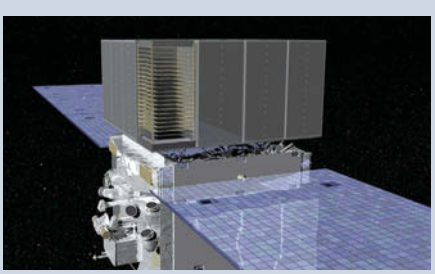
Even so, Fermi's finding adds to a sense that the secret of dark matter may soon be cracked. Efforts to detect it in underground experiments, such as XENON100 and LUX, and to produce it in the Large Hadron Collider, should at least narrow the range of dark-matter candidates.

A Limit on Space-time Foam

Fermi (pictured at right) is producing other news in esoteric physics. Quantum mechanics seems to require that space-time is not smooth and continuous, but irregular and foamy on the extremely submicroscopic scale of 10^{-33} centimeter. This is vastly too small to see directly. But if spacetime is foamy *enough,* it should cause very-high-energy gamma rays to travel just a trace under the speed of light.

Last June we reported that Fermi saw a very high-energy photon arriving from a gamma-ray burst 9 seconds late, after racing its lower-energy companions for 12.2 billion years. Was this a quantum space-time slowdown?

Apparently not. Fermi has detected another high-energy short gamma-ray burst, this one 7.3 billion years old, and its highest- and lowest-energy photons arrived in synch. Says Fermi scientist Peter Michelson, "This measurement eliminates any approach to a new theory of gravity [i.e. spacetime] that predicts a strong energy-dependent change in the speed of light."



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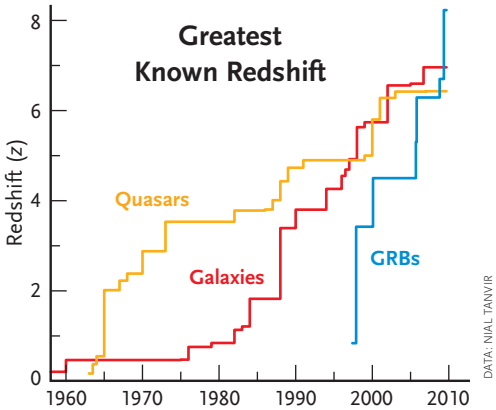


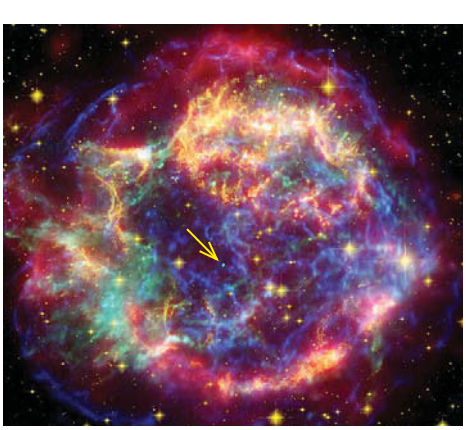
The Redshift-Record Race

Although the refurbished Hubble recently found signs of galaxies at redshift 8.5, the most distant *confirmed* object is still the gamma-ray burst seen last April 23rd at redshift 8.2. GRB 090423 happened when the universe was only about 630 million years old and stars and galaxies were new.

Future redshift record-breakers are likely also to be gamma-ray bursts (GRBs) if trends continue. The graph above, by Nial R. Tanvir (University of Leicester), charts the last half century of redshift record-holders among galaxies, quasars, and GRBs. This last category has been gaining by the biggest leaps and bounds.

The 4-inch Carbon Atmosphere of Cassiopeia A

The Cassiopeia A supernova remnant, pictured below, is only about 330 years old. It was born when a massive star reached the end of its nuclear rope and blew itself to bits. Left in the remnant's center is the youngest known neutron star (arrowed), and this object has presented astronomers with a problem. Based on its X-ray brightness, spectrum, and known distance, it should be only about 10 kilometers across or less. That's a little smaller than any neutron star can be, according to how physics tells us neutron stars ought to be structured. What's going on? Could its insides be made of hypothetical "quark matter" instead of neutrons?



X-RAY: NASA / CXC / SAO. OPTICAL: NASA / STSCI. INFRARED: NASA / JPL-CALTECH / STEWARD / O.KRAUSE *ET AL.*

Two theorists now show that you don't need any such exotic physics. If the star has a hot atmosphere of carbon rather than hydrogen or helium, its brightness corresponds to a neutron star about 24 to 30 kilometers across — right in line with the normal size, if you can call a neutron star "normal."

And carbon is reasonable to expect. Such a *young* neutron star should still be so hot that hydrogen and helium might fuse into carbon right on its exposed surface. The star's gravity should be so intense that it compresses the stellar atmosphere to be just 4 inches (10 cm) thick, enhancing its density and the rate of nuclear fusion.

The image of Cas A here combines a mid-infrared view from the Spitzer Space Telescope (red), a visible-light image from the Hubble Space Telescope (yellow), and X-ray images from the Chandra X-ray Observatory (green and blue). The neutron star appears at only the high energies.

And Then There Were 400

Last October, Europe's lead team of exoplanet hunters unveiled a list of 30 new planets (and two brown dwarfs) orbiting main-sequence stars — bringing the exoplanet catalog up to 403 worlds. The group said their statistics indicate that at least 40% of Sun-like stars have planets with less than a sixth the mass of Jupiter.

But don't expect the total to stay near 400 for long. In early January, scientists with NASA's Kepler mission should announce a whole flotilla of new exoplanets seen transiting their stars. These early finds by Kepler should be mostly hot, fast-orbiting objects, since these reveal themselves with multiple transits soonest. Some large ones may prove to be red-dwarf stars rather than planets. But for objects with small silhouettes, planets are the only things they can be.

Phoenix in the Winter Snow

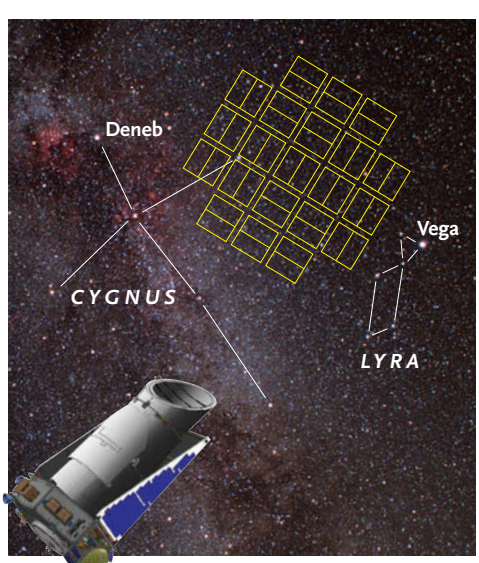
NASA's Phoenix polar lander on Mars has been quiet for more than a year, after it succumbed to the circuit-cracking cold of the approaching Martian winter. But it's still sitting on its flat plain among the low Scandia Hills. As the Sun crept above the horizon with the return of Martian spring, the orbiting HiRISE camera managed to image Phoenix amid dry-ice snow. The entire plain was covered with several inches of frozen carbon dioxide. In the image above, contrast has been greatly boosted to emphasize texture differences in the CO_2 snow and ice.

NASA / JPL / UNIV. OF ARIZONA

The weight of this Martian wintry mix almost certainly broke off the lander's solar panels, even if by some chance the cold didn't destroy the electronics. But NASA controllers still planned to signal the craft to wake up, just in case.

Kepler's Detectors: The Facts

A story has gone around the internet that NASA's Kepler telescope (below), launched last March to find planets as small as Earth transiting their stars, has been par-



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tially crippled by noisy circuitry. As with many internet rumors, there's truth and there's exaggeration. The electronic noise affects three of Kepler's 84 data channels from its 42 imaging chips; the other 81 channels are fine. And mission controllers are storing the data from the faulty three with the expectation that they can write algorithms to clean it up.

Kepler is continuously monitoring 100,000 stars in a 105-square-degree patch of sky between Vega and Deneb for any tiny dips in their light. The positions of Kepler's imaging chips are mapped on the sky photo on page 14. The mission should continue for at least 3½ years. ✦

News Note stories are presented in greater depth, with links to further information, at SkyandTelescope.com; search on SkyTelFeb10.

Mission Update

Jonathan McDowell

Space Astronomy in 2010

Although 2010 looks to be a fairly light year for launches of new astronomy missions, plenty of science will be done by craft already up. Here are some events to look forward to in the upcoming months:

The year should begin with the exciting WISE infrared sky-survey satellite (December-issue cover story) completing its orbital checkout after a scheduled December 9th launch (good luck, Ned, Pete, and Amy!).

In February the Solar Dynamics Observatory (SDO) will take off to monitor the Sun from geostationary Earth orbit (January issue, page 22).

In May Japan will launch the Venus Climate Orbiter, recently named Akatsuki ("Daybreak").

In June the Japanese Hayabusa probe will return from its seven-year asteroid voyage and land in the Australian desert, perhaps with traces of an asteroid surface sample intact.

Rosetta, which made its final flyby of Earth in November, will pass the big asteroid 21 Lutetia on July 10th. And EPOXI, the former Deep Impact flyby spacecraft, will whiz past Comet 103P/Hartley-2 on October 11th.

Many more astronomy missions continue their work on a daily basis. An inventory, by location:

• In Earth orbit, the Hubble Space Telescope heads up a small flotilla of visible-light, infrared, and ultraviolet observatories including Canada's MOST, France's COROT planet finder, and Japan's infrared AKARI. The X-ray sky continues to be served by the great Chandra and XMM-Newton observatories, along with Suzaku, the Rossi XTE (nearing the end of its long life), and the MAXI package (in its prime) on the International Space Station. Fermi and Integral continue to survey the gamma-ray sky.

SDO is joined in Sun studies by Koronas-Foton, TRACE, SORCE, RHESSI, and Hinode, as well as the ESA Solar package on the Space Station. IBEX charts the mysterious band of particles emanating from the edge of the solar system. The PAMELA experiment studies positrons aboard the Resurs-DK satellite.

• Around the Earth-Sun L_1 Lagrangian point, the elderly SOHO and ACE sentinels monitor the Sun. Around L_2, WMAP and Planck compete to return the best data on the cosmic microwave background, while Herschel gets down to its program of deep far-infrared observing.

• In lunar orbit, the Lunar Reconnaissance Orbiter continues mapping away; see page 28.

• In orbit around the Sun, Kepler and Spitzer maintain their astronomical observing programs, and STEREO A and B watch at the Sun from their different viewing angles. In addition to Rosetta and EPOXI, Stardust, Dawn, Messenger, and New Horizons continue toward targets they will reach within the next five years.

• At Mars, Opportunity continues to traverse the Martian sands, though its twin rover Spirit may be bogged down for good. In Martian orbit, Mars Odyssey, Mars Express, and Mars Reconnaissance Orbiter look down from above.

• Venus Express orbits Earth's cloudy sister.

• At Saturn, the 13-year-old Cassini spacecraft is extending its hugely productive exploration of the planet, its rings, and especially its many moons.

• Finally, the two Voyagers, launched way back in 1977, are still heading outward, taking readings at the boundary of interstellar space.

NASA / JPL / SPACE SCIENCE INSTITUTE

On November 2nd, the enormously successful Cassini probe made its seventh flyby of Saturn's moon Enceladus — and its deepest plunge yet through the vapor-and-ice plumes jetting from the moon's south polar region. On its way in, Cassini took this image of the plumes backlit by the Sun. Half of Enceladus's night side glows dimly by yellow Saturnshine.

Ave Atque Vale

I started reading this magazine when I was a teenager, and it's been a blast to actually see my name in it each month for the past 16 years. When I began the Mission Update column in 1993, I was a relatively junior scientist and still had free time on evenings and weekends. But, in a little-known cosmological effect, as the universe evolves and expands, one's personal time shrinks.

I have therefore reluctantly decided to lay down my pen (okay, keyboard) and bid farewell to the pages of *Sky & Telescope*. However, you can still keep up with astronomy-from-space happenings in News Notes, which will expand to fill this location. I've promised to send editor-in-chief Bob and his crew hot tips that I come across. And I remain onboard as a Contributing Editor.

I hope you'll also occasionally drop by my ever more irregularly updated Jonathan's Space Report, at **www.planet4589.org**.

— Jonathan McDowell

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NASA Slams the Moon

J. KELLY BEATTY

S&T: CASEY REED

NASA's "crash and splash" gambit dredged up water from a darkened lunar crater — but not nearly as much as scientists expected to find.

IF YOU LOOK UP "DRY" in a dictionary, you won't find the Moon's picture next to the definition — but it should be. By the mid-1970s, the dusty rocks returned by six teams of Apollo astronauts and three Soviet robotic missions had all but certified that the stark lunar landscape contains no water whatsoever.

Yet comets *do* slam into the Moon now and then, bringing water and a host of other volatile compounds. Where does it all go? In 1979 geochemist James Arnold revived a radical idea first proposed two decades earlier: Some of the water from those collisions should become "cold-trapped" in the frigid floors of craters near the lunar poles, where — by a quirk of orbital geometry — the Sun never shines.

If water actually accumulates in these inky recesses, how can we tell it's there? Photographs of the craters' floors showed only blackness, and other efforts to probe them proved inconclusive or contradictory. For example, during the 1990s the Clementine and Lunar Prospector

orbiters found tantalizing indirect evidence that deposits of frozen water might lie below a foot or two of lunar grit near the poles, yet in 2003 radar scans with the giant Arecibo dish found nothing of the sort.

It turns out that the Moon isn't as absolutely bone dry as had once been thought. Alberto Saal (Brown University) and others recently found trace amounts of water in little beads of a rare volcanic glass that erupted onto the lunar surface billions of years ago (*S&T:* July 2008, page 14). Meanwhile, spectrometers on three spacecraft have detected water molecules clinging to surface rocks across much of the lunar landscape (January issue, page 16).

But if humans are ever going to call the Moon home, they'll need more than whiffs of water to survive, so the exploratory focus keeps returning to those enigmatic polar shadows and what kind of icy cache might lie hidden within them.

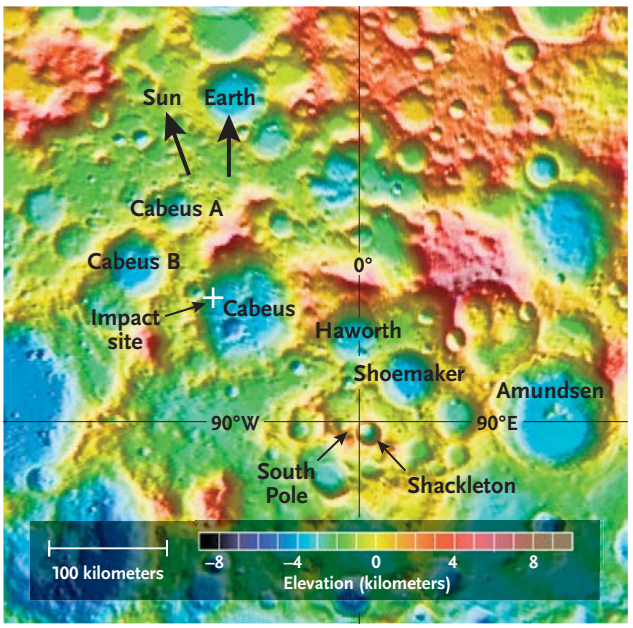
The Bullet

A few years ago scientists and engineers at NASA's Ames Research Center designed a mission to help settle the debate (*S&T:* June 2009, page 20). Their concept was simple: Slam a big enough bullet into a permanently shadowed lunar crater, and the resulting plume of debris should be infused with water vapor that can be detected and measured spectroscopically once it rises into sunlight.

If only it had been that easy!

What became the Lunar Crater Observation and Sensing Satellite (LCROSS) started its mission smoothly enough. Last June 24th the spacecraft hitched a ride atop an Atlas V booster and a Centaur upper stage that combined to propel NASA's Lunar Reconnaissance Orbiter (the primary payload) toward the Moon. LRO soon separated and, five days later, eased itself into lunar orbit. Meanwhile, the Centaur remained attached to LCROSS, which carried the brains and maneuvering thrusters needed to steer the spent rocket to its target. The coupled craft swung past the Moon, coasted onto a looping trajectory, and awaited a climactic return encounter.

Their ride got bumpy in late August, when wild firings of LCROSS's thrusters squandered more than 300 pounds (140 kg) of fuel before engineers regained control. Enough



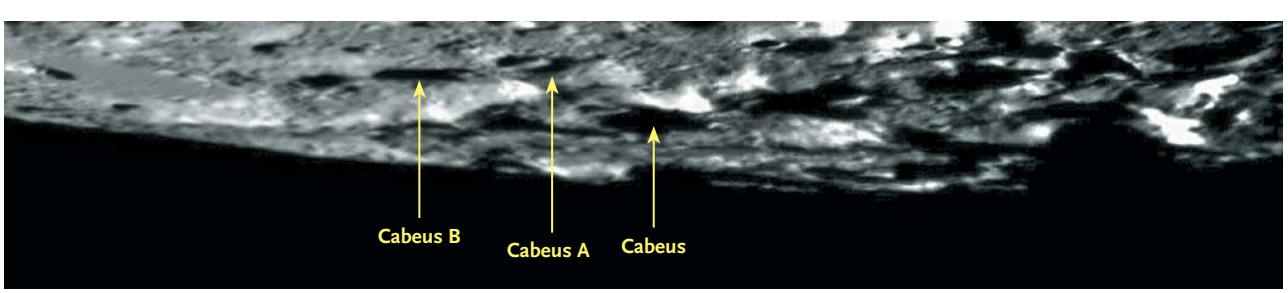
NASA / GODDARD SPACE FLIGHT CENTER

Using a laser altimeter aboard the Lunar Reconnaissance Orbiter, researchers have constructed this map of the terrain near the Moon's south pole. Note how the large ridge on the rim of Cabeus blocks the LCROSS impact site from view on Earth.

remained, barely, for the spacecraft to line up the Centaur on its eventual lunar target. The pair separated about 9 hours, 40 minutes before impact.

The late-June launch favored a southern aim point. Back on Earth, NASA managers argued over which crater would likely yield the most water. The final targeting decision relied heavily on scouting reports from LRO instruments, particularly its Russian-built Lunar Neutron Exploration Detector, which senses where hydrogen (in water, presumably) is concentrated in the lunar landscape.

But LEND was sending back mixed messages. According to principal investigator Igor Mitrofanov (Space Research Institute, Moscow), the strongest hydrogen counts were generally *not* associated with the areas that never see the Sun. One of the few shadowed sites that passed the "LEND test" was Cabeus, an obscure crater at latitude 85° south that's 61 miles (98 km) across, and it eventually got the managers' nod.



NEW MEXICO STATE UNIVERSITY

This view of the Moon's south pole, taken with a 24-inch telescope, closely matches the lighting geometry and libration seen from Earth at the time of LCROSS's impact. The LCROSS team initially targeted a spot within Cabeus A but later switched to Cabeus.

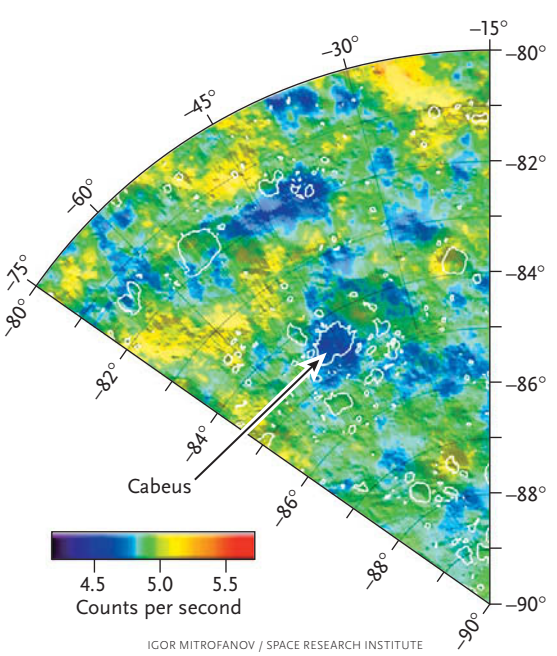
Just as critical was the Centaur impact's timing — October 9th at 11:31 Universal Time. At that moment LRO would be almost directly over the crash site, just 48 miles up, and a waning gibbous Moon would be high in the night sky for giant telescopes in Hawaii, California, Arizona, and New Mexico. Also looking on would be the Hubble Space Telescope, Odin (a Swedish satellite equipped to detect water), and two Earth-imaging satellites swung toward the Moon. Legions of amateurs also trained scopes on the Moon's south pole.

Much Ado About Something

Right on schedule — and, more critically, on target — the Centaur slammed into Cabeus at 1½ miles per second. Four minutes later, after flying through the debris cloud raised by the rocket's crash, the instrument-laden, 1,300-pound (600-kg) shepherd craft augered in not far away.

Thanks to NASA images streamed live over the internet, the world watched for lunar fireworks. But as space spectacles go, the LCROSS impacts were a bust (see page 18). No incandescent flash lit up the monitors in mission control, nor did billowing plumes of dust stream upward into the sunlight and into view of telescopes back on Earth. Astronomers sifted through flat-lined observations from Hubble, Keck, Gemini, Subaru, and other giant eyes, looking in vain for any trace of the event.

It didn't help that telescopic views of the impact sites were blocked by a high ridge along Cabeus's Earth-facing rim. The plume had to rise at least a mile before it popped into sunlight — and by then, apparently, it had become too diffuse to show up. The only positive sightings from Earth involved a pulse of sodium added to the Moon's tenuous exosphere.



IGOR MITROFANOV / SPACE RESEARCH INSTITUTE

Scientists can indirectly sense the presence of water on the Moon by mapping the "slow" neutrons knocked off its surface by cosmic rays. Fewer neutrons imply the presence of more hydrogen atoms (presumably in water). This data from LRO's Lunar Neutron Exploration Detector shows that Cabeus (arrowed) exhibits strong hydrogen abundance.

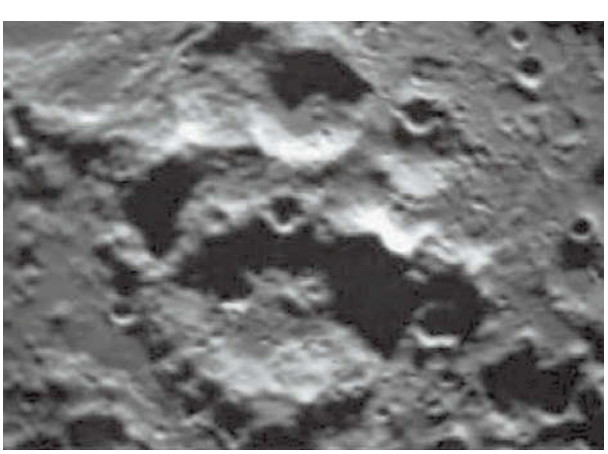
DOMINIC HART / NASA-AMES

LCROSS scientists Anthony Colaprete and Kimberly Ennico review early results from the Centaur and spacecraft impacts.

Fortunately, nothing blocked the view of the nine cameras and spectrometers aboard the LCROSS shepherd, which trailed the rocket by about 400 miles. Instruments aboard LRO also had front-row seats. "We are blown away by the data returned," exclaimed LCROSS chief scientist Anthony Colaprete (NASA/Ames Research Center) one week after the mission's culmination. Instruments had detected a flash when the Centaur hit, the rising plume of hot debris that followed, and the crater left behind. In that sense the mission was a smashing success.

The rocket's impact gouged out a pit about 70 to 100 feet (20 to 30 m) across, in line with expectations. A splash of debris extends another few hundred feet beyond the crater rim. But the incandescent flash created by the Centaur's impact was only a third as bright as predicted, a dim blip that the team struggled to find amid the underexposed camera frames.

The debris plume's size and height also roughly matched expectations, growing to about 6 miles across in the first 20 seconds after the impact. But it's now clear that the mass of material tossed from the crater was nowhere close to the 350 tons suggested by some modelers.



NASA

A near-infrared camera aboard LCROSS recorded this view of Cabeus minutes before the spacecraft crashed into it.

Based on small-scale hypervelocity experiments conducted at NASA Ames, impact specialists Peter Schultz and Brendan Hermalyn (Brown University) argue that a low yield should have been expected — both because the empty Centaur collapsed into itself as it hit and because the spray of debris went mostly "out" instead of "up." This explains why the plume remained hidden behind the high ridge and out of view of the telescope armada on Earth.

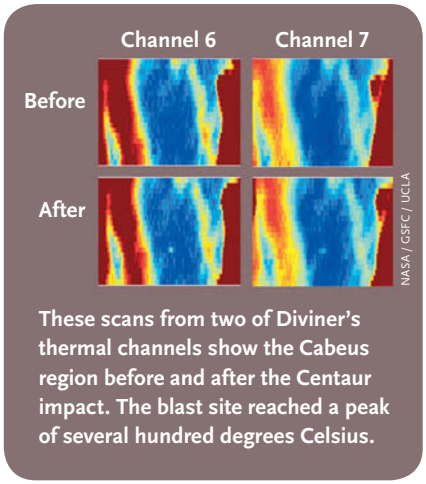
It's also possible that the Centaur pancaked into the crater's floor, instead of hitting nose first. "It was definitely rotating or tumbling," notes observer Marc Buie (Southwest Research Institute), who tracked the rocket's final hours with the 2.4-meter reflector at Magdalena Ridge Observatory in New Mexico.

A Strange Brew

Not until mid-November, after poring over the results for several weeks, was Colaprete finally able to announce that two LCROSS instruments had seen clear evidence of water vapor in the towering plume of hot dust and gas. An infrared spectrometer recorded two distinct water absorption bands at 1.4 and 1.85 microns, and another spectrometer registered ultraviolet emission lines from 306 to 310 nanometers — telltale tracers for hydroxyl (OH) radicals created when water molecules dissociate in sunlight.

So there *is* water, at least within Cabeus, and as Colaprete said during a November 13th press briefing, "We didn't just find a little bit, we found a significant amount." He estimates that the part of the plume in the instruments' field of view contained about 220 pounds (100 kg) of water vapor, about 25 gallons if it were liquid. Clearly, there's no giant slab of ice lying beneath the crater's floor. Instead, the water is mixed with (and perhaps chemically bound to) the rubbly mix of dust and larger particles. Estimating the plume's ice-to-rock ratio will be challenging because researchers must determine how much debris was excavated and how much of that was observed.

LCROSS found other spectral fingerprints besides water — apparently the blossoming debris cloud had other interesting "flavorings" mixed in. Mission scientists are still combing through their spectra, but candidate compounds include carbon dioxide (CO_2), carbon monoxide (CO), and various hydrogen-bearing molecules such as methane (CH_4), methanol (CH_3OH), and ethanol (C_2H_5OH). The team has ruled out contamination from the Centaur itself.

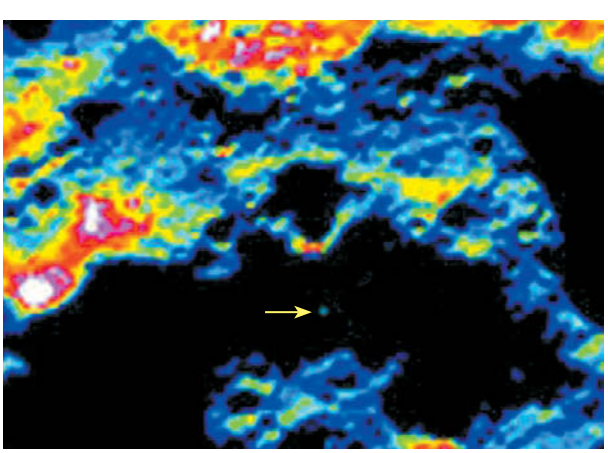


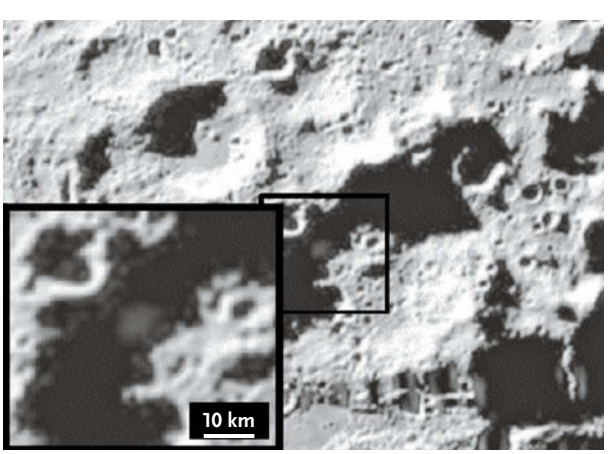
These scans from two of Diviner's thermal channels show the Cabeus region before and after the Centaur impact. The blast site reached a peak of several hundred degrees Celsius.

"The full understanding of the LCROSS data may take some time; the data are that rich," says Colaprete, who adds that with methanol in the water, he would not drink it until it was purified.

Geochemists had a hunch that the crash might dredge up a strange brew. They'd been tipped off back in mid-September by Diviner, an LRO instrument designed to map surface temperatures. Its sensors found that the polar regions are far colder than expected, as low as 35 K (–397°F) in some spots. As improbable as it is remarkable, the shadowed floors within Cabeus and its neighbors are the most frigid places known in the *entire solar system!* According to Diviner principal investigator David Paige (UCLA), "The temperatures in these super-cold regions are definitely low enough to cold-trap water ice, as well as other more volatile compounds, for extended periods."

So what else might be lurking in the lunar shadows? One tantalizing candidate comes from LRO's Lyman-Alpha Mapping Project instrument. LAMP probed the ultraviolet spectrum of the impact plume after it had





Left: **From an altitude of about 400 miles, LCROSS's mid-infrared camera caught a faint thermal signature when the Centaur rocket slammed into Cabeus.** ***Right:*** **A visible-light camera on LCROSS's shepherding craft captured the post-impact plume of debris.**

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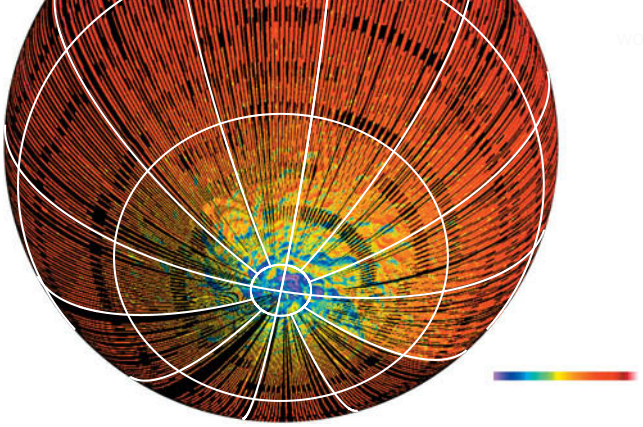


Diviner, an instrument aboard the Lunar Reconnaissance Orbiter, revealed that, even during daytime, shadowed areas near the Moon's north pole have the lowest temperatures ever measured in the solar system: 35 K (–397°F).

Top: **A near-infrared spectrometer aboard LCROSS recorded several notches (yellow regions) in the ejecta plume's spectrum, which correspond to absorption by water vapor.** ***Above:*** **An ultraviolet/visible spectrometer recorded several emission lines resulting from solar ultraviolet light breaking water molecules apart into hydroxyl (OH) molecules and free hydrogen (H).**

risen high enough to be projected against black space above the lunar limb.

"We definitely saw something," notes LAMP scientist Randy Gladstone (Southwest Research Institute). But that "something" wasn't water. Nor was it oxygen or hydrogen atoms, both of which have strong ultraviolet emissions. There's some hint of hydrogen molecules (H_2) — and though water might be the source, it could also have come from exotic ices such as ammonia (NH_3) or methane, or solar-wind gas trapped in the lunar soil.

LAMP's strongest and most intriguing detection came at the wavelength of 184 to 185 nanometers. Gladstone says the only known elements able to create that particular spectral line are iron, perhaps magnesium . . . and mercury. "Both mercury and iron still look like the best bets for explaining the plume emission we see with LAMP," explains Gladstone, though the match remains tentative and more data-crunching is in progress.

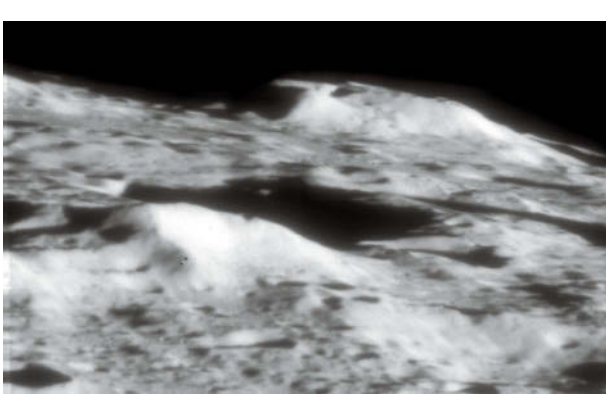
Liquid mercury on the Moon?

In an obscure, decade-old article titled "Don't Drink the Water," George W. Reed, Jr. (then at Argonne National Laboratory) describes how mercury was found in drill tubes of lunar regolith returned by the crews of Apollos 12, 15, 16, and 17; other work suggests it might be present in the Moon's wispy-thin exosphere as well.

No matter what its source, Reed concluded, some of this mercury must end up as deposits in the ultracold interiors of permanently shadowed lunar craters. Moreover, the Centaur slam only needed to heat the target area to about 400 K (260°F) to release any mercury trapped in the dark dirt. Thermal imaging from Diviner argues that the impact site probably got that hot and then some, though analysis of its data continues. Paige notes that it still glowed at least 300 K 90 seconds after the impact.

Now that LCROSS has come and gone, it's still unclear how much water exists on the Moon, how it is distributed, or where it came from. As Paul Spudis (Lunar and Planetary Institute) points out, this mission "presupposed that we understood the Moon well enough to identify in advance the most likely site for ice." Yet, he continues, we still don't know where all the ice deposits are located or what other compounds might be present.

All of that said, last October's splashy LCROSS spectacle represents a first step in obtaining answers to those important questions. ✦



ANTONIN BOUCHEZ / PALOMAR OBSERVATORY

Despite rock-steady views, Palomar Observatory's 200-inch reflector saw no hint of a debris plume emerging from behind the large foreground ridge that marks Cabeus's rim. The field of view in this infrared image is 40 arcseconds wide, corresponding to 44 miles (71 km).

Senior contributing editor ***J. Kelly Beatty*** *always has a drink handy when he observes the Moon. He thanks LCROSS and LRO scientists for sharing their preliminary results as this story was going to press.*

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Dennis di Cicco

Starizona's HyperStar

This accessory almost makes "snapshot" deep-sky astrophotography a reality.

Celestron's Fastar-compatible Schmidt-Cassegrain telescopes (SCTs), such as the 14-inch model seen here, are ready-made for Starizona's HyperStar system. And selected other Celestron and Meade SCTs can be modified to use it. Either way, it takes only seconds to swap the scope's secondary mirror for the HyperStar lens assembly, turning the scopes into prime-focus f/2 astrographs.

ALL PHOTOS ARE BY THE AUTHOR WITH IMAGE PROCESSING BY SEAN WALKER

Starizona's HyperStar

US price: from $595
(model tested costs $1,295)
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Tucson, AZ 85704
520-292-5010
http://starizona.com

"Fun." It almost seems unfair to summarize something as sophisticated at Starizona's HyperStar, which transforms selected f/10 Schmidt-Cassegrain telescopes into incredible f/2 astrographs, with a simple three-letter word, but "fun" is what keeps coming to mind when I think about my time testing this product last summer and fall.

And why wouldn't it be fun? I took up the hobby of astrophotography when the fastest color film had a speed rating (then called ASA) of 160, and even my shortest exposures for deep-sky objects were measured in tens of minutes. With HyperStar and my Nikon D300 DSLR camera set to ISO 200, typical exposures were measured in tens of *seconds*! Indeed, the longest individual exposures used for any of the images accompanying this review were only 2 minutes. That's brief enough for me to dispense

with guiding, and in many cases I wouldn't have even needed a polar-aligned, equatorial-mounted telescope; altazimuth tracking would have been sufficient. You can't make deep-sky photography much more fun than that.

What is HyperStar?

In short, HyperStar is a lens assembly that replaces the secondary mirror of an f/10 Schmidt-Cassegrain telescope (SCT), converting the optical system into a prime-focus astrograph with a focal ratio of approximately f/2 (the f/number depends on the particular telescope). Starizona currently offers HyperStar systems for 6-, 8-, 11-, and 14-inch Celestron scopes and Meade's 10- and 14-inch SCTs. HyperStar works with many astronomical CCD cameras, and some models work with DSLRs.

Not all SCTs are compatible with HyperStar, and Starizona's website gives details on which scopes are and aren't supported. The easiest scopes to use with HyperStar are Celestron models that carry the Fastar name, or are specified as Fastar compatible (this includes the newly introduced Edge HD scopes). All of them have secondary-mirror holders ready-made for HyperStar — it takes barely a minute to unscrew a retaining ring, remove the mirror, and screw on HyperStar. You can convert back to the scope's normal configuration in an equally short time. Another HyperStar plus for Celestron's Fastar-compatible scopes is that their optical components are mounted with tighter mechanical tolerances than regular SCTs, since the HyperStar system doesn't have all the flexibility of collimation available when the scopes are fitted with their adjustable secondary mirrors.

All compatible Meade and non-Fastar Celestron SCTs require a conversion kit from Starizona that replaces the mechanical assembly for the scopes' secondary mirrors. Meade scopes that have the new Advanced Coma Free (ACF) optics are incompatible with HyperStar.

In addition to his DSLR, the author used a Quantum Scientific Imaging 583 camera with a Kodak KAF-8300 CCD. It was noteworthy for its compact size and internal filter wheel. Other cameras with the monochrome KAF-8300 chip would have needed an external filter wheel that blocks more of the scope's aperture and uses larger, more expensive filters than the QSI camera.

The 1½°-wide field recorded by the KAF-8300 chip and the author's setup was ideal for shooting large deep-sky objects such as the Andromeda Galaxy, M31. This view was assembled from sets of five 2-minute exposures made through red, green, and blue filters.

It's worth interjecting a historical note here. The HyperStar concept originated with Celestron in the late 1990s when the company developed its line of Fastar scopes and auxiliary optics called the Fastar Lens Assembly. While Fastar-compatible scopes continue today, Celestron discontinued its Fastar lens system about five years ago when Starizona introduced the functionally identical HyperStar. The line has been expanded to now include models for DSLRs and other large-chip cameras.

Because the HyperStar lens and your camera are mounted directly on the SCT's corrector plate, they form part of the telescope's "central obstruction." While the HyperStar's diameter isn't much bigger than that of the secondary mirror it replaces, cameras can be much larger. Even so, the conventional wisdom circulating among visual observers that says it is important to keep a scope's central obstruction as small as possible is not applicable to imaging setups. Indeed, many of the optical designs for today's high-end imaging telescopes have central obstructions approaching, and sometimes exceeding, 50% of the aperture's diameter.

The only caveats that go with the HyperStar system

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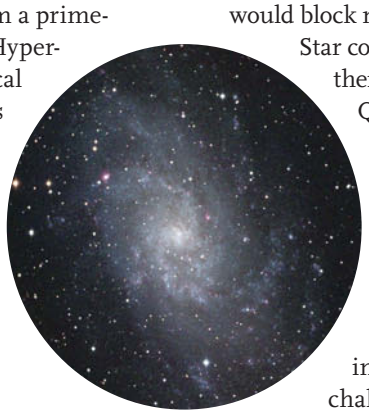
While it might not garner any awards in an astrophotography contest, this HyperStar image of the Double Cluster in Perseus is a 10-second exposure with the 14-inch Celestron and a Nikon D300 DSLR camera set to ISO 200.

involve the lens assembly and camera extending far out from the front of the scope. This presents a considerable lever arm that's rigidly attached to the corrector plate. You need to be very careful moving around the front of the telescope, since a hard bump to the camera could spell disaster for the corrector. You also need to be cautious with any wires running to the camera, especially if you have a Go To telescope. Snagging a wire could tug on the camera hard enough to prove fatal to the corrector.

The Joys of f/2

Apart from the topic of camera lenses, about the only time anyone mentions "f/2" and "astrophotography" in the same sentence is when they're talking about Schmidt cameras. And that turns out to be a pretty good analogy for HyperStar. A Schmidt camera has a corrector plate and a spherical primary mirror that form a prime-focus image on a curved focal surface. HyperStar uses an SCT's corrector and spherical primary, and the HyperStar lens flattens the field as well as corrects for several optical aberrations that arise from the SCT optics not being an exact match for those in a true Schmidt camera.



With a wide field and deep limiting magnitude, HyperStar is ideal for hunting novae, supernovae, and comets. The spiral galaxy M33 was captured with 2-minute exposures.

Every astrophotographer knows the appeal of using an f/2 focal ratio for deep-sky shooting. It produces bright images of extended objects such as nebulae and galaxies at the focal plane, making short exposures possible. But there are two important advantages of using an f/2 *telescope* for astrophotography rather than an f/2 camera lens. The first is raw aperture. The effective diameter of the glass collecting light with even the smallest HyperStar-compatible scope exceeds that of any f/2 camera lens made today. And with the typical exposures used by astrophotographers, the limiting magnitude of stars recorded is purely a function of raw aperture, not f/number. With all other factors being equal, you'll capture more stars with an 8-inch telescope than you will with a 6-inch, or with any camera lens regardless of its f/number.

The other advantage is focal length, which translates into image scale and the detail you'll record in your deep-sky images. The "longest" f/2 telephoto lenses today have focal lengths of about 200 millimeters. The "shortest" HyperStar — the one for Celestron's 6-inch SCT — has a focal length of 290 mm. The Celestron and Meade 14-inch scopes have HyperStar focal lengths of 675 mm (f/1.9) and 700 mm (f/2.0), respectively — that's impressive!

In the Field

Celestron lent us its 14-inch Fastar-compatible telescope for our review of the company's CGE Pro mount (November 2009 issue, page 50). It provided the perfect opportunity to test the HyperStar, which we borrowed from Starizona. I used it mainly with my Nikon D300 DSLR camera and a Quantum Scientific Imaging (QSI) 583 CCD camera. Since the optical spacing between the HyperStar lens and the camera's detector is important, Starizona makes special adapters for each HyperStar/camera combination.

The "numbers" for my setups were impressive. The Nikon covered a 2°-by-1.3° field and the QSI a 1.5°-by-1.2° field. Both had image scales of about 1.6 arcseconds per pixel, which is excellent for deep-sky work. While the compact size of the QSI camera was important, even better was its internal filter wheel. Many CCD cameras based on Kodak's KAF-8300 chip have external filter wheels that would block more of the telescope's aperture in the HyperStar configuration. With HyperStar's f/2 light cone, there was slight vignetting in the corners of the QSI frame when I used the camera's standard filter wheel made for conventional 1¼-inch filters. But I also tested QSI's new filter wheel that has slightly larger filters and doesn't vignette the KAF-8300 chip at f/2.

There are no hidden pitfalls to setting up the HyperStar system, and shooting images is equally straightforward. Focusing, on the other hand, can present a few challenges even though you accomplish this

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by turning the same knob you normally use for focusing Celestron and Meade SCTs. While your head blocks some of the telescope's aperture, you can achieve rough focus by looking into a DSLR's viewfinder for those HyperStars that work with DSLRs.

That would have been great with the 14-inch Celestron if my arms were about 2 feet longer than they are! An electric motor on the focuser or a willing assistant is one solution, but trial and error also works. The best solution is being able to view your camera's output on a separate monitor. This is the case with all astronomical CCD cameras, but it's also a capability of many DSLR's. My Nikon D300 can, and coupled with the camera's live-focus function, it made focusing the system a breeze.

HyperStar's performance is very sensitive to collimation, and to that end there's a set of push/pull collimation screws on the lens assembly. My eagerness to shoot images in the fleeting moments of clear, moonless skies during New England's dismal weather last summer initially kept me from tweaking the collimation. I did, however, adjust it when I began shooting with the Nikon (and after the QSI had been returned to the manufacturer). As explained in the HyperStar manual, the process is relatively easy, even if you just use trial and error.

Once my camera was focused, I just sat back, slewed the scope around, and took "snapshots" of deep-sky objects. Under my suburban Boston skies, I settled for 2-minute exposures through the QSI's red, green, and blue filters when there was no interference from moonlight. With the Nikon D300 set to ISO 200, 30-second exposures were a good balance between image quality and light pollution. When a moderately bright Moon was up, I reduced the Nikon's exposures to 10 seconds and concentrated on star clusters, which were less effected by the added sky brightness than shots of nebulae.

The author recorded the eastern half of the Veil Nebula, NGC 6992/95, with the QSI camera and five 2-minute exposures through color filters. Exposures this short did not require guiding with the 14-inch scope mounted on Celestron's CGE Pro German equatorial mount reviewed in last November's issue, page 50.

WHAT WE LIKE:

HyperStar is simple to set up and use

Easy to switch telescope between f/10 and f/2

WHAT WE DON'T LIKE:

The need to be extra careful moving around the front of a HyperStar-equipped telescope

One nice feature of Starizona's HyperStar is how easily you can switch your telescope between its normal configuration and the HyperStar system. Sean Walker captured the lunar crater Messier and its surrounding rays with the 14-inch Celestron in its normal optical configuration. You can read more about how he created this and other lunar images in his article beginning on page 72 of this issue.

Despite my far-from-ideal conditions for color work with an f/2 system, I was impressed with the images, especially those of the big, splashy objects that astrophotographers love to shoot pictures of to hang on their walls. The best results, however, really call for darker skies than I experience from my backyard. And for emission nebulae, it's nice to have a camera that's sensitive at the deep-red wavelength of hydrogen-alpha light, which my Nikon isn't.

While I used the setup for recreational astrophotography, HyperStar has a lot of potential for scientific work, especially searches for novae, supernovae, and comets. Since HyperStar can capture many of these objects with exposures short enough to eliminate the need for guiding, it would be simple to set up an automatic search program with a computer-controlled telescope. Such short exposures also make it practical to shoot a pair of images of each field, thus providing a confirmation image that could prevent random image artifacts from causing false alarms.

If someone had told me a decade ago that I could make quality deep-sky photographs with a conventional camera and 30-second exposures, I would have told them they were nuts. Thanks to HyperStar, I once again have proof that we're living in great times! ✦

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*When he's not working on product reviews in his backyard observatory, senior editor **Dennis di Cicco** specializes in deep, wide-field hydrogen-alpha imaging.*

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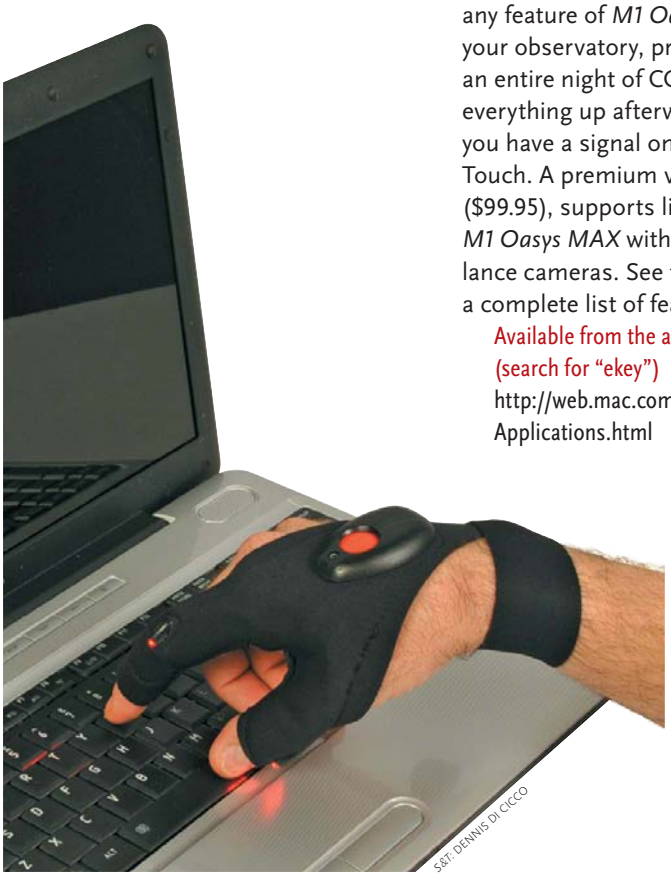
CHRIS HETLAGE

▲ IPHONE OBSERVATORY CONTROL Now you can control the automated functions of your *M1 Oasys*-equipped observatory from your iPhone using the *eKeypad M1* app ($39.95). This new app, written by Jayson Callaway and adapted by Chris Hetlage, allows you to activate most any feature of *M1 Oasys* to remotely open your observatory, program and initiate an entire night of CCD imaging, and lock everything up afterward from wherever you have a signal on your iPhone or iPod Touch. A premium version, *eKeypad Pro* ($99.95), supports live video for users of *M1 Oasys MAX* with Panasonic surveillance cameras. See the website below for a complete list of features.

Available from the app store (search for "ekey")
http://web.mac.com/japps/eK_Family/Applications.html



S&T: DENNIS DI CICCO

ORION TELESCOPES & BINOCULARS

▲ HIGH-SPEED GUIDING Orion Telescopes & Binoculars continues to expand its line of imaging products with the introduction of the Orion SteadyStar Adaptive Optics Guider ($1,799.95). This accessory couples with an autoguider of your choice to monitor a guide star and correct the image as fast as 40 times per second. Its 40-millimeter clear aperture is suitable for cameras with APS-size detectors without introducing vignetting. The unit requires 90 mm of inward focus travel. The Orion SteadyStar Adaptive Optics Guider comes with operational software, a 10-foot USB cable, a 10-foot autoguiding cable, a 12-volt DC power cable, and a hard case. The unit is also compatible with *MaxIm DL* and is ASCOM compliant.

Orion Telescopes & Binoculars
89 Hangar Way, Watsonville, CA 95076;
800-447-1001; www.oriontelescopes.com

◀ HANDY LIGHTS Mission Lights introduces the GloveLite ($24.95), a handy pair of LED flashlights integrated into the thumb and forefinger of a neoprene strap. The 3-millimeter LEDs allow you to have light illuminating wherever your hand goes, and its low-profile power switch is conveniently located on the back of the hand. GloveLite is available with red, white, or green LEDs, and also comes in a larger size called OverGlove, designed to be worn over gloves in cold temperatures.

Mission Lights
68 Mount Hope Ave., Bangor, ME 04401
207-945-6588; www.missionlights.com

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LAND, SEA, AND SKY

◄ **PREMIUM TRIPLET** Takahashi expands its line of premium apochromatic refractors with the introduction of its TSA-120 ($3,795, optical tube only). This new 4.7-inch refractor features an air-spaced triplet objective with one element made of FPL-53 extra-low-dispersion glass for crisp, color-free observing. Its 900-mm f/7.5 focal-length is perfect for high-contrast views of stars, planets, and galaxies, and the tube measures only 28-inches long when its dew shield is retracted. The TSA-120 comes with a 2-inch rack-and-pinion focuser with nearly 9-inches of focus travel to accommodate any bino-viewer or star diagonal available today. Additional accessories such as a finderscope, tube rings, and a photographic field flattener are sold separately.

Land, Sea, and Sky (Texas Nautical Repair)
1925A Richmond Ave., Houston, TX 77098
713-529-3551; www.takahashiamerica.com

► **ROLL-OFF OBSERVATORY GUIDE** Author John Hicks's book *Building a Roll-off Roof Observatory: A Complete Guide for Design and Construction* (softcover, $59.95) provides step-by-step information on planning, zoning, and building an observatory to permanently house your equipment. As a professional landscape architect, Hicks considers many steps overlooked by others, including structural considerations and footing design to suit your soil conditions. The book also includes a CD-ROM with three complete, detailed sets of printable scale plans. 145 pages, ISBN 978-0-387-76603-4.

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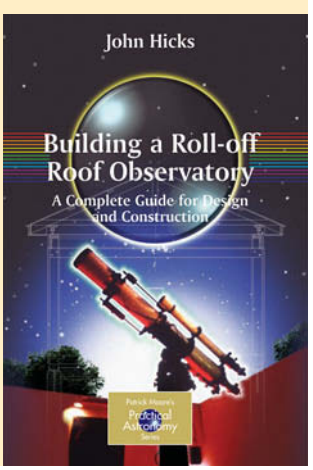

SPRINGER VERLAG

SBIG

◄ **BIG CHIP ON A BUDGET** Santa Barbara Instrument Group (SBIG) announces its new ST-8300M and ST-8300C CCD cameras ($1,995 each). The cameras feature Kodak's KAF-8300 CCD sensor in either monochrome or single-shot color versions. Its 8.3-megapixel array of 5.4-micron-square pixels has an imaging area that measures approximately 18 by 14 millimeters. The camera's thermoelectric cooling is capable of stable temperatures down to 40°C (72°F) below ambient, and the body accepts SBIG's CFW9 and CFW10 filter wheels. The camera communicates with your computer via a USB 2.0 interface, downloading each full-resolution exposure in roughly 8 seconds. Each purchase comes complete with camera-control software, a 15-foot USB cable, a T-thread-to-2-inch nosepiece, an autoguiding cable, a universal AC power supply, and a custom hard case. A new filter wheel is in the works to accommodate 36-mm filters.

SBIG
147-A Castilian Dr., Santa Barbara, CA 93117
805-571-7244; www.sbig.com

New Product Showcase is a reader service featuring innovative equipment and software of interest to amateur astronomers. The descriptions are based largely on information supplied by the manufacturers or distributors. *Sky & Telescope* assumes no responsibility for the accuracy of vendors' statements. For further information, contact the manufacturer or distributor. Announcements should be sent to nps@SkyandTelescope.com. Not all announcements can be listed.

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Fred Schaaf
Northern Hemisphere's Sky

Luck of the Draw

Winter deals stargazers a great hand of cards.

MOST READERS ARE probably getting their first look at this issue around the turn of the year. The departing year is the IYA, the International Year of Astronomy. We look fondly back on its accomplishments. But what's ahead? In this column next month I'll describe a fresh idea: the International Decade of the Sky.

For now, though, let's take a fresh look at the February evening sky displayed on our map.

Turn of the year, turn of the cards. Imagine the sky as a round card table and the constellations as cards. What hand have we been dealt for February evenings?

In most card games, the highest cards are the ace, king, queen, and jack. Some games also have wild cards — most often jokers or 2s — that can be turned into any card we want. Perhaps we can start by considering any constellation with a 1st-magnitude star to be a high card.

If that's so, our current spread is by far the most excellent of the year. The spring constellations include three high cards, summer four, and autumn only one. But the winter constellations have six.

Diamond-like Sirius, the brightest star in the night sky, must make Canis Major the ace of diamonds. Orion, with two 1st-magnitude stars, must surely be a king. Auriga and Gemini are fine constellations, but they're far less prominent than Orion, so let's call them jacks.

BACK SOURCE OF CARDS: MARCOPOLO/BIGSTOCKPHOTO.COM
FRONT SOURCE OF CARDS: CAROL WOODCOCK / ISTOCKPHOTOS

Which constellation is queen? I vote for Taurus. Yes, it's a masculine bull, but its splendid naked-eye clusters — the Pleiades and Hyades — are both groups of sisters. And to my mind they make Taurus a grander constellation than Gemini or Auriga.

That leaves Canis Minor — a feeble constellation indeed aside from 1st-magnitude Procyon. Its pattern has only two stars, so perhaps we should make it a deuce — sometimes just a lowly 2, but sometimes a wild card.

Speaking of wild cards, being a king, or even an ace, isn't really mighty enough for Orion. Perhaps Orion should be the one joker — always counted as wild — in the deck of the constellations. With its eye-catching shape, incredible belt, and magnificent nebula, Orion is simply the best constellation for almost any situation.

The ultimate double north star. Last month I promised some fresh perspectives on the star Capella. One of these is caused by precession, the 26,000-year-long wobble in Earth's axis. Capella is now the second most northerly of the 1st-magnitude stars. But in his book *The Astronomical Companion*, Guy Ottewell notes that at the opposite side of the precession cycle (13,000 years past and future from now), Capella is at a remarkably different location — the celestial equator.

Over longer periods of time, the motions of the stars through space also change their positions and apparent brightnesses. Capella was the most brilliant star in the heavens from 210,000 to 160,000 years ago (*S&T*: April 1998, page 59). Capella was actually even brighter before that — 240,000 years ago, when it was just 28 light-years from us, rather than its current 42, and shone at magnitude –0.8. But at that time, Aldebaran was even brighter, at magnitude –1.1.

But here's what's most amazing. If we go back just over 400,000 years, Aldebaran and Capella were very close together in the sky — and at one point were together near the north celestial pole. They were both considerably brighter than magnitude 0, with Aldebaran about twice as bright as Capella. As far back as we can reliably calculate, this was Earth's greatest double North Star. ✦

***Fred Schaaf** welcomes your comments at fschaaf@aol.com.*

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Links to all products in this ad are at www.astronomics.com/sky0210.

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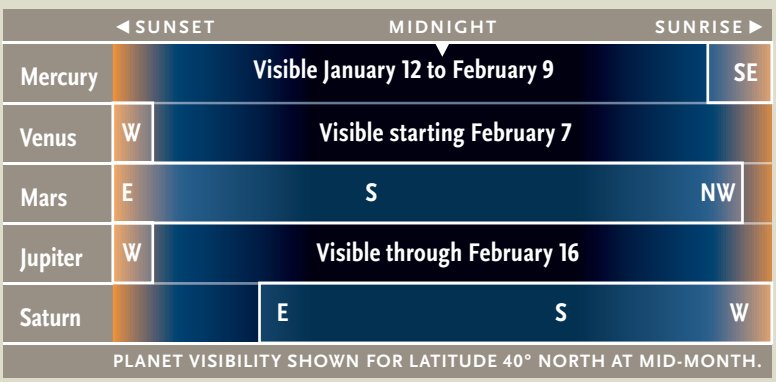
MOON PHASES

SUN	MON	TUE	WED	THU	FRI	SAT
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28						

PLANET VISIBILITY



PLANET VISIBILITY SHOWN FOR LATITUDE 40° NORTH AT MID-MONTH.

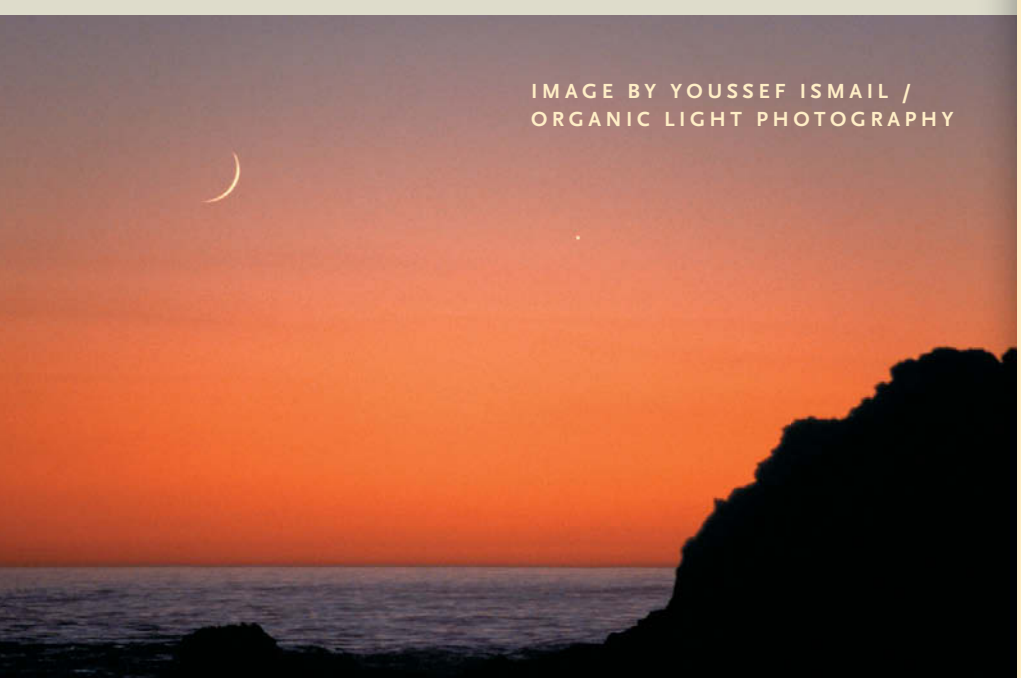


IMAGE BY YOUSSEF ISMAIL / ORGANIC LIGHT PHOTOGRAPHY

THE MOON was 37 hours old and 3½° left of Venus over Pescadero State Beach in California on October 26, 2003. February 14th will offer a similar scene, but with a much thinner Moon in a brighter sky.

February 2010

1–15 **EVENING:** This is a good time to view the zodiacal light from mid-northern latitudes. Find a dark location with a good western horizon, and start looking roughly 80 minutes after sunset. A vague but huge, tall, tilted pyramid of pearly light should become visible above the fading twilight. It aligns on the constellations of the zodiac.

3 **NIGHT:** Spica is about 4° upper left of the gibbous Moon low in the east-southeast around midnight (in North America). Above them glows Saturn.

5 **LAST-QUARTER MOON** (6:48 p.m. EST).

7 **DAWN:** Antares is 3° or 4° lower left of the waning crescent Moon.

11, 12 **DAWN:** Fine but challenging binocular views occur very low in the east-southeast a half hour before sunrise on these mornings. Mercury is 7° lower left of the thin crescent Moon on the 11th, and 4° right of a very thin crescent Moon on the 12th; see page 48.

13 **PREDAWN:** The 6th-magnitude asteroid Vesta and 7th-magnitude HD 89930 form a "double star" that changes orientation dramatically every hour. They're less than 1′ apart at 5 a.m. CDT. See page 54 for more on Vesta.

NEW MOON (9:51 p.m. EST).

14 **DUSK:** North Americans have an opportunity to see an extraordinarily young and thin Moon very low after sunset just 5° to the right of Venus and Jupiter; see page 49.

15–18 **DUSK:** Jupiter and Venus are within 2° of each other barely above the west-southwest horizon 15 minutes after sunset. They're closest (½° apart) on the 16th. Binoculars or a small telescope will give the best view.

16 **EVENING:** Vesta passes between Gamma Leonis and 40 Leonis.

18 **CLYDE TOMBAUGH** discovered Pluto exactly 70 years ago today. Pluto is now in northern Sagittarius, just high enough to be visible through large backyard telescopes as the first signs of dawn appear.

21 **FIRST-QUARTER MOON** (7:42 p.m. EST).

25 **EVENING AND NIGHT:** Mars is 5° or 6° from the gibbous Moon.

28 **FULL MOON** (11:38 a.m EST).

See SkyandTelescope.com/ataglance for details on each week's celestial events.

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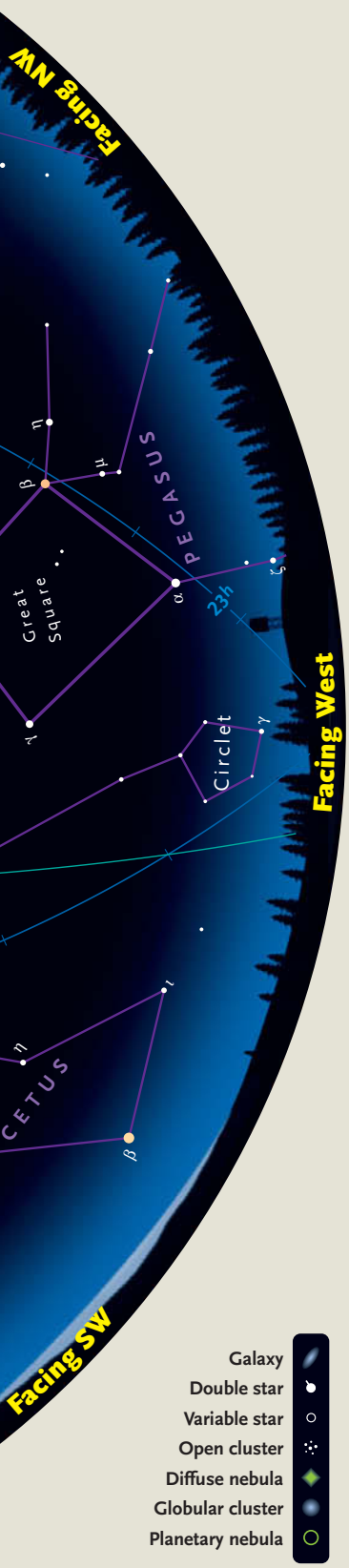
Facing North
Facing NE
Facing East
Facing SE
Facing South
17h
14h
11h
8h
5h
2h
20h
+60°
+80°
+40°
+20°
0°
−20°
−40°
Zenith
ECLIPTIC
EQUATOR
Polaris
Thuban
Little Dipper
Mizar & Alcor
M51
Big Dipper
M82
M81
Deneb
M39
Double Cluster
M31
M52
Capella
Algol
M34
Pleiades
Aldebaran
Hyades
Bellatrix
Betelgeuse
Rigel
Saiph
Procyon
Alphard
Regulus
Sickle
Castor
Pollux
Mars
M44
M67
M48
M50
M47
M46
M93
M41
Sirius
M42
M37
M38
M36
M35
M33
Mira
Moon Feb 18
Moon Feb 21
Moon Feb 25
URSA MAJOR
URSA MINOR
DRACO
CYGNUS
CEPHEUS
LACERTA
CASSIOPEIA
CAMELOPARDALIS
CANES VENATICI
LEO MINOR
LEO
LYNX
GEMINI
AURIGA
PERSEUS
TRIANGULUM
ANDROMEDA
ARIES
PISCES
CANCER
SEXTANS
HYDRA
CANIS MINOR
MONOCEROS
ORION
TAURUS
CANIS MAJOR
PUPPIS
LEPUS
COLUMBA
ERIDANUS
FORNAX
CAELUM
−1
0
1
2
3
4
Star magnitudes



Galaxy
Double star
Variable star
Open cluster
Diffuse nebula
Globular cluster
Planetary nebula

Using the Map

WHEN

Late December	11 p.m.
Early January	10 p.m.
Late January	9 p.m.
Early February	8 p.m.
Late February	Dusk

These are standard times.

HOW

Go outside within an hour or so of a time listed above. Hold the map out in front of you and turn it around so the yellow label for the direction you're facing (such as west or southeast) is at the bottom, right-side up. The curved edge is the horizon, and the stars above it now match the stars in front of you in the sky. The map's center is the zenith, the point overhead.

Example: Rotate the map a little so that "Facing East" is right-side up. A little more than halfway from there to the map's center is brilliant Mars, with Castor and Pollux above it. Go out, face east, and look halfway up the sky. There are Mars and the Twins!

Note: The map is plotted for 40° north latitude (for example, Denver, New York, Madrid). If you're far south of there, stars in the southern part of the sky will be higher and stars in the north lower. Far north of 40° the reverse is true. Mars is positioned for mid-February.

You can make a sky chart customized for your location at any time at SkyandTelescope.com/skychart.

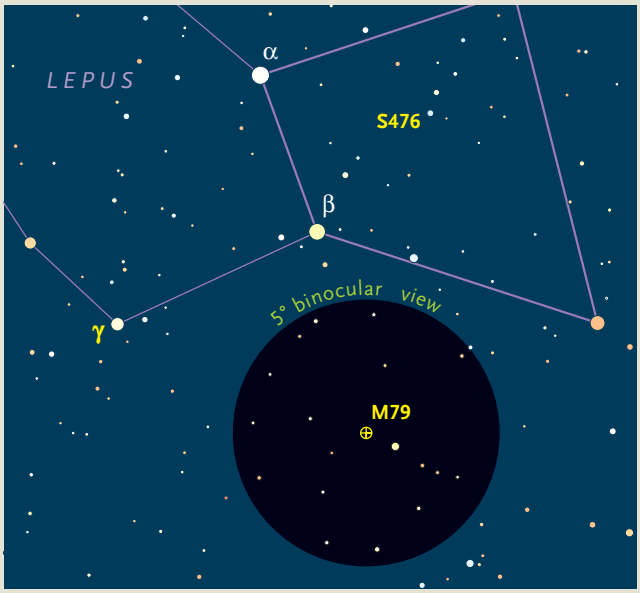
Binocular Highlight: The Hare's Messier

Lepus, the Hare, isn't a constellation much explored by binocular stargazers. Little wonder. With Orion dominating the sky just to the north, it's easy to overlook the little bunny cowering at the Hunter's feet. But this is where you'll find **M79**, the winter sky's lone Messier globular. In addition, tucked away in the rabbit's warren, are two extra, modest attractions to help make your visit worthwhile.

Found by extending a line from Alpha (α) Leporis through Beta (β), M79 is situated ½° northeast of a 5.4-magnitude field star. That star is an important reference point, since M79 is not exactly the most conspicuous Messier object. With my 15×45 image-stabilized binoculars, the globular is readily apparent as a tiny, fuzzy patch. But with 10×50s, I had to look with greater care to discern its 7.7-magnitude glow. Take your time with this one, especially if you observe under skies brightened by light pollution.

Not far from the cluster are two attractive doubles. The easier one is **Gamma (γ) Leporis**. With mounted binoculars, splitting Gamma's 3.6- and 6.3-magnitude components is fairly undemanding. Indeed, because the stars are separated by a generous 97″, the double looks better in my 10×50s than in my 15×45s.

South 476 (S476) is considerably more challenging. Comprised of 6.3- and 6.5-magnitude stars separated by a scant 39″, S476 is a delightful equal-brightness pair in my 15×45s. However, the double approaches the resolution limit for mounted 10×50 binoculars. To split this one, focus carefully and make sure the target is positioned close to the center of the field of view, where the optics of your binoculars are sharpest. ✦ — *Gary Seronik*



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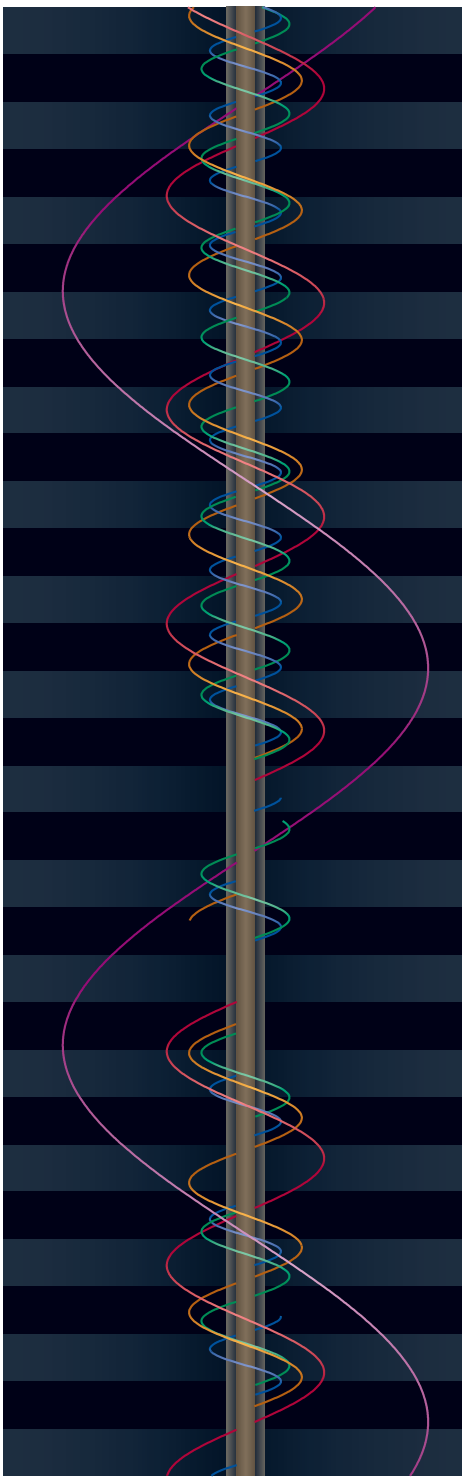

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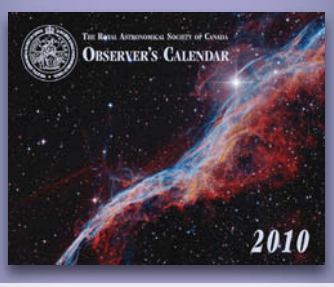

New! Observer's Calendar 2010

This calendar was created for astronomers, by astronomers. Each page has photographs that were taken by amateur astronomers, digitally formed using the latest techniques. Includes descriptive captions, Canadian and U.S. holidays, monthly grids with a host of astronomical information.

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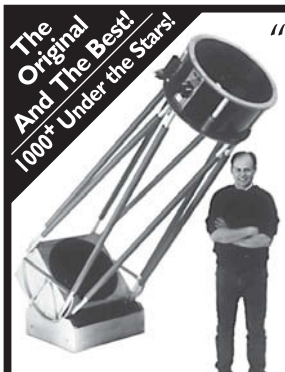

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The Lunar Graveyard

A surprising number of dead spacecraft rest forever on the Moon.

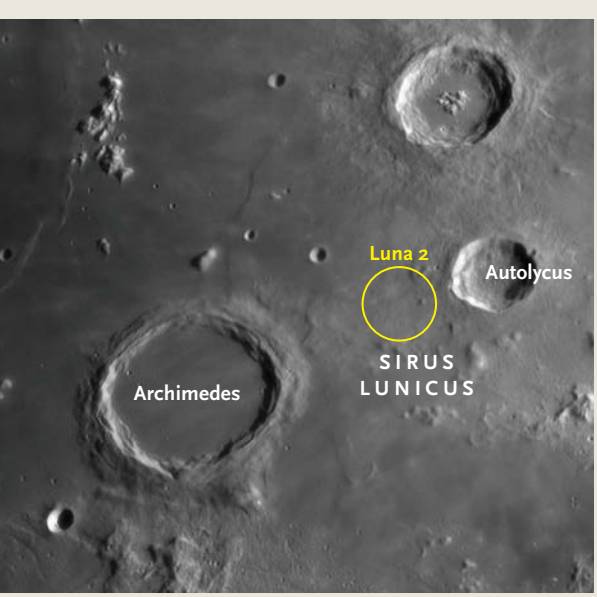
ELEPHANTS HAVE graveyards and so do lunar probes. Since the Soviet Luna 2 probe became the first vehicle to approach the Moon in 1959, approximately 70 spacecraft and rockets have crashed on the lunar surface. Some of these probes were doing exactly what they were designed to do, while others had completed their orbital missions. But for a third group, their designers had higher expectations. Crashes can be divided into three categories: hard landers (planned impacts), end-of-mission crashes, and "oops" crashes.

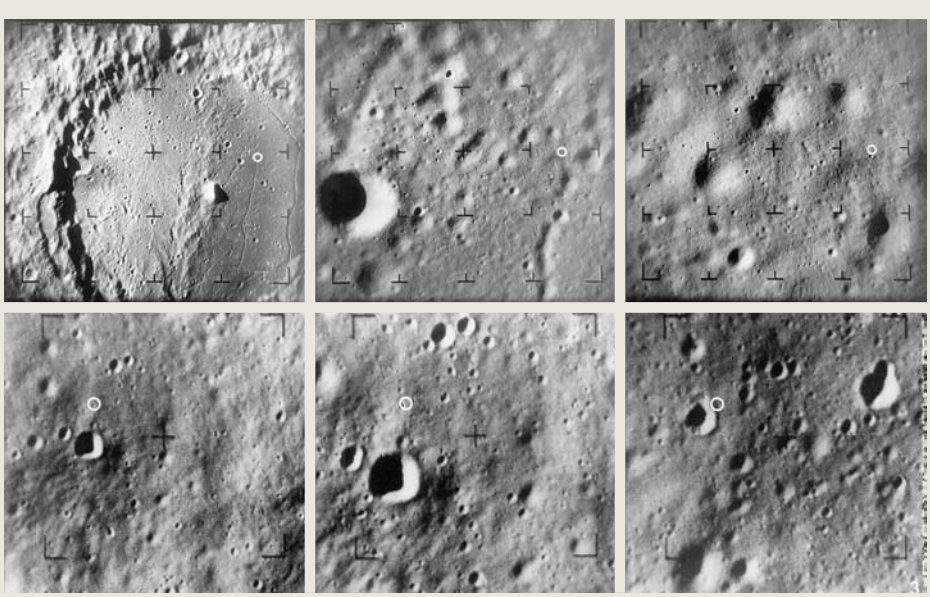
When the Soviet Union launched Luna 2 in 1959, its purpose was simply to hit the Moon as a demonstration of that country's power. The craft impacted into a region near the upper center of the Moon's face, startling humanity. But as is true for many early missions, we aren't exactly sure where it hit. You can see the general area by observing the region between **Archimedes** and **Autolycus**. A piece of this terrain has been named **Sinus Lunicus** (Luna Bay) to commemorate the historic feat.

The American Ranger spacecraft of the 1960s were also planned to smash into the Moon, but were meant to transmit images while descending to provide high-resolution views of the surface in preparation for Apollo's soft landings. The program seemed to be jinxed; success was elusive until the final three missions. Ranger 7 smacked down in a place that was later named **Mare Cognitum** (the Known Sea), and Ranger 8 hard landed in **Mare Tranquillitatis**, a trailblazer for Apollo 11. The most successful mission occurred when Ranger 9 sent back a 19-minute stream of more than 5,800 images before crashing inside the crater **Alphonsus** near one of its volcanic dark-halo craters. For amateur observers, these little volcanoes serve as landmarks to the general area of Ranger 9's final resting spot.

Hard landers have been rare since guidance and control technology matured enough for successful soft landings. But last year the most famous hard landing of all happened; in fact, two did. The Lunar Crater Observa-

Left: **Because Luna 2 carried no cameras, we don't know its exact final resting spot on the Moon. The impact is thought to be located somewhere between the large crater Archimedes and Autolycus.** ***Right panels:*** **One early hard lander with a precisely known location is Ranger 9, which returned thousands of images during its suicide plunge into Alphonsus Crater.**





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"... ideal for today's digital astrophotographers."
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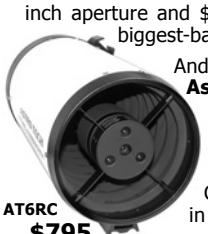
That's what *Sky & Tel* said in their 4-page 12/09 review of the **Astro-Tech AT8IN** imaging Newtonian and **AT6RC** and **AT8RC** Ritchey-Chrétien astrographs.

AT8IN
$449

Sky & Tel said that "Astro-Tech has done a great job of balancing performance and price on all three of these imaging telescopes. By optimizing them for use with the cameras that many beginning and intermediate-level astrophotographers are using, the company has created affordable instruments that can produce stunning images. It's an exciting time to be entering the field of deep-sky astrophotography."

Of the **Astro-Tech AT8IN** 8" f/4 imaging Newtonian, shown above, *Sky & Tel* said "while all three of the Astro-Tech scopes represent excellent value, the AT8IN, with its 8-inch aperture and $449 price tag, wins the biggest-bang-for-the-buck award."



AT6RC
$795

And *Sky & Tel* said that the **Astro-Tech AT6RC** 6" f/9 Ritchey-Chrétien, ***a Sky & Tel Hot Product for 2009***, left, was "a superb match" to the APS-C size imaging chips used in many DSLR cameras.

About the **Astro-Tech AT8RC** 8" f/8 Ritchey-Chrétien, below (A ***Sky & Tel Hot Product for 2010***, along with the $2695 10" f/8 **AT10RC**), *Sky & Tel* said "of the three scopes, I liked this one the most. Its advanced features . . . carbon fiber tube, quartz optics, and dual mounting rails (Losmandy- *and* Vixen-style dovetails) . . . were part of the reason. But it was how nicely this scope is matched to APS-C and 35-mm formats that really wowed me . . . what's not to like?"

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Don't just take our word for it. Ask *Sky & Telescope*. Remember what they said? That these three "affordable" Astro-Tech astrographs, optimized exclusively for digital imaging, truly do make this "an exciting time to be entering the field of deep-sky astrophotography."

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tion and Sensing Satellite (LCROSS) consisted of two impactors. The first was the Centaur rocket that launched the Lunar Reconnaissance Orbiter to the Moon. It was hoped that the impact of the 350-ton rocket into a permanently shadowed polar crater would release a water-rich plume of ejecta visible to terrestrial telescopes. A small probe, equipped with cameras and spectrometers to identify gases in the plume, followed like a lemming, smashing onto the crater's floor (see page 28). Because the target was the polar crater **Cabeus**, you can't see into it with your telescope, though you can see its rim during favorable librations.

A number of lunar spacecraft successfully completed their missions and were guided to hard landings. Most recently, the Japanese Kaguya orbiter ended its planned mission with a crash near the crater Demonax (see page 20.)

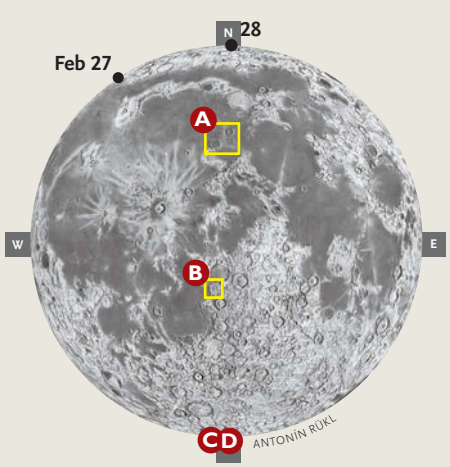
Back in 1999, NASA's successful Lunar Prospector orbiter was crashed into a polar crater in an earlier attempt to splash water-rich debris into a visible cloud. The probe carried the ashes of the pioneering geologist Eugene Shoemaker, marking the first burial on the Moon. In honor of this event, the IAU officially named the crater **Shoemaker**. While nearly impossible to see from Earth, when you observe the mountains on the southern limb, you're very near Shoemaker.

The largest number of lunar crashes belong to the "oops" category. These were the unplanned crashes that destroyed spacecraft designed for soft landings. In the 1960s, both the Soviets and Americans had difficulty making controlled descents. Lunas 5, 7, 8, and Surveyors 2 and 4, all met the endings their makers feared. At least nine of the Luna probes failed in attempts to return lunar samples, though Luna 16, 20, and 24 ultimately were successful. Of the failures that made it to the Moon, two crashed in **Mare Crisium** and one in nearby **Mare Fecunditatis**. Although the exact positions of these wrecks are unknown, it's likely that the half-meter resolution camera on LRO will pinpoint the crash debris fields of these robotic explorers, and perhaps find the earliest contribution to the lunar graveyard, the nearly mythical Luna 2. ✦

For a daily lunar fix, visit contributing editor ***Charles Wood's*** *website: lpod.wikispaces.com.*

The Moon • February 2010

Highlighted	Feature	Description
A Archimedes	Crater	51 miles
B Alphonsus	Crater	74 miles
C Cabeus	Crater	61 miles
D Shoemaker	Crater	32 miles



For key dates, black dots on the map indicate what part of the Moon's limb is tipped the most toward Earth by libration under favorable illumination.

Phases

Last quarter	February 5, 23:48 UT
New Moon	February 14, 2:51 UT
First quarter	February 22, 0:42 UT
Full Moon	February 28, 16:38 UT

Distances

Perigee	February 27, 21^h UT
222,344 miles	diam. 33′ 48″
Apogee	February 13, 2^h UT
252,612 miles	diam. 29′ 7″

Librations

Cleostratus (crater)	February 27
Byrd (crater)	February 28

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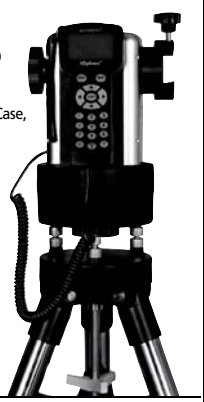

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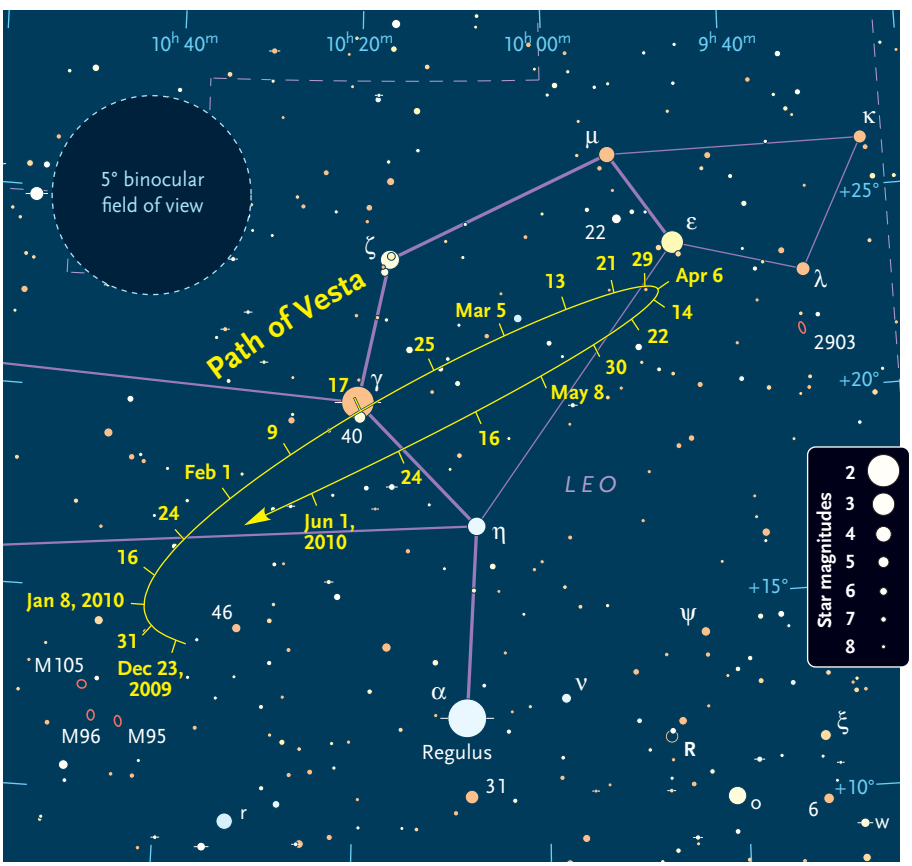
Bright Asteroid by Leo's Sickle

Vesta is a prime binocular target this winter and spring.

Late these evenings Leo climbs the eastern sky with the promise of the distant springtime to come. Leo's forequarters form the landmark Sickle asterism, and in and around the Sickle this season lurks the most prominent asteroid in the sky: 4 Vesta. Although Vesta is not the largest asteroid, it generally becomes the brightest around its season of opposition; its unique surface material is less dark colored than most of the stuff in the asteroid belt.

Vesta reaches opposition on the night of February 17–18, when it will shine at magnitude 6.1. (Notice that, as you'd expect, this date comes halfway through Vesta's retrograde loop on the map here.) Using the map, you can follow Vesta starting immediately. It's magnitude 7.4 as early as December 20th, when you'll have to wait up until about 11 p.m. to see Leo well risen in the east. Vesta is magnitude 7.2 on January 1st, 6.4 on February 1st, 6.2 on March 1st, 6.8 on April 1st, 7.3 on May 1st, and back down to 7.7 on June 1st. That means it's in binocular range for the whole time.



Vesta loops in Leo this year. Tick marks on its track show its position every eight days at 0h Universal Time (which falls on the evening of the previous date in the time zones of the Americas). Put a pencil dot on the track for when you'll observe. Stars are plotted to magnitude 8.0, which is fainter than Vesta will be throughout the time period shown.

Threading the Needle

A very special coincidence happens right around opposition. Between the evenings of February 16th and 17th for the Americas, Vesta threads the gap between Gamma Leonis (magnitude 2.5) and 40 Leonis (magnitude 4.8), which is located 22 arcminutes to Gamma's south. This familiar binocular pair will have a faint new interloper! Watch the asteroid's progress from night to night — or even, with a telescope, from hour to hour. Around those dates Vesta moves northwestward by 1 arcminute in a little less than 2 hours — or, at high magnification, 1 arcsecond in a little less than 2 minutes of time.

This meteorite, nearly 4 inches (10 cm) long, is thought to be a piece of Vesta's surface. Both are made of the volcanic mineral pyroxene, a substance that makes Vesta (and smaller asteroids that have broken off from it) unique. The meteorite fell in Western Australia in 1960.

RUSSELL KEMPTON

The fourth asteroid discovered, Vesta was found as a moving object by Heinrich Wilhelm Olbers on March 29, 1807, while it was in Virgo. It's about 500 km (300 miles) in diameter — essentially tying 2 Pallas for second place among the asteroids and far behind 1 Ceres at 950 km. But Vesta is denser than either of these and contains 9% of the asteroid belt's mass.

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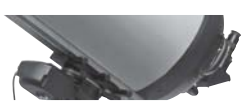

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All About STARGAZING Forecasts

Phillip J. Creed

Learn how to interpret weather forecasts — and make your own.

MARK TWAIN reputedly quipped that everybody talks about the weather, but nobody does anything about it. That certainly strikes a chord with stargazers! Even the most experienced and best-equipped astronomers' plans are often cruelly thwarted by the whims of Mother Nature.

While we are indeed powerless to change the weather, technology has greatly improved our ability to predict it. Amateur astronomers now have instant access not only to forecasts from government agencies and news media, but to the satellite imagery and supercomputer weather models used to generate them. Understanding how forecasts are formulated will greatly boost your ability to determine whether, when, and where you're likely to have a great night under the stars.

CLEAR SKIES Ahead?

The most fundamental requirement for astronomy is a cloudless sky. Most weather forecasts tell you if it's supposed to be cloudy, partly cloudy, or clear. Unfortunately, the word "clear" is open to interpretation. The sky is often riddled with wispy cirrus clouds when a forecast from the U.S. National Weather Service (NWS) says that it's "mostly clear." This might be good enough for visual observing through the gaps between the clouds, but it's a serious impediment to imagers.

Deep-sky observers also care greatly about *transparency* (the clarity of the air). And for viewing planets, *seeing* (the ability to get sharp views at high magnifications) is critical. A sky that weather forecasters call "clear" may

Stars and weather are two mighty forces of nature that share the same sky. Unfortunately, their relationship is often antagonistic.

TUNÇ TEZEL / THE WORLD AT NIGHT

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be veiled by haze that allows fine views of the planets but seriously degrades the appearance of galaxies. Conversely, the clear but turbulent air behind a cold front often causes excellent transparency together with poor seeing.

Stargazing forecasts took a giant leap forward when Allan Rahill, a meteorologist at the Canadian Meteorological Centre (CMC), developed algorithms to predict transparency and seeing from standard meteorological data. In September 2001, he started posting forecasts on the CMC website designed specifically for astronomers (*S&T*: April 2003, page 62). The CMC maps show predicted cloud cover, transparency, and seeing across Canada and the U.S. at hourly intervals up to two days in advance.

But few people knew about these forecasts until 2001, when fellow Canadian Attilla Danko found a new way to present the same data, slicing it by location rather than time. Danko maintains several thousand *Clear Sky Charts* for sites scattered across North America. Each shows all of the CMC data for that location on a single page. So if you look at the Clear Sky Chart for the site nearest your home, you can see at a glance whether you're likely to have better luck tonight or tomorrow night.

MODEL Citizens

Wonderful as the Clear Sky Charts are, they have their limitations. What if you're planning more than two nights ahead? What if you want a second opinion? This is where it helps to know how weather forecasts are made.

Meteorologists use numerical weather models running on banks of supercomputers at various government offices around the world. The computers collect data from satellites, surface stations, commercial aircraft, and weather balloons. Then they divide the atmosphere into millions of individual cells and calculate how the cells are likely to interact over time. But observations are never perfect, and some aspects of weather are inherently unpredictable. So the various supercomputer models always yield different answers — sometimes more so and sometimes less.

To formulate a forecast, meteorologists combine or tweak the models' predictions based on their own experience and judgment. You can follow this entire process in the forecast discussions posted online by each office of the NWS. Once you've figured out how to decipher the jargon, these discussions provide invaluable insight into how much confidence the meteorologists have in their own forecasts.

The Clear Sky Charts are based on data from the CMC's Global Environmental Multiscale (GEM) model. The GEM is updated twice a day, so the same is true of the Clear Sky Charts. That's good but not ideal; a lot can change in 12 hours.

The U.S. National Centers for Environmental Prediction (NCEP) maintain many different weather models, the most important being the Global Forecast System (GFS) and the North American Mesoscale (NAM). NAM's cell grid is much finer than the GFS's, but it covers only North

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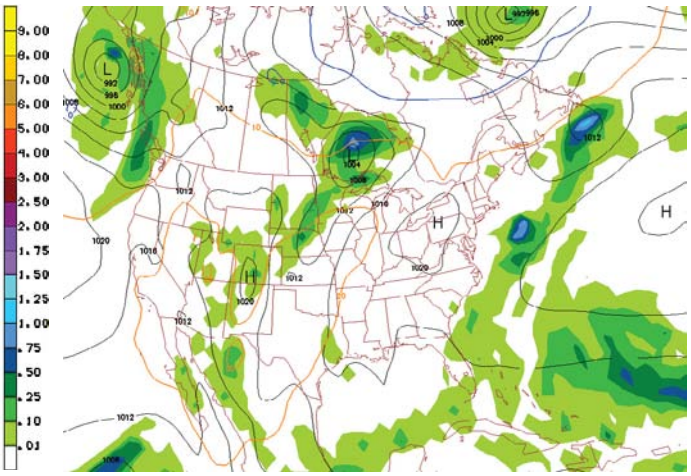


This map from the NCEP website shows the GFS prediction made at 12h UTC (8 a.m. EDT) on August 24, 2009 for precipitation and barometric pressure at 6h UTC (2 a.m. EDT) on August 25th. Precipitation is shown in color, and pressure with black isobar lines.

America for the next 84 hours, whereas the GFS predicts weather everywhere on Earth for more than two weeks. Both are updated four times a day.

The websites Atroforecast and SkippySky use GFS data to forecast astronomical conditions over a wider area and farther in advance than the CMC does. They provide an alternative to the Clear Sky Charts in Europe and elsewhere, and a valuable cross-check in North America.

You can reach all the websites in this article using hyperlinks at SkyandTelescope.com/weather — or through your favorite internet search engine.

For the most recent and detailed data, you can go straight to the GFS and NAM. The NPEC website provides access to selected data from these models, and you can get a more extensive cross-section (including the high-altitude humidity needed to predict cirrus clouds) from IPS MeteoStar and Penn State University's Department of Meteorology.

The updates at 18h UTC (1 p.m. EST) and 0h UTC (4 p.m. PST) are particularly useful for North Americans making the go/no-go decision for the night. But be sure to check the dates on the maps. The updates often take place an hour or two after the nominal time, and you don't want to use old data.

What should you look for? The Hippocratic oath applies to telescopes as well as patients: first, do no harm. A cloudy night won't hurt your optics, but a rainy one might. The GFS map above shows predicted precipitation and mean sea level pressure (MSLP). Rainy areas are best avoided, while high-pressure systems are most likely to have cloudless skies. But if the isobars (lines of equal pressure) are squeezed tight together, expect high winds and poor seeing.

Different layers in the atmosphere are labeled by the pressure at that altitude. The map showing relative humidity at 700 millibars (about 10,000 feet) is labeled "700mb RH." Cloud cover is likely if this value is above 70%. High humidity at 300 mb (30,000 feet) is likely to cause cirrus clouds. If you see high winds at 300 mb, it means that the jet stream is overhead, which usually causes poor seeing.

Finally, the National Weather Service's Model Output Statistics site translates both the GFS and NAM models into forecasts of surface temperature, wind, cloud cover, and fog up to a week in advance.

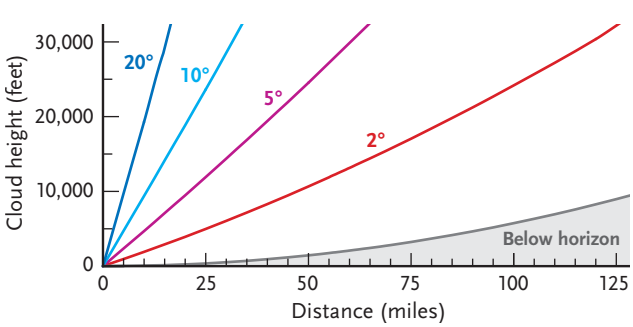
THE HORIZON League

Sometimes it's not enough for skies to be clear overhead. Many of the finest deep-sky objects, such as Omega Centauri or the False Comet in Scorpius, barely poke above the horizon in most of the United States. Canadians and Europeans have to look low in the south to see the Sagittarius Milky Way. Comets usually appear brightest when they're closest to the Sun, so they're often visible only in bright twilight or very low in the sky. A clear horizon is essential for such endeavors.

Different kinds of clouds are found at different heights, as shown on page 61. Stratus clouds are low, around 5,000 feet above the ground, while cirrus clouds can top 30,000 feet. The height of the clouds, in combination with their distance from the observer, determines their apparent elevation above the horizon, as shown below.

Finding a horizon that's clear of cirrus clouds can be quite a challenge, as many northerners found when looking for Comet McNaught in January 2007. Cirrus clouds 100 miles distant sometimes prevented the comet from being visible, even when 95% of the sky was clear!

To guarantee clear horizons, check the forecast not only at your own location but everywhere along your sight line for 100 miles or more. If you're using a Clear Sky Chart, click on the block for the time you're planning to observe, and it will link to the corresponding CMC map, showing clouds in the surrounding area. The NAM and



The labeled lines show the apparent angular altitude of clouds at various heights and distances.

GFS maps of relative humidity at 300 mb are particularly useful for forecasting distant cirrus clouds.

SEEKING Starry Climes

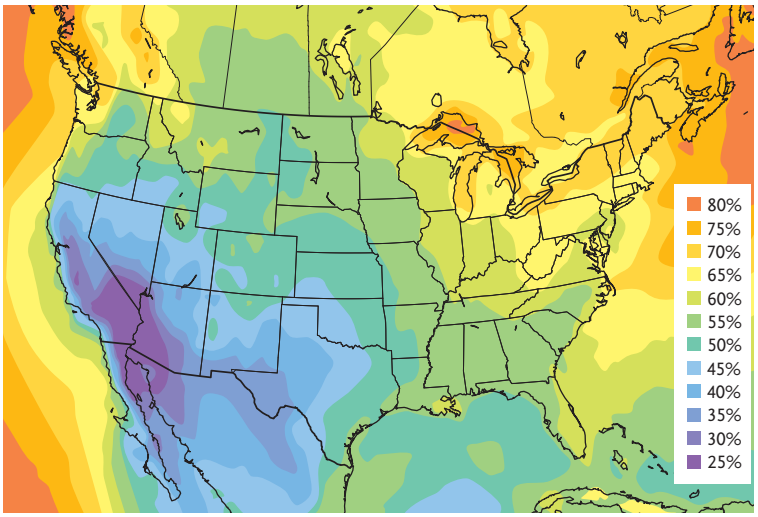
If you're a stargazer from the Baby Boom generation, you may be looking to retire to a warmer place. Or perhaps you're thinking of relocating to a new job, building a remote observatory, or bringing a telescope on your next vacation. In each case, you will certainly want to know about the stargazing prospects for the new location.

The National Climate Data Center is the official U.S. repository of long-term climate data, showing you the average weather over the past few decades. Other countries have their own offices, and a considerable amount of climate data is available from commercial websites.

Many people's first instinct is to look at the amount of precipitation per year, but this can be misleading. Warm air can hold more moisture than cold air, but warm places tend to get brief downpours, while cooler locations are more likely to experience prolonged drizzle. Seattle and Dallas both average about 35 inches (90 cm) of rain per year, but Seattle has twice as many rainy days.

Cloud cover and percentage of possible sunshine are more useful. These statistics are only kept for daytime hours, but they tend to correlate fairly well with conditions at night. The number of days per year with fog is also important for gauging how dew-prone an area is.

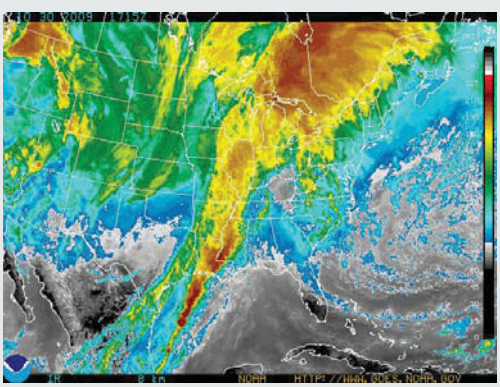
Recently, archived satellite data from NASA's MODIS program has been made available. This is invaluable because the satellites' infrared cameras record clouds by night as well as day. The map at upper right shows the average nighttime cloud cover from February 2000 to July 2009 for the U.S. and southern Canada.



The MODIS website generates visualizations of archived data on demand. This one shows the percentage of cloudy nighttime hours.

Amateur astronomers live in exciting times. From long-term climate data to short-term forecasts, stargazers now have easy access to tools used by professional meteorologists. We may not be able to do anything about the weather, but we can anticipate it, prepare for it, and travel to avoid it. ✦

Phil Creed *enjoys observing comets and deep-sky objects during the occasional breaks in Ohio's endemic cloudiness.*



Infrared images measure the temperature of the surface that the satellite is seeing. Clear skies expose the ground, which is relatively warm. Low clouds are cooler, and high clouds are coldest of all. This image shows clear skies on the Gulf Coast, low-lying stratus along the East Coast, and high clouds west of the Appalachians.

WHAT'S Happening?

When I'm deciding whether to observe on any given evening, I start with the National Weather Service forecast and the transparency map from the Canadian Meteorological Centre. (I'm mostly a deep-sky observer, so I care less about seeing.) I feel most confident when the CMC and the NWS agree. Transparent nights tend to cool off faster, so if the NWS expects a big temperature drop, that's a good sign, too.

Next, I think about geography. I feel pretty safe if the CMC shows deep blue (clear skies) all over the Northeast, but a small blue circle around my home in Boston doesn't inspire confidence. Quite often, I'm near the edge of a large blue area, and that's when a relatively small shift in weather can have big consequences.

In that case, I start looking at photos from the Geostationary Operational Environmental Satellites — especially infrared images, which show clouds both day and night. I step through the CMC maps hour by hour and see how well they match what's happening. The clouds often develop more or less as predicted but run a few hours fast or slow. Other times, they do something totally unexpected. But it's always helpful to know what the clouds are actually doing, not just what they're supposed to do.

— *Tony Flanders*

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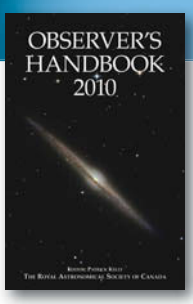

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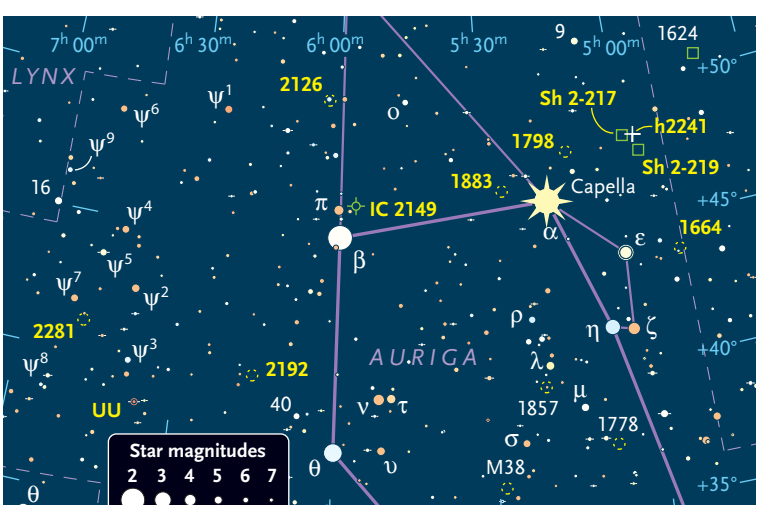
Auriga's Riches

Many wonderful but little-known clusters and nebulae adorn the celestial Charioteer.

STRADDLING the treasure-laden realm of the Milky Way, Auriga has a wealth of deep-sky delights. Last month we toured several of those nestled within the constellation's distinctive pentagon. Let's appraise a sample of the jewels and diaphanous silks outside the pentagon, starting in the far eastern reaches of Auriga.

This area of the sky is home to 11 stars that bear the Greek-letter designation Psi (ψ), but Psi[10] Aurigae actually resides within the neighboring constellation Lynx, and is more commonly known as 16 Lyncis. Two of the stars are close together and share the designation Psi[8]. Even if the pair appears single to your unaided eye, its combined magnitude of 5.6 still makes Psi[8] the faintest of the bunch, while Psi[2] is brightest at magnitude 4.8. How many Psis can you spy with your eyes?

The arresting open cluster **NGC 2281** sits 50′ south-southwest of Psi[7] Aurigae. Through my 105-mm (4.1-inch) refractor at 47×, NGC 2281 is a 20′ group of 35 moderately bright to faint stars. Many of the bright ones outline a paisley-shaped loop concave to the north-northeast. The pattern of stars at the loop's narrow end reminds me of the constellation Delphinus or, with a few additional stars, the Christian ichthys fish symbol. The fish sports a golden nose, while through my 10-inch reflector the root of his tail shows a similar hue. A colorful pentagon of stars surrounds NGC 2281, three of the corners marked



The bright, bluish stars of NGC 2281 (*right*) indicate that it's a relatively nearby and young cluster. It's almost 17° from the plane of the Milky Way, so the background stars are quite sparse. NGC 2192 (*left*) is more distant and older than NGC 2281, so its stars appear fainter, closer together, and redder.

ALL IMAGES FROM POSS II / CALTECH / PALOMAR OBSERVATORY

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by yellow-orange suns and another by a pair whose northern member is a smoldering orange ember.

For a deeply colorful star, let's slip 3½° southwest to the semiregular variable **UU Aurigae**. It ranges between magnitude 5 and 7 with superposed periods of 233 and 439 days. UU Aurigae is a carbon star, a cool giant that has an exceptionally ruddy tint because most of its blue light is filtered out by carbon molecules and carbon compounds in its atmosphere.

Sweeping from Theta (θ) Aurigae to 40 Aurigae and continuing the same distance beyond brings us to a much different open cluster, **NGC 2192**. My little refractor at 28× simply shows a small fuzzy patch. At 87× the group appears very granular and about 4′ across. It's sprinkled with very faint to extremely faint stars, the brightest one in the north-northeastern edge. Even my 10-inch scope at 192× only teases out 20 stars against a patchy haze of unresolved suns.

The disparate appearance of our first two clusters is largely a function of distance. Splashy NGC 2281 is only 1,800 light-years away, while diamond-dust NGC 2192 is 4½ times more remote. Another difference between the clusters is their age. NGC 2281 is about 360 million years old whereas NGC 2192 has been around for a whopping 2 billion years.

Our next stop is the intricate planetary nebula **IC 2149**, which lies 38′ west-northwest of the reddish orange star Pi (π) Aurigae. In my 130-mm refractor at 63×, it's a bright, miniscule, aqua nebula with a brighter center. At 234× the nebula is elongated, somewhat brighter near the central star, and widest at the west-southwestern end. With my 10-inch reflector at 299×, IC 2149 is brighter along the long axis, especially in the eastern half. An OIII filter helps improve contrast at lower magnifications.

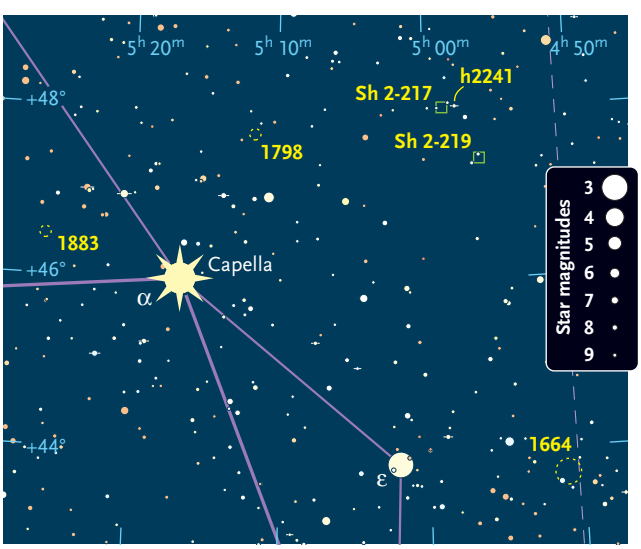
IC 2149 was discovered by Williamina Fleming and first reported in *Harvard College Observatory Circular* 111 in 1906. While inspecting photographic plates taken with the 8-inch Draper refractor during Harvard's stellar spectrum survey, Fleming saw that this object, previously cataloged as a star, exhibited the characteristic bright lines of a gaseous nebula.

If you sweep 2.2° eastward from Omicron (ο) Aurigae, you'll come to a slightly fainter, yellow star with a star of similar brightness ½° farther east. This last star anchors the northeastern edge of the open cluster **NGC 2126**.

The cluster is a pretty dusting of minute stars through my 105-mm refractor at 47×. I count 15 individuals in 6′ at 127×. My 10-inch reflector at 192× reveals 23 stars, mostly gathered into a 4′ triangle. A two-star tail off one side turns the triangle into a little arrow aimed north-northeast.

Two more diamond-dust clusters reside near brilliant Capella. NGC 1883 is 1.7° to its east-northeast, and NGC 1798 is 1.9° to its north-northwest.

In my 105-mm refractor at 87×, **NGC 1883** is a faint hazy patch lodged in the sharp end of a skinny triangle of stars that points south-southwest. The 2′ haze appears



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Left: **The faint nebula Sharpless 2-217 is centered 9′ east of the bright double star John Herschel 2241.** ***Right:*** **Sharpless 2-219 is smaller but somewhat more intense than Sharpless 2-217.**

granular, with one faint star tacking the eastern edge and a blurry blotch in the northwestern region. At 174× the blotch gives up one very faint star. At 213× my 10-inch scope displays a dozen pinpoint stars in a 2½′ area, and two outliers to the south.

NGC 1798 is bigger and brighter than NGC 1883. Through my little refractor at 122×, its misty glow shows three very faint stars and a non-stellar spot east-southeast of center, where images disclose a tiny knot of stars. My 10-inch reflector at 192× teases out 15 to 20 stars in 4½′ to 5′.

Two emission nebulae are found 2½° west of NGC 1798. Both are very challenging through my 105-mm scope at 76×. **Sharpless 2-217** lies 9′ east of **h2241**, an east-west pair of matched, white stars like little eyes in the dark. The feeble glow of the nebula spans roughly 4½′, engulfing an 11th-magnitude star and few fainter ones. A narrowband nebula filter helps Sh 2-217 stand out a bit better. Just ¾° southwest, **Sharpless 2-219** covers only 1½′. A 12th-magnitude star is embedded west of center. It makes a 5′ curve (concave east) with one star south and two north, magnitudes 9 to 12.

With my 10-inch scope at 118×, I noticed a small brighter patch in the southwestern part of Sh 2-219 that, in turn, seems to have a brighter spot inside. A closer look at 192× confirmed this, but I couldn't tell if the spot was stellar. A bit of research revealed that this scrap of scrim houses a highly obscured and crowded star cluster, visible in infrared images.

Now we'll move down to Epsilon (ε) Aurigae. Normally shining at magnitude 2.9, Epsilon is now being eclipsed

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Delicate NGC 1664 has been likened to a kite, a clover, a flower, and a ginkgo leaf.

by what is generally assumed to be a large, dark disk of material. Epsilon should currently weigh in at about magnitude 3.8. It's expected to regain some of its luster this summer, dim again, and then regain its usual sheen next spring (*S&T:* May 2009, p. 58).

The open cluster **NGC 1664** is found precisely 2° west of Epsilon. With its loops and chains of stars, NGC 1664 is a terrific cluster for connect-the-dot games. I've heard it described as a stingray, a kite with a long tail, a four-leaf clover, and a heart-shaped balloon on a string. Most of these images have occurred to me at one time or another, as well as an admittedly more esoteric one where I picture the stars as a ginkgo leaf with a wiggly stem. In my defense, ginkgo trees are planted along the main street of Scotia, New York, a village near my home.

In my 105-mm refractor at 17×, NGC 1664 is small group of very faint stars with a 7th-magnitude gem burnishing its southeastern side. At 87× the 6′ × 4′ ginkgo leaf sits at the center of NGC 1664 with its 7′-long stem wandering toward and passing just east of the bright star. Two dozen stars are loosely scattered around our ginkgo-kite-balloon-stingray-clover, swelling the group to about ⅓°. What does your imagination make of this cluster? ✦

Sue French *observes star clusters from upstate New York. She welcomes your comments at scfrench@nycap.rr.com.*

Clusters, Stars, and Nebulae Outside Auriga's Pentagon

Object	Type	Magnitude	Size/Sep.	RA	Dec.
NGC 2281	Open cluster	5.4	25′	6^h 48.3^m	+41° 05′
UU Arigae	Carbon star	5–7	—	6^h 36.5^m	+38° 27′
NGC 2192	Open cluster	10.9	5.0′	6^h 15.3^m	+39° 51′
IC 2149	Planetary nebula	10.6	34″ × 29″	5^h 56.4^m	+46° 06′
NGC 2126	Open cluster	10.2	6.0′	6^h 02.6^m	+49° 52′
NGC 1883	Open cluster	12.0	3.0′	5^h 25.9^m	+46° 29′
NGC 1798	Open cluster	10.0	5.0′	5^h 11.7^m	+47° 42′
Sh 2-217	Emission nebula	—	7.3′ × 6.3′	4^h 58.7^m	+48° 00′
h2241	Double star	9.3, 9.5	12″	4^h 57.8^m	+48° 01′
Sh 2-219	Emission nebula	—	2.0′	4^h 56.2^m	+47° 24′
NGC 1664	Open cluster	7.6	18′	4^h 51.1^m	+43° 41′

Angular sizes and separations are from recent catalogs. Visually, an object's size is often smaller than the cataloged value and varies according to the aperture and magnification of the viewing instrument. Right ascension and declination are for equinox 2000.0 coordinates.

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The Dobsonian at 30

After three decades, the Dobsonian revolution is still going strong.

HAVING RECENTLY concluded the International Year of Astronomy, an event that celebrated the 400th anniversary of Galileo's momentous telescopic observations, it's perhaps appropriate to look back at another, more-recent moment in history — the arrival of the Dobsonian telescope. Some may think it preposterous to mention John Dobson and Galileo in the same paragraph, but the groundbreaking efforts of both men definitely enhanced our enjoyment and understanding of the night sky.

While there was an inevitability to Galileo's accomplishments (*someone* would have eventually turned a telescope skyward), there was no guarantee that anything like the Dobsonian telescope would have emerged without its inventor's particular circumstances and talents. Indeed, if you cast your mind back to the 1970s and the kinds of telescopes that were being created in home workshops and being manufactured commercially, the Dobsonian really does seem revolutionary. And like most revolutions, this one took awhile to get going.

John Dobson built his first telescope in 1956 and by the late 1960s he was a regular fixture on the streets of San Francisco, showing the Moon and planets to anyone and everyone he encountered. Yet Dobson's elegantly simple big-aperture scopes didn't catch on immediately with amateur telescope makers. This was because few ATMs had seen or heard of Dobson's scopes, and those who had were mostly skeptical. As then *Sky & Telescope* Editor-in-Chief Charles A. Federer, Jr., famously stated in a 1970s letter rejecting an article proposal by Dobson, the design "can hardly lead to satisfactory instruments of the kind most amateurs want in these large sizes."

S&T: DENNIS DI CICCO

John Dobson's 24- and 22-inch reflectors tower over participants at the 1978 Riverside Telescope Maker's Conference near Big Bear, California. It was the ATM community's first major encounter with John Dobson, and his big scopes, which were brought to the conference by the San Francisco Sidewalk Astronomers.

The first stirrings of the Dobsonian revolution occurred at the 1978 Riverside Telescope Maker's Conference (RTMC). It was at that event that the ATM community got to meet Dobson and see his 22- and 24-inch reflectors. As *S&T*'s Dennis di Cicco reported in the August 1978 issue, "the sheer size [of the telescopes] startled anyone seeing them for the first time."

Two years earlier, Dennis had seen Doug Berger's 16-inch reflector on a "Dobson mount" at the 1976 RTMC and brought the concept back home, where he adapted it for a 16-inch mirror owned by the Amateur Telescope Makers of Boston. That scope became the East Coast's introduction to the Dobsonian idea when it was displayed at the 1977 and 1978 Stellafane conventions in Vermont.

The following year's events began to accelerate rapidly. In 1979 the Dobsonian telescope received widespread attention when Richard Berry, who had seen the Boston club's scope at Stellafane in 1978, published a series of how-to articles in his new *Telescope Making* magazine. In many respects, Berry's magazine and the Dobsonian telescope enjoyed a symbiotic relationship — the popularity of one enhanced the popularity of the other. Bob Kestner's article "It's Stability that Counts" in issue #4 got the ball rolling for countless telescope makers. Kestner's article and several others that followed were bundled into the reprint publication, "*How To Build a Dobsonian Telescope,*" published in April 1980. On the strength of those articles, ATMs began abandoning their lathes in favor of table saws, and swapped aluminum for plywood. The revolution was underway.

Nevertheless, in the early '80s, as now, most stargazers didn't make their own telescopes. For the Dobsonian revolution to really change amateur astronomy, a commercial

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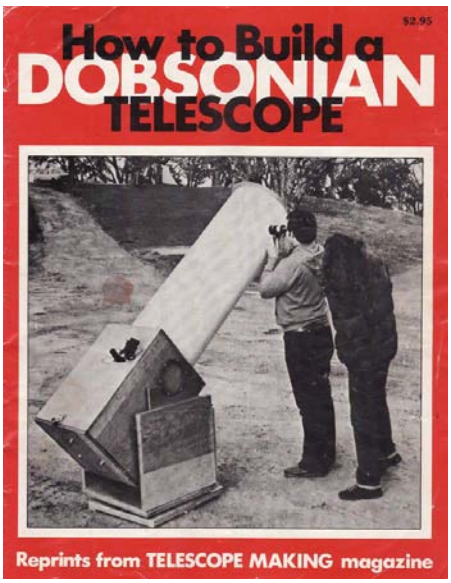

For many telescope makers newly caught up in the Dobsonian revolution, this 36-page publication from 1980 served as a manifesto. Inside were detailed plans for building Dobsonian telescopes, reprinted from Richard Berry's now-defunct magazine *Telescope Making*.

vendor needed to enter the fray. And that's what happened. In 1980, California-based Coulter Optical arrived at RTMC with the first commercially made Dobsonian — a 13.1-inch f/4.5. Advertisements for that scope appeared in the June 1980 issue of this magazine. Coulter's initial offering sold for the unheard of price of $395. To put that into perspective, a minimally equipped 8-inch Schmidt-Cassegrain advertised in the same issue cost twice as much. Big aperture at a low price — who could resist? In the long run, few did.

Coulter transformed the rough-and-ready Dobsonian into a rough-and-ready mass-marketed item. The company also changed the design in an important way. It was Coulter, not Dobson, who established the f/4.5 Newtonian as the standard Dobsonian configuration. It was so successful that even today many ATMs feel that, along with Teflon-and-Formica bearings, short-focus mirrors are one of the Dobsonian's defining characteristics.

Listing the ways the Dobsonian telescope has revolutionized telescope making could fill the chapter of a book. The design has become the most popular style of telescope for today's home builders. But it's also no exaggeration to say that the Dobsonian has altered amateur astronomy in the most fundamental way possible — by changing what we view with our telescopes. The availability of large apertures at affordable prices allows us to look beyond the solar system and peer into the deep sky as never before. In a way, there's poetic justice to this. After all, John Dobson's initial motivation for building big telescopes was to show you, me, and everyone else the universe beyond the astronomical backyard that Galileo explored with his telescope. And for that, I say thanks John! ✦

Contributing editor ***Gary Seronik*** *builds Dobsonians and observes the night sky at his home in Victoria, British Columbia.*

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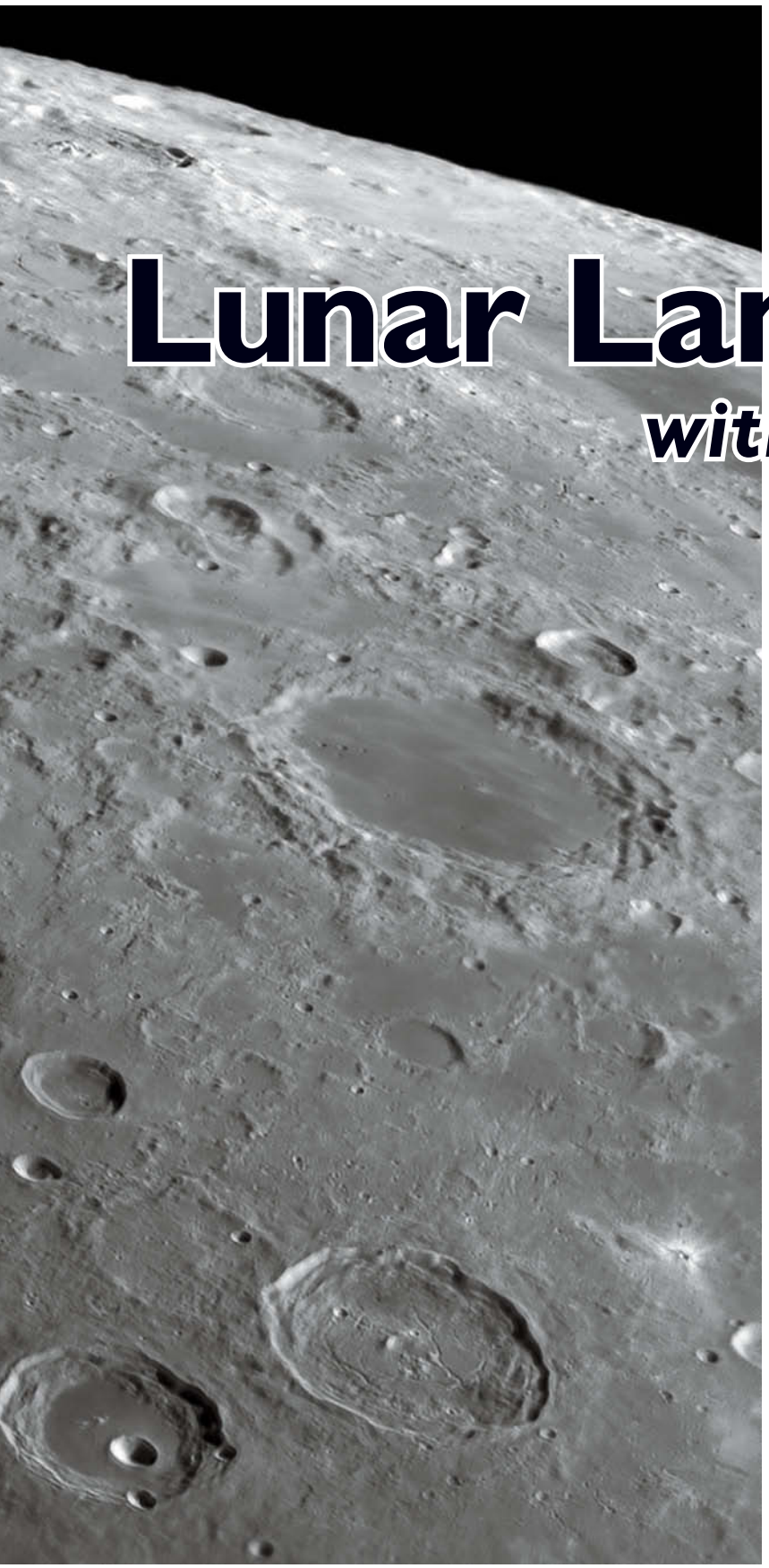

Lunar Landscapes with AviStack

SEAN WALKER

A powerful freeware program takes your lunar images to the next level.

EVERY NEW TELESCOPE owner heads for the Moon. After all, it's the brightest object in the night sky, and it's visible throughout the year. So you'd think taking great close-up photographs of craters, mountains, and maria would be pretty easy. If only that were so! Capturing high-resolution views of the lunar surface can be more difficult than imaging the planets, because of the sheer size of the target. Fortunately, the free software program *AviStack* (www.avistack.de) can help you take incredible Moon images.

Besides the usual variables of our atmosphere, the biggest challenge when shooting lunar close-ups is the wealth of detail visible throughout your imaging area. Unlike the planets, which all appear smaller than 1 arc-

Taking high-resolution pictures of the lunar surface is easier than ever if you use *AviStack* (www.avistack.de). This free software package by Michael Theusner sorts and stacks a variety of video and image files. This mosaic of the prominent crater Endymion was recorded by the author with a Celestron C14 and Imaging Source DMK21AU04.AS video camera. Each 3,000-frame video clip was processed using *AviStack*, and the final results were stitched together in *Adobe Photoshop*.

All Moon photos are courtesy of the author.

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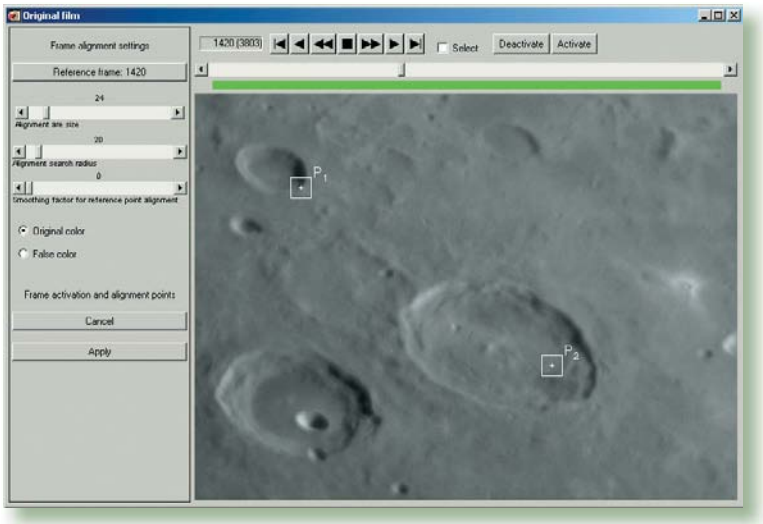
minute across, the Moon can easily fill the entire field of view of your telescope and camera. This means that if you choose to stack images using a single registration point for alignment, features progressively farther from that point will be blurred due to the constant churning of our atmosphere. Michael Theusner's *AviStack* is designed to sort groups of images and stack only the sharpest areas from each individual frame. It runs on both Mac and Windows operating systems. *AviStack* utilizes a technique known as multi-point alignment. It "monitors" many separate points throughout your image; mismatches from frame to frame are warped into place based upon the initial alignment points chosen.



After importing your images or video into *AviStack*, the first order of business is to choose two alignment points. Be sure to choose distinct features located far from each other to ensure good results across your entire image.

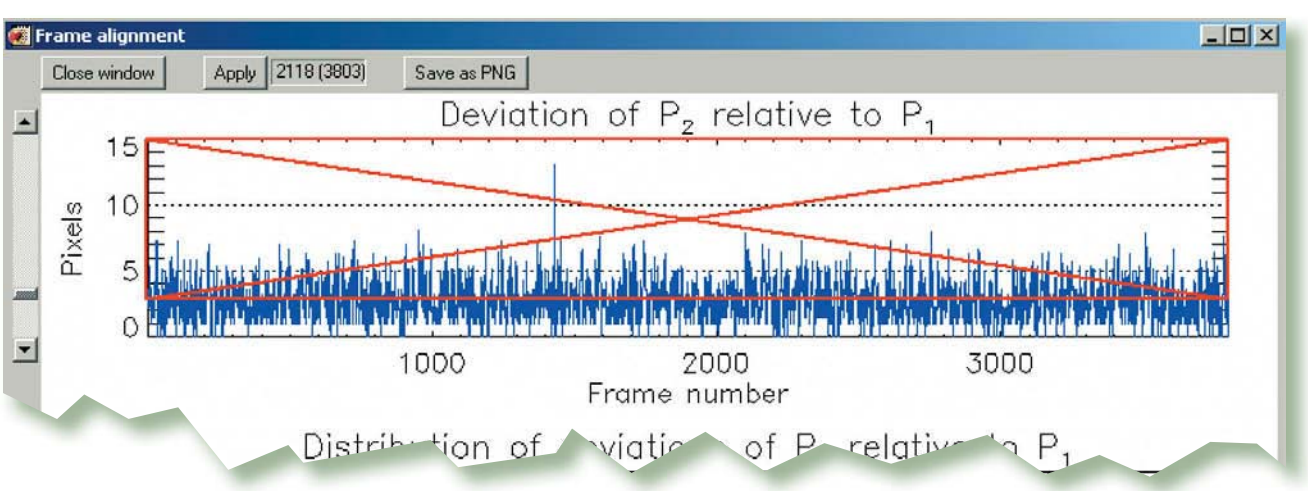
Stacking with *AviStack*

AviStack allows you to work with a series of images saved in a variety of formats, such as BMP, FITS, JPEG, PNG, and TIF, as well as AVI, MPEG, and MOV video clips. You start by bringing your images into the program using the File pull-down menu at the top left of the screen. Once you've selected your series, click the Set Alignment Points button. This opens a preview window that allows you to select the sharpest frame of your image series. Simply scroll through your frames and choose two distinct details near opposite edges of the picture to use as alignment points; if you're using a PC, the left mouse button activates the first point, and the right selects the second. You can increase or decrease the size of the alignment points using the various sliders on the left side of the window to encompass the feature you've chosen, or smooth the region to avoid locking on to random noise.

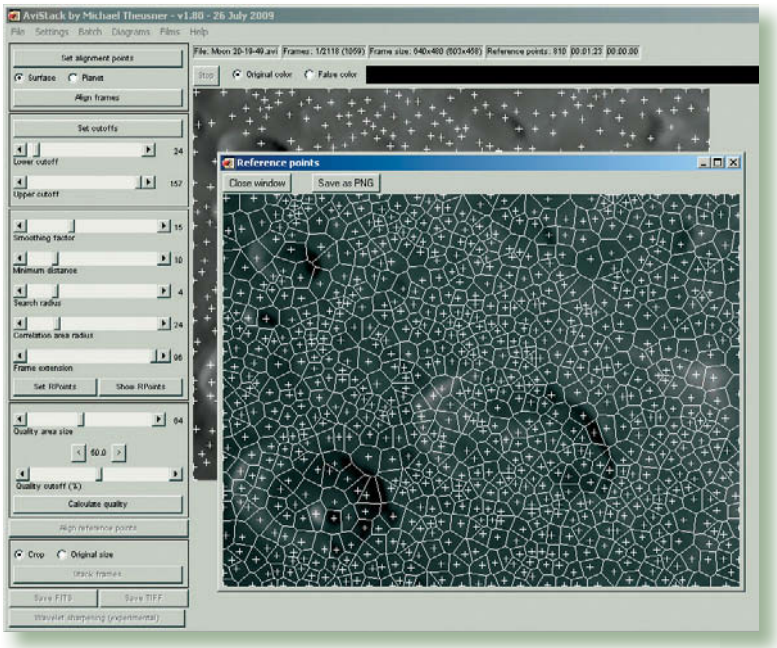
When you're content with your selection, click Apply. As each step is completed, the next step becomes active along the left side of the main window. When you click the Align Frames button, *AviStack* examines each frame of your series and measures its quality, as well as any shift between them to generate an average frame that your final stack will be warped to fit.

Once this action is completed, a new window pops up with three graphs that display the deviation of your two alignment points throughout your images. The top graph allows you to reject the worst offenders by pulling down a slider located at the left of the graph. As you pull the slider down, note the decreasing total frames to stack, as shown in parentheses at the top of the screen. When you're ready to move on, click the Apply button at top. The program then quickly generates your average frame and allows you to proceed to the next step.

If you shot the lunar terminator and your image contains a large area of black shadows, or there are some overexposed areas, you don't want *AviStack* to generate alignment points in these regions. Move the next two

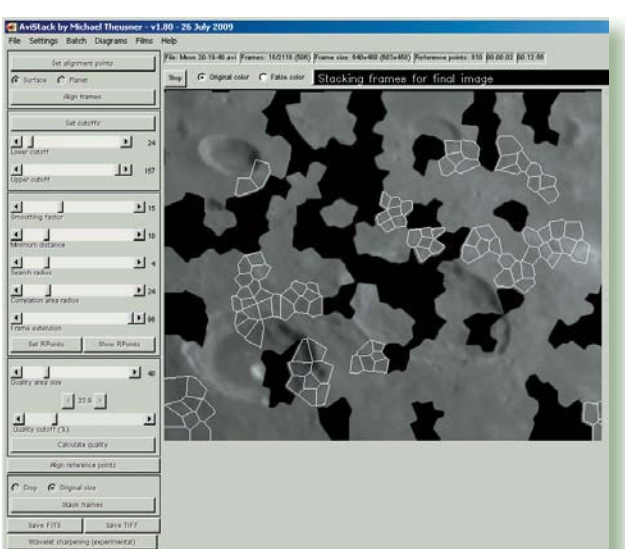


After the program has run through your images, it produces three graphs that detail how much your two registration points bounced around during your capture sequence. The graph above allows you to reject the worst frames by pulling down the slider at the left.



Once you've set any cutoffs and adjusted the reference-point parameters, *AviStack* will automatically generate hundreds of reference points in your image. The author finds that more reference points are useful when observing conditions were above average. *AviStack* can generate tens of thousands of reference points on large files; this is especially useful when stacking DSLR images.

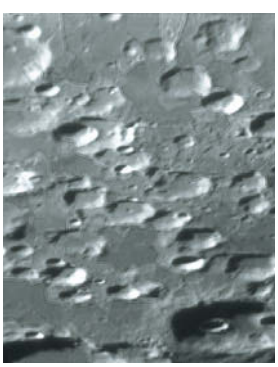
sliders at the left to adjust the Lower and Upper Cutoffs to exclude these regions. Below these are another series of sliders that adjust the settings for the mass generation of reference points in the image. The first, Smoothing Factor, blurs the image slightly to prevent the program from choosing noise as genuine reference points. If your image series is properly exposed and relatively sharp, lowering the smoothing factor will let *AviStack* choose more reference points. Increasing the smoothing factor does the opposite. I tend to use a low smoothing factor, and keep the default settings for Minimum Distance, Search Radius, and Correlation Radius.



Perhaps the most fun you'll have using *AviStack* is watching your final image rapidly come together like a puzzle built from hundreds of carefully chosen polygonal pieces.

The last slider in this step, Frame Extension, will limit reference points placed near the edge of the image frame. I increase this number to the maximum (96) so that as much area as possible in my images are aligned. Click the Set R Points button, and *AviStack* will generate your reference points. Depending on your settings and pixel dimensions of the image, this can be hundreds or even thousands of reference points. You can change any of the sliders and generate a new reference map by clicking the Set R Points again until you're satisfied with your selections.

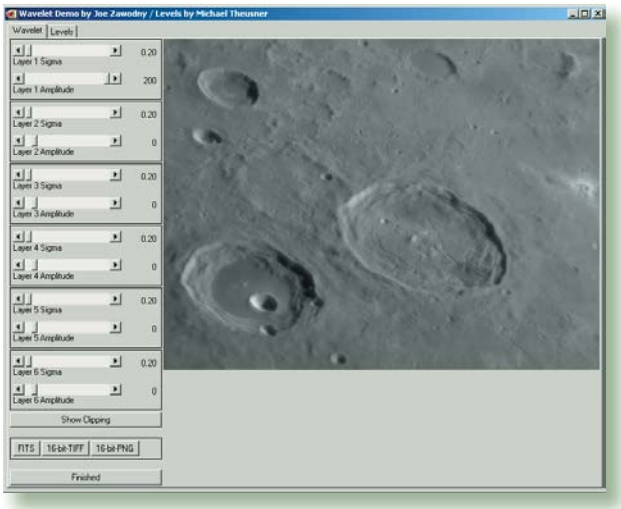
Next, *AviStack* measures the quality of your reference point selections and allows you to limit the amount of frames stacked in the final image. Move the Quality Area Size slider to again vary the size you want the program to examine on your frames. Below that is your final Quality Cutoff adjustment slider. As you move this slider, monitor the number of frames to stack at the top of the screen in parentheses. When you click the Calculate Quality button, the program again examines your selections, and then allows you to move on to the final alignment stage.



For lunar imaging, the author found that *AviStack* produced better results than *RegiStax*. However, when he tried stacking videos taken through thin clouds, the resulting *AviStack* image was riddled with mismatched bright and dark areas.

At this point, you can click the Align Reference Points button. Once you do this, *AviStack* examines every reference point on each image, and rejects any that deviate from your chosen parameters. This can take a long time. I shoot with an Imaging Source DMK21AU04.AS video camera, and I usually record 3,000 frames in each video clip, and stack about 500 of them. My 2.1-gigahertz laptop with a dual-core processor takes roughly 45 minutes to complete this step. Fortunately, you can run the program in the background and continue other tasks until the work is complete.

When alignment is completed, you can initiate the final stacking. If your image is part of a larger mosaic, I advise selecting the Crop button so that the outer area that *AviStack* couldn't align is excluded from your final image. This avoids having mismatched overlap between mosaic panels. Now you can click the Stack Frames button and



Once you've saved your stacked image, you can sharpen the results using the Wavelet Sharpening tools. These appear to function similar to those found in other programs. There's also a Levels adjustment tab in case you need to brighten your image.

watch the magic as your final image builds up from hundreds of tiny polygon regions; it's interesting to observe. When stacking is done, save your image as either a TIF or FIT file before continuing on to Wavelet sharpening. This way you can have a "raw" stack available for future processing experiments, rather than redoing the entire process.

Additional Sharpening

Once you have your final stacked image, you can move on to the additional Wavelet sharpening options by Joe Zawodny at the bottom left of your screen. Although *AviStack* developer Michael Theusner tempers your expectations about how well these work by calling them experimental, I find they function just as well as other routines for sharpening planetary images. I tend to only use the Layer 1 Sigma and Amplitude sliders to avoid creating sharpening artifacts, but you may want to experiment to find the optimum settings for your images.

So how does *AviStack* compare to other software for planetary image processing? In most cases, I find my results superior to those produced using *RegiStax* (www.astronomie.be/registax), but when I image through variable haze or clouds, *AviStack* will create an image with regions of mismatched brightness levels. In those conditions, *RegiStax* is a better choice. And although *AviStack* also works on planet images, *RegiStax* always produces a better result for me. I suggest having both programs available in your image-processing arsenal. Both are powerful programs that complement each other nicely, rather than compete. And it's tough to beat their prices! ✦

S&T *imaging editor* ***Sean Walker*** *shoots the Sun, Moon, and planets from Manchester, N.H. Visit http://masil-astro-imaging.netfirms.com/home.html to see some of his work.*

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◂ FIRST ROCK FROM THE SUN

John Boudreau

Mercury reveals subtle albedo features in this high-resolution image captured on the morning of October 2, 2009.

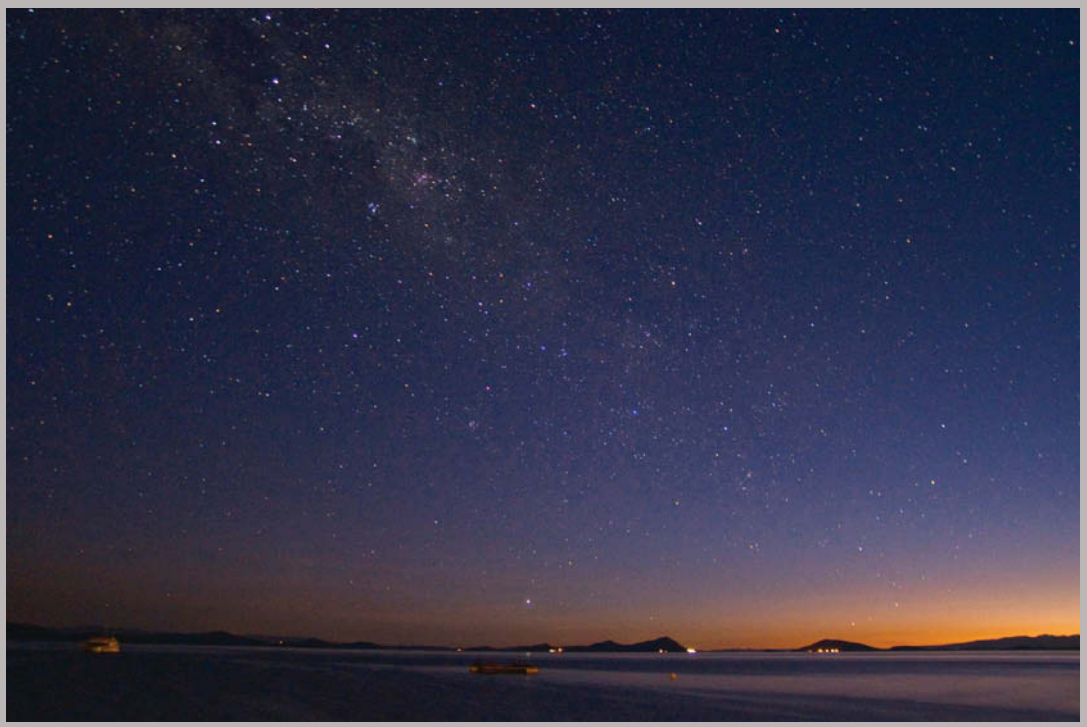
Details: *Celestron C11 Schmidt-Cassegrain telescope with Imaging Source DMK21AU04 .AS video camera. Stack of multiple frames recorded through a Baader infrared-pass filter.*

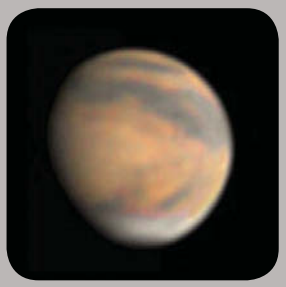
▲ STARBIRTH IN IC 1396

Larry Van Vleet

The stellar nursery IC 1396 in Cepheus reveals a delicate interplay of gas clouds in this false-color image.

Details: *Takahashi BRC-250 Ritchey-Chrétien astrograph with FLI Proline PL16803 CCD camera. Total exposure was 13½ hours through Astrodon narrowband filters.*





▲ MARS APPROACHES

Damian Peach

As Earth neared Mars during late 2009, familiar features such as dark Mare Cimmerium in the south (top) became visible through small telescopes. Recent dust storms have uncovered the dark feature at the bottom-right known as the Hyblaeus Extension.

Details: *Celestron C14 Schmidt-Cassegrain telescope and Lumenera SKYnyx 2-0 video camera.*

◄ TWILIGHT MOONSET

Tunç Tezel

A young Moon shares the evening sky with Mercury and Saturn over Uluabat Lake near Bursa, Turkey, last August 22nd.

Details: *Canon EOS 5D DSLR camera with 100-to-400-mm zoom lens.*

◄ TITICACA NIGHT

John Fisanotti

The southern Milky Way, including the pinkish Eta Carinae Nebula, emerge from twilight over the shores of Lake Titicaca, which borders the countries of Bolivia and Peru.

Details: *Nikon D300 DSLR camera with 14-mm Nikkor lens at f/2.8. Total exposure was 30 seconds at ISO 640.* ✦

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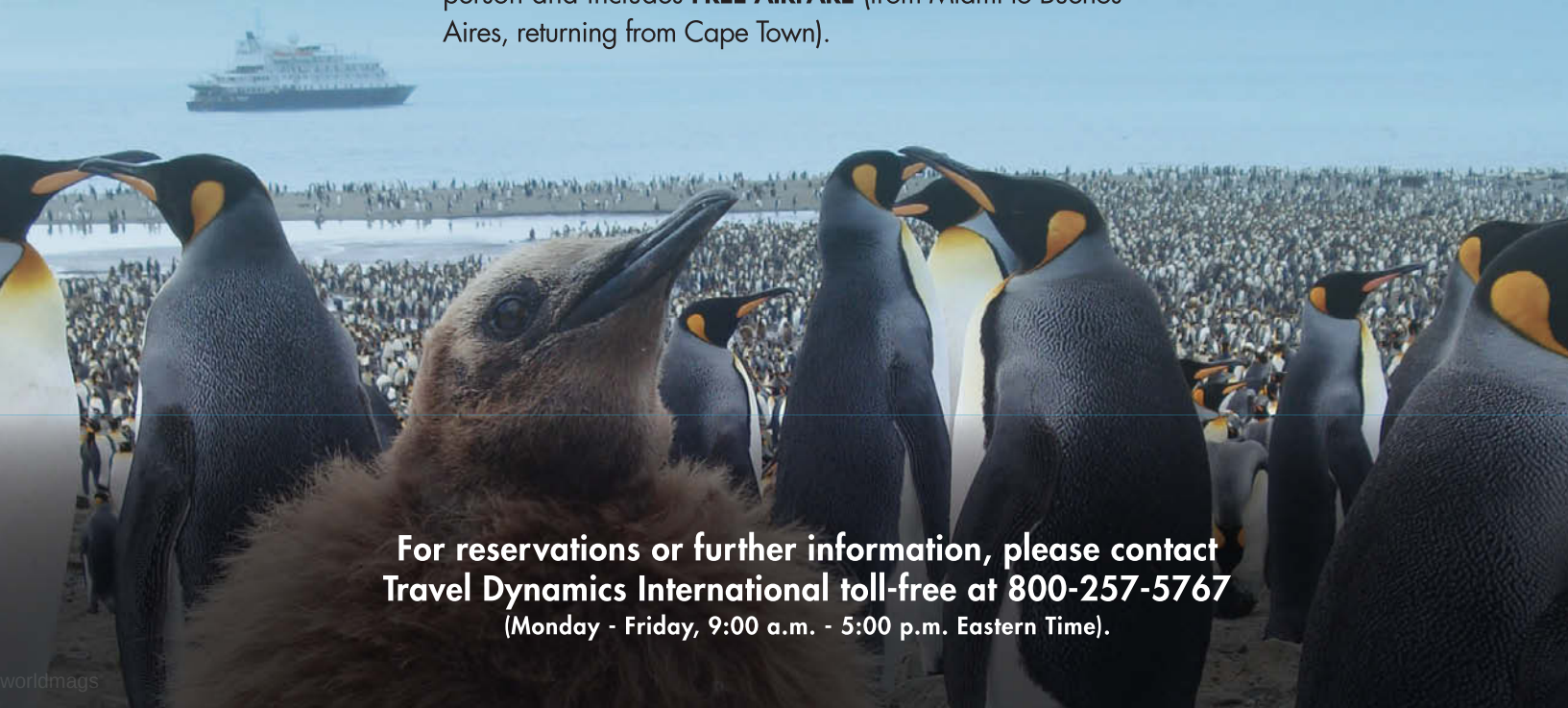

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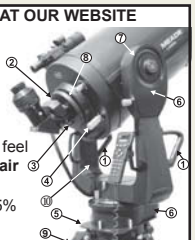

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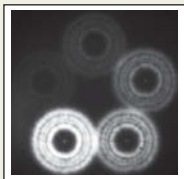

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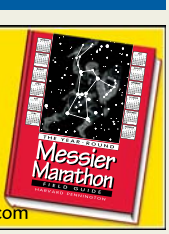

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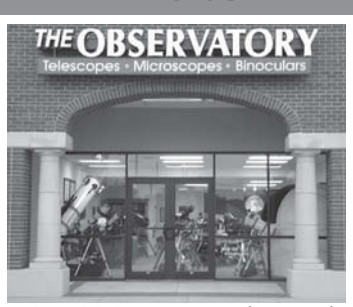

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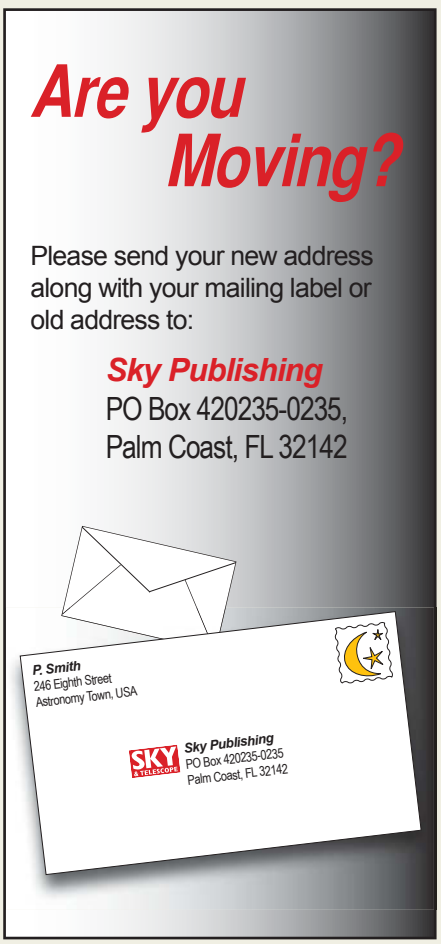

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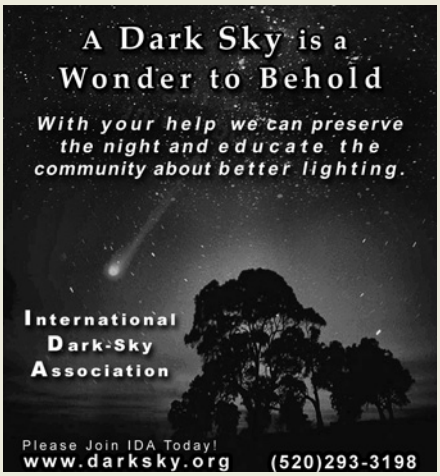

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Expanding Diversity in Professional Astronomy

We•ll need broader ethnic representation to continue the rapid pace of discovery.

O ' ' '<
for the “eld of U.S. astronomy over the next years and beyond is to promote and achieve racial and ethnic diversity within the ranks of the profession. While the number of women receiving Ph.D.s in astronomy has signi“cantly increased over the last two decades, the number of minority students receiving Ph.D.s has been basically ”at, at about to % of all astronomy Ph.D.s in any given year.

Why is greater ethnic diversity in the profession of critical importance? Quite simply, astronomers need to secure a diverse workforce in the ‘eld in order to insure that the best scienti“c research is accomplished.

Intelligence is a quality not monopolized by any one group. The ability, drive, and interest required to succeed in astronomy is distributed among the population without regard to race, gender, or socioeconomic background. By not actively promoting diversity, astronomers risk losing talented people to other professions and “elds, which means that there will be astronomical discoveries that will take longer to realize or that simply won•t get made.

The •astronomy enterpriseŽ is expanding beyond traditionally boundaries. The top-priority scienti“c goals over the last years have required the work, creativity, and expertise of professionals with experience in engineering, computer science, instrument building, and project management, as well as astronomy and physics. Thus, in order to achieve any of our priority scienti“c objectives, we must pay attention to the recruitment and training of the next generation of scientists and engineers.

Unfortunately, while the astronomy enterprise increasingly needs quality professionals in a variety of science, technology, engineering, and math (STEM) ‘elds, the numbers of U.S. students pursuing careers in these disciplines has been steadily decreasing. Only about % of U.S. college students major in any STEM “eld. These numbers are projected to worsen over the next decade unless something is done to reverse the trend.

The overall demographics of the U.S. workforce are also changing. Ethnic groups that have been traditionally underrepresented in science, and especially in astronomy, are the same groups whose populations are growing fastest. Current education gaps among these people will exacerbate the problems already recognized.

So what do we need to do to increase the numbers of minorities participating in astronomy? Quite simply, we need to create opportunities for ethnic minorities to excel in astronomy. For example, the number of quali“ ed minority engineers and computer scientists is vastly larger than the number of minority astronomers. Involving these professionals and students in the larger astronomy enterprise is one way to increase participation on relatively short timescales. But in the long run, we need to: a) directly engage the minority public, b) actively encourage the pursuit of STEM careers among these students, c) mentor students through astronomy career paths, d) recognize knowledge gaps in otherwise promising students and rectify them, and e) continue active mentoring of early career scientists after they receive a Ph.D.

Does the will exist to broaden diversity among the ranks of professional astronomers? For the sake of scienti“c discovery, let•s hope so!

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Dara J. Norman is an astronomer at the National Optical Astronomy Observatory in Tucson, Arizona. Her research interests include active galactic nuclei and their environments, and galaxy evolution.

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