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Pullout Sky Chart!

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THE ESSENTIAL MAGAZINE OF ASTRONOMY

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The Rosette Nebula dual frame mosaic image taken with Tele Vue-NP127is and Apogee Alta U9000 CCD camera by Tim Puckett and Adam Block. See Apogee ad for additional NP127is image.

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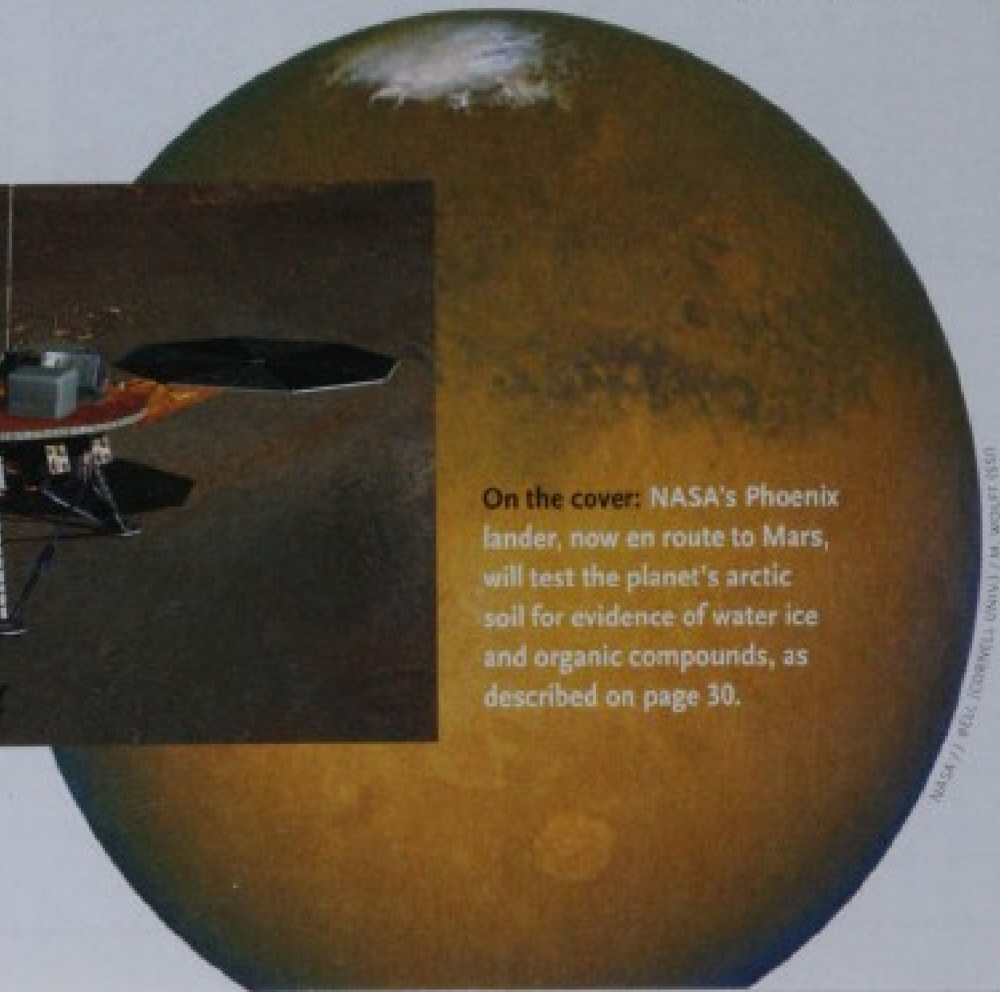
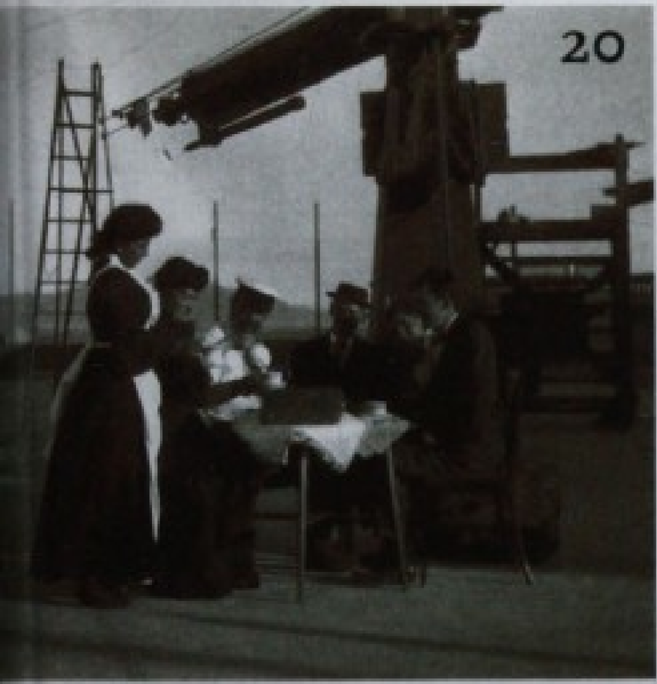
VOLKER WENDEL & BERND FLACH-WILKEN

NASA / JPL-CALTECH / CORBY WASTE



On the cover: NASA's Phoenix lander, now en route to Mars, will test the planet's arctic soil for evidence of water ice and organic compounds, as described on page 30.

NASA / J. BELL (CORNELL UNIV.) / M. WOLFF (SSI)



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No Laughing Matter

Do you think light pollution is funny?

EVERY SUNDAY, 32 million US newspaper readers enjoy *Parade* magazine, which features a question-and-answer column by Marilyn vos Savant, supposedly the person with the world's highest IQ. I usually like her writing, but her July 29th column disappointed me. Entitled "Questions Too Funny to Answer," it listed reader queries "so special" that she couldn't deign to tackle them.

I admit I *did* laugh at the first few, which included "Does a 10-gallon hat really hold that much?" and "Why can't Michael Jackson carry his own umbrella?" But then I came to this one: "Where did all the stars go? In the '50s, the sky was loaded with them."

That's not a "funny" question at all! Apparently vos Savant has never heard of light pollution. Thanks to the profusion of poorly designed artificial lighting, most of us see far fewer stars than we used to. Sky glow from cities and towns is why professional observatories are built in remote locations. It's also why most amateur astronomers have to travel far from home to enjoy truly dark skies.

TODD CARLSON (2)

Look at the accompanying photos. The left-hand one shows the sky over Toronto during 2003's widespread power outage and reveals the Milky Way in all its splendor (something that many young people have never seen). The right-hand photo shows the same view after the lights came back on one night later. To explore the global extent of artificial sky glow, check out Stuart Goldman's column on page 44.

Light pollution is not just an astronomy problem, but also an economic one. We spend billions of dollars each year carelessly lighting the undersides of airplanes. With light fixtures designed to direct illumination only where it's needed, we could use lower-wattage bulbs and avoid wasting all that money.

There's a long list of health and safety issues stemming from excessive outdoor lighting too. Thus it's heartening that a growing alliance of astronomers, lighting engineers, environmentalists, and politicians is working to combat light pollution (see Robert Gent's letter on page 10).

By dismissing the disappearing-stars question, vos Savant missed an opportunity to enlighten 32 million people. In contrast, *The New Yorker* tackled the question head-on in a fine article in its August 20th issue. Sadly, though, *The New Yorker* goes to a minuscule fraction as many readers as *Parade*.

Rick Fienberg
Editor in Chief

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IN THE NEXT ISSUE

Mira's Marvelous Tail

Seen in ultraviolet light, the famous variable star in Cetus looks like a comet with a 2° tail. Who knew?

Cool Cat

We test a computerized telescope that combines portability and performance. Oh, and it's orange.

Dark Skies for the Geminids

One of the year's best meteor showers peaks on December 13–14 with no interference from moonlight.

Tucson Two-Shooter

The new Large Binocular Telescope in southeastern Arizona aims to prove that two enormous eyes are much better than one.

BOTTOM: LBT OBSERVATORY / AARON CERANSKI; TOP: NASA / JPL-CALTECH

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On newsstands October 30th!

 Don Lago

Channeling the Big Bang

Before scientists even measured energy from the Big Bang, people could watch it at home every night.

REACHING OUT to touch the microwave oven, I thought of the hand reaching out to Adam on the Sistine Chapel's ceiling. I thought of the powers of creation. There was no better symbol of nature's creativity than seeds, popcorn in this case, for within those specks hide the universe's hard-earned secrets of building order.

I touched the button and let there be light: the seeds within began unfolding order, though not in their preferred organization on a cornstalk. The seeds banged and banged. The action slowed, and the light went off. I opened up the bag and felt microwave energy cooling off, pouring out heat and odors.

I sat down and turned on the TV to one of the channels that showed the Big Bang, a screen full of jumping gray static. Wow! The energy! The roiling chaos! The heat! — no, wait: that was heat from my popcorn. But the chaotic energy I was seeing was unmistakably from the Big Bang. I leaned forward to try to discern patterns in the frantically flickering screen. My eyes were dizzy from the madness.

The energy of the Big Bang is still flowing through space. In fact, it makes up most of the radiation in the universe, far more than that from all the stars. As the universe expanded, this energy cooled, downshifted to longer wavelengths, and finally became microwaves. The discovery and measurement of this cosmic microwave background radiation was one of the most important advances of 20th-century astronomy.

Yet before scientists with ultrasensitive instruments discovered this radiation, people could already watch it every night. The average television set picks up the remnant of the Big Bang and turns it into the static, or "snow," that fuzzes the screen when a set isn't tuned to a broadcast or cable channel. I stared into the Big Bang blizzard, imagining the white dots flying across the screen to be a snowstorm of galaxies flying away after the Big Bang. Look — there goes our Milky Way!

These flashes of energy were the actors in the frenetic show, a story more profound than the human-made tales on other channels. Here was a visceral reminder of our primordial beginnings. I switched channels to a drama of some sort, and even there a touch of snow came through: the Big Bang was animating human motions and voices.

I turned back to the Big Bang Channel and listened to the universe speak. The white noise was a faint echo of everything's creation; it was cosmic surf rolling onto shore after 14 billion years at sea. My TV, serving as seashell, allowed me to hear a deep force that reflected my own pulse. Ancient waves rolled into my ears and brain, thrilling me.

Almost all of the Big Bang energy flowing through space causes no excitement at all. A tiny portion of it falls onto planets but doesn't agitate stones or air. Even in the antennas built just to detect it, this energy stirs only the tiniest of reactions.

But reaching the antenna of a human brain it caused far greater excitement than it had in billions of years. It set off a new Big Bang of sorts — not just mental visualizations but an emotional resonance, a burst of consciousness. I was a bell being rung by the Big Bang — a school bell calling for attendance, a fire bell calling for action, a church bell calling for celebration.

My salty popcorn had me calling for water. I poured H_2O into myself, hydrogen that was born in the Big Bang but which had now become the celebrant of the creative power within seeds. And it was good. ✦

*The author of more than 50 published essays, **Don Lago** lives in Flagstaff, Arizona, where in 1912 Lowell Observatory astronomer Vesto M. Slipher discovered the redshifts of the Big Bang universe.*

Letters

Driver Education

I was happily using a Celestron NexImage planetary camera until an unrelated problem crashed my PC. In the process of recovering I upgraded to Windows Vista, only to find that there aren't any Vista-compatible drivers available for the NexImage yet.

If you're thinking about getting into digital astrophotography or buying a new camera or PC and you expect to be running Windows Vista, make sure you find out if Microsoft or your camera manufacturer supplies an appropriate driver!

Alton Cowan
16 Casa Linda
Brownsville, TX 78521

Save Our Skies (and Ten Bucks)

Increasingly, stargazers are finding their favorite observing sites threatened by light pollution. Often members of astronomy clubs and societies feel powerless to slow or stop the spread of skyglow. One way is to join the International Dark-Sky Association (IDA), which works worldwide to raise awareness about light pollution's problems and solutions.

Here's a special incentive to encourage more amateurs to join our organization. From now through November 30th, the IDA is offering an introductory one-year $20 membership for astronomy-club members — $10 off the usual rate. To receive this discount, visit the IDA website at www.darksky.org/support/membership.php or phone the IDA's main office at 520-293-3198.

Robert L. Gent
International Dark-Sky Association
3225 North First Ave.
Tucson, AZ 85719

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.

Putting the "No" in Nobel

Gabe Benoit ably dispels one of the myths concerning the lack of a Nobel Prize for astronomy (September issue, page 12). Nevertheless, during the first half of the 20th century, astronomers *were* deliberately excluded from consideration for a Nobel Prize.

Mauro Dardo, in his book *Nobel Laureates and Twentieth-Century Physics* (Cambridge University Press, 2004), notes that the Nobel Prize for physics was not given to an astronomer until 1967, when it was awarded to Hans Bethe for his work on how the Sun generates energy. According to Dardo (page 302):

> The Nobel Physics Committee's attitude towards fields which they had considered peripheral to physics, such as astronomy, . . . remained negative for many years. . . . The Committee's attitude was so unyielding that leading astrophysicists such as Arthur Eddington, Edwin Hubble and Henry Norris Russell . . . were persistently ignored.

Tim Hunter
Tucson, AZ
tbh@3towers.com

Moon Madness

Rick Fienberg may have gone a little too far in asserting that there's no correlation between the phase of the Moon "and *any* aspect of human behavior" (September issue, page 8). Often around new Moon, but rarely around full Moon, you'll find people in dark places with telescopes, looking at the sky!

David Policansky
Washington, DC
dpolican@nas.edu

For the Record

- *On page 40 of the September issue, the photos of Surveyor 5's soil-analysis tool were swapped; the left-hand photo is the one that shows the tool after a brief rocket firing.*

SKY & TELESCOPE On the Web

Shoot the Sky

Are you ready to start capturing those magnificent views you've been seeing through your eyepiece? Care to try your hand at imaging the dusky details of Mars, the clouds of Jupiter, or the colorful whorls of the Orion Nebula? Our online **astrophotography department** has tons of tips and information for you to hone your skills. CCD cameras, webcams, image processing — it's all there.
SkyandTelescope.com/astrophotography

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Planets on Parade

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ROBERT LOCKWOOD

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Oc·cul·ta·tion *(n.)* When the Moon or a planet passes directly in front of a more distant planet or star. Learn all those mysterious astro terms with our online glossary.
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Short-Lived Sunspot

Spanning more than 240 feet (73 meters), the International Space Station can be resolved in backyard telescopes. But because of the craft's rapid orbital motion, observing it at high magnification poses quite a challenge. Philadelphia-area photographer Jerry Lodriguss was determined to catch the ISS on the fly. CalSky (www.calsky.com) predicted that on the afternoon of July 8th it would make a 0.47-second-long pass directly in front of the Sun as seen from nearby Vincentown, New Jersey. Armed with a 5.1-inch (130-mm) f/8 Astro-Physics refractor, Baader white-light solar filter, and Canon EOS digital SLR camera, Lodriguss shot a burst of 1/4000-second frames at the appointed time and came away with this prize showing the ISS near a sunspot group at the solar limb.

To read the full story behind this image, visit Jerry Lodriguss's Digital Showcase at www.astropix.com.

News Notes

Monster Galaxy Mashup

Motorists slow down to rubberneck a car wreck, and astronomers have some of the same impulse. Colliding galaxies are fairly common — but a truly monster merger is under way in a distant galaxy cluster in Ursa Major known as CL0958+4702. Kenneth Rines (Harvard-Smithsonian Center for Astrophysics) and several colleagues recently coordinated X-ray, visible-light, and infrared observations to diagnose what's going on. They found a tangle of four galaxies as big or bigger than our Milky Way (the tiny white patches in the image here) surrounded by a haze of many billions of stars (gray-blue) ejected by the melee. "What we have here is like four sand trucks smashing together, flinging sand everywhere," says Rines. "When the merger is complete, this will be one of the biggest galaxies in the universe."

NASA / JPL-CALTECH / K. RINES

Monster Galaxy Void

On really cosmic scales, the universe looks like a spongy foam of galaxy clusters, strings, and walls that are typically tens or hundreds of millions of light-years in size, separated by emptier voids. Radio astronomers have now found the largest void yet, measuring nearly a billion light-years across. It's in (or rather behind) the constellation Eridanus. Lawrence Rudnick, Shea Brown, and Liliya R. Williams (University of Minnesota) found the void while mining through the VLA Sky Survey — hundreds of thousands of observations covering nearly the entire sky made by the Very Large Array radio telescope in New Mexico. They also found a corresponding "cold spot" in the cosmic microwave background (CMB) radiation as seen by NASA's Wilkinson Microwave Anisotopy Probe (WMAP) satellite. Together these indicate a huge region devoid of nearly all matter roughly 6 to 10 billion light-years from Earth.

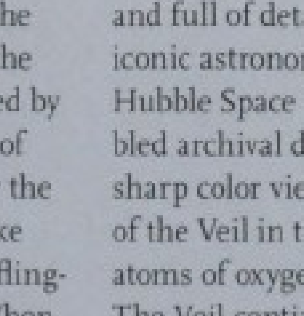
NASA / ESA / HUBBLE HERITAGE TEAM (STSCI/AURA)

Hubble Penetrates the Veil

For amateurs with large telescopes, the Veil Nebula — a wispy supernova remnant — is one of the most-sought deep-sky objects of autumn evenings. Huge and full of detail, it's also one of the most iconic astronomical images. Recently, Hubble Space Telescope scientists assembled archival data to produce extremely sharp color views of three small pieces of the Veil in the light emitted by excited atoms of oxygen, sulphur, and hydrogen. The Veil continues to show ripply, tangled detail in its expanding shock fronts down to Hubble's finest resolution — some 5,000 to 10,000 years after the blast that set the shock wave going.

Nearby Neutron Star

Neutron stars — incredibly dense balls of nearly pure neutrons just 20 miles or so in diameter — usually make themselves known by the high-energy fireworks of material crashing down onto them from a nearby companion star. A few very young ones are known from the tattered remnants of the supernovae that gave them birth. Until recently astronomers knew of only seven "clean," isolated neutron stars that are just sitting quietly in space.



CASEY REED / PENN STATE UNIV.

Now there's an eighth, recently identified in Ursa Major. It's an odd duck. NASA's Swift and Chandra satellites have examined it in X-rays, but strangely, astronomers find no radio energy coming from it. Despite a surface temperature of 2.5 million degrees C, the star is so small that it should shine at an undetectable 32nd magnitude, says team leader Robert Rutledge. It's probably only 250 to 1,000 light-years away, making it one of the closest neutron stars known.

SSC / CASEY REED

A Very Puffed-Up Planet

The newest exoplanet found transiting the face of its star is a weirdo. It has a diameter 70% larger than Jupiter, similar to the previous record-holder for size, but has only 0.84 Jupiter's mass. This means its average density is just 0.2 gram per cubic centimeter — a fifth the density of water and about that of balsa wood.

Of the 24 transiting "hot Jupiters" discovered so far, about half are puffed up to larger-than-expected sizes by some kind of internal heat source. But this one seems almost inexplicable.

Stars that Smoke

R Coronae Borealis, easily spotted in binoculars at 6th magnitude most of the time, is one of the most familiar variable stars that amateurs keep tabs on. It's the prototype for a class of yellow-white, carbon-rich supergiants that drop without warning to a tiny fraction of their normal brightness. What happens is that carbon vapor leaving the star condenses into soot so thick that it blocks up to 99.9% of the star's light from view.

Recently astronomers used the European Southern Observatory's Very Large Telescope Interferometer to map two large, infrared-emitting smoke clouds as close as 30 astronomical units from RY Sagittarii, the second-brightest R Coronae Borealis star in the sky. This is the closest dusty cloud ever detected around an R CrB-type variable since the first such direct detection in 2004.

ESO / P. DE LAVERNY / D. MEKARNIA

Thirty Meter Telescope

In August the hugely ambitious Thirty Meter Telescope Project received another $15 million from the Gordon and Betty Moore Foundation, in addition to the $35 million the foundation gave previously.

The title of the world's largest single, visible-light telescope will soon pass from the 10-meter Kecks in Hawaii to the 10.4-meter Spanish GranTeCan (see last month's issue, page 18). But the TMT will seize the title in a huge way. Its primary optic will consist of 492 individually controlled hexagonal segments combining into a single mirror 30 meters (100 feet) wide. A six-laser guide star adaptive optics system will be built right in. Site selection is scheduled for next May; locations in Chile, Hawaii, and Mexico are on the short list. Plans call for the telescope to begin operations in 2016.

TMT PROJECT

Mission Update *Jonathan McDowell*

BALL AEROSPACE & TECHNOLOGIES CORP.

Kepler Dodges Axe, Aims for Alien Earths

NASA's planet-finding Kepler mission is back on track for an early 2009 launch following a brush with cancellation. The ballooning cost of this space observatory, now exceeding $500 million, led to an ultimatum by NASA's science boss, Alan Stern. Some quick adjustments and a decision to shorten the primary mission from 4 to 3½ years squeezed Kepler back into its allotted budget.

The 1-ton spacecraft will travel in a 372-day orbit around the Sun, similar to that of the infrared Spitzer Space Telescope. Its Schmidt optics, with a 0.95-meter (37-inch) aperture, will rank as the largest telescope ever placed beyond Earth orbit, beating Mars Reconnaissance Orbiter's 0.5-meter HiRISE camera and the 0.85-meter reflector aboard Spitzer.

Kepler will spend all its time staring at a single field at the border of Cygnus and Lyra, along our galaxy's Orion spiral arm, monitoring 100,000 stars. In each star it will measure brightness changes of less than one part in 10,000, the degree of sensitivity needed to reveal any Earth-size planets transiting across the stars' faces. Ground-based telescopes have been very successful at finding Jupiter-class transiting planets, but smaller worlds require observing from above the atmosphere.

Fewer than 1% of Earth-size planets in Earth-size orbits around Sun-like stars will actually transit their stars from our viewpoint. So the telescope must monitor a lot of stars to find such planets even if they are common. Besides Sun-like G-type stars, Kepler will also watch many K- and M-class orange and red dwarfs. Early next decade, we may finally know how common other Earths are in the galaxy.

Astronomers are already compiling a catalog of target stars, using the 1.2-meter telescope on Mount Hopkins in Arizona to estimate their distances and sizes and to eliminate unworthy giants and variables. The mission is designed to find several hundred terrestrial planets with orbital periods of up to a year, which would put them in the "habitable zone" around their stars.

Kepler has a huge field of view — 105 square degrees — and a 95-megapixel camera that will track stars as faint as 15th magnitude. An onboard computer will analyze the images, create light curves for the stars of interest, and send only that data to the ground. This greatly reduces the time needed to talk to Earth, but it also means that the telescope can't observe serendipitous new objects even if they appear smack in its field of view.

SOURCE: NASA / ARC

The Kepler spacecraft will stare at this field between Vega and the western wing of Cygnus, monitoring the light from 100,000 stars to find any small planets transiting them. Boxes show the coverage of the camera's CCD chips.

This limitation doesn't worry the Kepler team, which will likely be swamped with data. In addition to planets, the precise light curves should reveal tiny seismic oscillations in the target stars, a means of probing their interiors. ◆

Jonathan McDowell, an astronomer at the Harvard-Smithsonian Center for Astrophysics, reports on all manner of spacecraft activity at www.planet4589.org.

Risky Meteorite Recovery

MICHAEL FARMER

On July 6th the sky fell over western Colombia, when a massive bolide broke apart in the lower atmosphere with ferocious explosions that shattered windows and shook the ground. Moments later, stones pelted homes in the poor barrios surrounding the city of Cali. Meteorite hunters Michael Farmer and Robert Ward flew there from Arizona and teamed up with local amateur astronomers to recover some of the fragments. After several days, they had located and purchased only about 10 ounces (270 grams) from barrio residents. An attempted armed robbery convinced them to leave. Farmer estimates that the Cali event must have dropped many more fragments, but these landed in dense cane fields and will probably never be found.

Even though the recovered stones turned out to be a rather common type of chondritic (rocky) meteorite, they're now fetching thousands of dollars per gram on the collectors' market.

Enceladus: Geysers Without Water?

You don't need liquid water to explain the sprays of ice that are jetting out of huge cracks in Saturn's moon Enceladus. Astronomers from the University of Illinois have put forth a new model in which clathrates — frozen mixtures of water ice and other volatile solids such as CO_2 (dry ice) — can fly apart when exposed to the vacuum of space due to crustal cracking. Once the process gets started, it can go on continuously until an entire large pocket of the material is used up. This could produce long-duration geysers of gas and snow powder without the material having to warm to anywhere near its melting temperature.

50 & 25 Years Ago *Leif J. Robinson*

November 1957

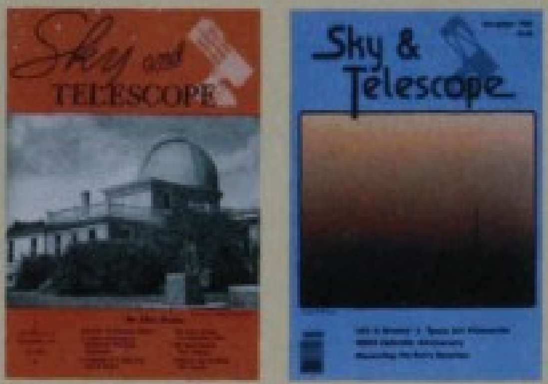
The Age of Orion's Core "The compact cluster of faint stars surrounding the Trapezium, in the heart of the Orion nebula, is growing in size . . . according to the work of K. A. Strand. . . . This expansion indicates a common origin for the cluster stars only 300,000 years ago. . . .

"Strand's findings illustrate the importance of positional observations of the stars over long intervals. He made measurements of recent Orion photographs . . . and compared them with similar plates taken 50 years earlier. . . ."

Strand's age still holds up. The Trapezium, spanning a region some 3 light-years across, consists of younger members of the Orion Nebula Cluster, which contains about 2,000 stars bunched within about 20 light-years.

Sputnik Details "The artificial-satellite age began on October 4, 1957, when a Russian test vehicle started to circle the earth 15 times a day. . . .

"In *Soviet Aviation*, Prof. Y. A. Pobedonostsev stated that the three-stage launching rocket attained a speed of about 4,500 miles per hour in the first two minutes. When the first stage dropped away, the vehicle was moving upward at a 45-degree angle. At second-stage burnout, the speed was nearly 12,000 miles an hour. Unpowered flight lasted until horizontal motion was achieved about 625 miles from the launching site; then the third-stage motor took over to boost the speed to approximately 18,000 miles per hour before ejection of the artificial moonlet."



November 1982

Unmasking Galactic Nuclei "X-rays from the Type I Seyfert galaxy NGC 6814 recently have been observed to vary on a time scale of 100 seconds. The finding is important, for it sets an upper limit to the size of the emitting region at a few light minutes. . . .

"If the 'engine' is a black hole accreting matter, its diameter must be less than the light-travel time across its Schwarzschild radius. . . . Such a black hole cannot have a mass of more than 10 million Suns."

Black holes have become the canonical explanation for active galactic nuclei, such as occur in Seyferts.

NASA / JPL

Geysers Not a Cassini Threat

Planetary scientists are eagerly awaiting Cassini's closest flyby of Enceladus next March 12th, when the craft will swoop within 100 km (60 miles) of the surface. But will ice particles from the geysers pose a threat?

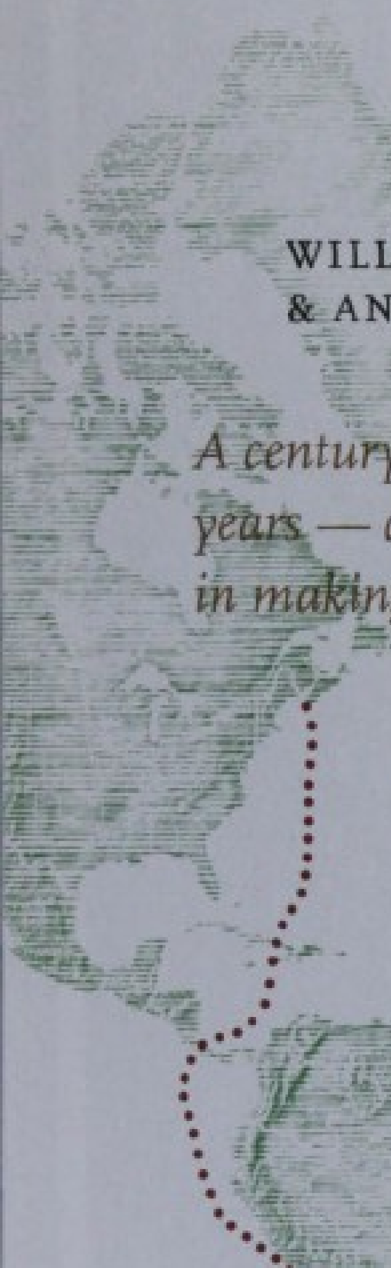
No, says Larry Esposito (University of Colorado), principal investigator for the spacecraft's Ultraviolet Imaging Spectrograph. Esposito describes UVIS observations that indicate the particles in the sprays are too small to do damage. ✦

To read more about these stories, go online to SkyandTelescope.com and search for the keyword SkyTelNov07. To read astronomy news as it breaks, visit SkyandTelescope.com/newsblog every weekday.

The Great Mars Chase of 1907

WILLIAM SHEEHAN
& ANTHONY MISCH

A century ago Mars came closer to Earth than it had been in a dozen years — and astronomer Percival Lowell came closer than he ever would in making his case that the planet was inhabited.



SOUTHBOUND The Lowell expedition's huge telescope and its handlers reached Chile in June 1907, choosing a site about 40 miles inland from the port of Iquique. *Left:* After spending nearly two months in the bleak Atacama Desert, the observing team relaxed aboard ship en route back to the United States.

MAP OF CHILE & GROUP PHOTO: DAVID PECK TODD ARCHIVES / YALE UNIV. LIBRARY

AS 1907 DREW TO A CLOSE, the staid *Wall Street Journal* asked its readers, "What has been in your opinion the most extraordinary event of the past twelve months?" For the *Journal*, it was not the "financial panic which is occupying our minds to the exclusion of most other thoughts" but rather "the proof afforded by astronomical observations . . . that conscious, intelligent human life exists upon the planet Mars."

The Red Planet had come to opposition on July 12th of that year, as it does every 26 months (see page 66). But 1907's proximity was unusually favorable. Mars approached within 38,500,000 miles of Earth — closer than it had been at any time since 1892.

Percival Lowell, whom British astrophysicist J. Norman Lockyer called "the greatest authority on Mars we have," had by then scrutinized the planet intensively from his Flagstaff, Arizona, observatory since 1894. Convinced of Mars's habitability, Lowell was eager to add the QED to his argument by presenting the world with undeniable photographic evidence of the water-bearing canals he believed to be crisscrossing the planet's surface.

His assistant, Carl Otto Lampland, had obtained promising results in 1905. On May 11th that year, Lowell and Lampland believed they'd captured on film a network of fine lines etched on the Martian surface. In his book *Mars*

PLANET HUNTING To get the best possible photographs of Mars in 1907, Percival Lowell dispatched a team of astronomers to Chile. There they erected this 18-inch refractor under the rain-free skies of the Atacama Desert, taking time to enjoy their tea too.

and Its Canals, Lowell stirringly announced: "Thus did the canals at last speak for their own reality themselves."

However, the available methods of mass reproduction could not preserve such fine detail, and Lowell briefly considered employing his friend George Russell Agassiz to retouch the photographs to bring out linear features. But magazine editors howled that such treatment would "spoil the autographic value of the photographs themselves."

Ultimately, the only recourse was to obtain better images that would "speak for themselves" even through the coarsening processes of publication. All eyes turned eagerly to see what would emerge from the developing tray during the close approach of 1907.

The Southern Advantage

The planet's declination that summer, 28° south, was unfavorable for Northern Hemisphere observers. But Lowell had been in regular contact with David Peck Todd, an old friend and professor of astronomy at Amherst College in Massachusetts. Todd had just acquired an 18-inch Clark refractor for the school, and he proposed shipping it via Panama for the purpose of photographing Mars from the Southern Hemisphere, where the planet would stand close to the zenith in the sky. Lowell endorsed the idea at once, agreeing to pay the expenses for what came to be known as the "Lowell Expedition to the Andes."

The expedition members included Todd and his wife, Mabel Loomis Todd; Lowell staff astronomer Earl C. Slipher; A. G. Ilse, an engineer from Alvan Clark and Sons; and Todd's student, R. G. Eaglesfield. (The Todds' 27-year-old daughter, Millicent, later joined the group in Chile but did not participate in the observing.)

Before setting out, Todd was interviewed by the *Boston Transcript*. "We are going to South America," he said, "in hope of getting the facts, and to obtain information on the question of the Martian canals. . . . Is Mars inhabited? This is a question my wife has often asked me, but do you know I've never been able to answer it? Maybe when I come back — well, we will wait and see."

The 7-ton telescope had to be disassembled and crated up in Amherst, then shipped to the Chilean port city of Iquique. On May 6th, as the expedition prepared to sail out of New York, Lowell telegraphed a last message to Todd: "Don't forget tooth brush and telescope may be useful." Lowell's humorous banter attests to his euphoric

LOWELL OBSERVATORY ARCHIVES (2)

MEN OBSESSED Intense scrutiny of Mars convinced Percival Lowell *(left)* that the planet was crisscrossed by water-filled canals and thus inhabited by intelligent beings. Lowell's representative on the 1907 expedition was staff astronomer Earl C. Slipher *(right)*.

mood. He followed up with a few lines of doggerel, which attest to his high expectations for the adventure's success:

All Hail!
To you about to sail —
May you avail
In our Martian grail
And then to me the matter mail.

In the Canal Zone in Panama they "came near liquefying with the oppressive heat," and upon reaching Iquique itself they worried about "tidal waves." From there they traveled 40 miles inland to the nitrate-mining center of Alianza, located 4,000 feet above sea level, where they determined to set up the refractor in the midst of the nitrate fields. The last leg of the journey, along a sinuous and steep spur track, was by means of a "quaint little car, a white mule, and an Indian rider." Standing at last in the observing compound on June 17th, Todd described the otherworldly bleakness of the scene:

> The region is an utter desert; the moon itself could not reveal greater barrenness — not a tree or a flower or a blade of grass for miles, not even moss or lichens. . . . The clustered dwellings of the workers in the nitrate fields . . . gave an almost populous effect to the barren landscape . . . with happy promise of all sorts of mechanical aid in setting up the telescope. . . . Around the whole settlement stretched the solemn, brown, impressive pampa, undulating to the great mountain border, the Andes, its peaks here and there snow-capped, lofty, and magnificent. Here, in the midst of all this forbidding waste, we found one of the best astronomical stations ever occupied.

The refractor was set up, in domeless splendor, under the burnished desert skies. It never rained, though a distant thunder — the rumbling of earthquakes — could be heard three or four times a day. Because of the southerly latitude, the polar axis of the telescope had to be readjusted by means of a wedge in order to bring it into alignment. But doing so shifted the center of gravity to a position in which the telescope was nearly unbalanced. To keep it from being toppled by earthquakes, the team fastened guy wires tied to spikes driven into the ground.

Canals "Startling in Their Certainty"

Despite occasional fog and haze, most of the time the air was sublimely still and clear. Under these conditions, the view of the planet high overhead was unforgettable. As Todd described his first view of it:

> On first looking at Mars through a large telescope from a great elevation, as the Chilean pampa, with the sky perfectly clear, the air steady, and a high magnifying power on the planet close to the zenith, every observer, whether professional or [amateur], was amazed at the wealth of detailed markings that the great reddish disk exhibited. Its clear-cut lines and areas were positively startling in their certainty; the splendor of that first visual glimpse in steady air can never be forgotten. . . . Nearly everybody who went to the eyepiece saw canals; and once I fancied I heard even the bats, as they winged their flight down the pampa, crying, "Canali, canali, canali!"

As exciting telegrams began to arrive in Flagstaff from the expedition, Lowell seemed to strain more in eking out the meaning of the sometimes cryptically ellip-

DAVID PECK TODD ARCHIVES / YALE UNIV. LIBRARY

TALK OF THE TOWN Amherst College astronomer David Peck Todd, seen here with his wife, Mabel Loomis Todd (seated), and their daughter Millicent, were the toast of Boston during and after their adventures in Chile.

DAVID PECK TODD ARCHIVES / YALE UNIV. LIBRARY

THE BOSS APPROVES Percival Lowell was counting on the 1907 expedition to confirm the Martian canals' existence, and he dispatchd this enthusiastic telegram to Chile after seeing some of the initial photographic results.

tical messages than the observers in the Chilean desert did in making out the true nature of the planet's detail. At the end of July, Lowell wrote to Todd:

> Bravo! I telegraphed you and bravo! I repeat. Your dispatches cause our hair to stand on end and our voices to stick in our throat. . . . Now I am looking forward to letters detailing your remarkable exploits as per cables conscientiously deciphered. The last at first blush seemed a hopeless jumble but we . . . almost instantly jumped on the clue. Then we were stricken dumb. — We ourselves had succeeded in . . . registering on our plates several dozens of canals. . . .
>
> The world, to judge from the English and American papers, is on the *qui vive* about the expedition, as well as about Mars. They send me cables at their own extravagant expense and mention vague but huge (or they won't get 'em) sums for exclusive magazine publication of the photographs. . . . You must be having glorious views except for craning your necks. The Solis Lacus region is on at the moment and we had one fine view the other evening disclosing eight estuaries from it and other new and delicate detail.

With no cloudy nights to interrupt the observing, the team settled into a monotonous routine. Todd recalled: "Night after night the little automatic plate-holders went on with their click, click, click. . . . One night was much like another." Slipher was the most tireless worker. Of him it could be said, "for weeks at a time it was Mars, Mars, unadulterated Mars." He obtained in all 13,000 photographs of the planet.

Lowell was euphoric with the prints that began to trickle back to Flagstaff, writing to Todd in early September that they were "beyond expectation fine. We have all of us looked, admired and looked again. . . . The canal stock . . . has already risen in consequence." Lowell relished the fact that the photographs were already causing some of his skeptics to waver. "The results of this opposition have waked up England considerably," he gleefully noted.

The last observations at Alianza were made on August 1st, and once the expedition was safely home Todd and his family returned to Amherst. Soon thereafter, he and Lowell began to clash bitterly over the rights to reproduce the South American photographs.

From the start, Lowell had advised Todd that he reserved first right of publication for himself, putting Slipher in charge of "all prints, drawings, and negatives." However, after Lowell and Slipher published some of the photographs in the December issue of *The Century*, Todd asserted that *he* had been the team's leader and refused to acknowledge Lowell's exclusive rights. The Amherst astronomer arranged to have some of Slipher's images published in the January 1908 *Cosmopolitan*, which then had a circulation of 1 million, and rather disingenuously identified them as "reproduced from the films taken . . . by the photographers of Professor Todd's party."

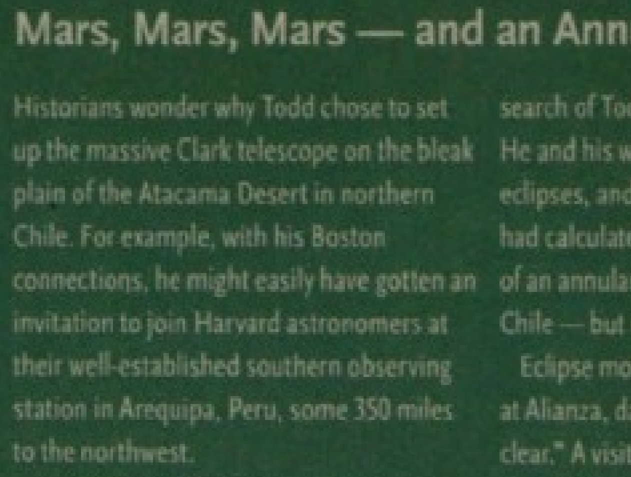
Although Todd claimed in this rather self-congratulatory article that "the entire expedition was bent on get-

Mars, Mars, Mars — and an Annular Eclipse

Historians wonder why Todd chose to set up the massive Clark telescope on the bleak plain of the Atacama Desert in northern Chile. For example, with his Boston connections, he might easily have gotten an invitation to join Harvard astronomers at their well-established southern observing station in Arequipa, Peru, some 350 miles to the northwest.

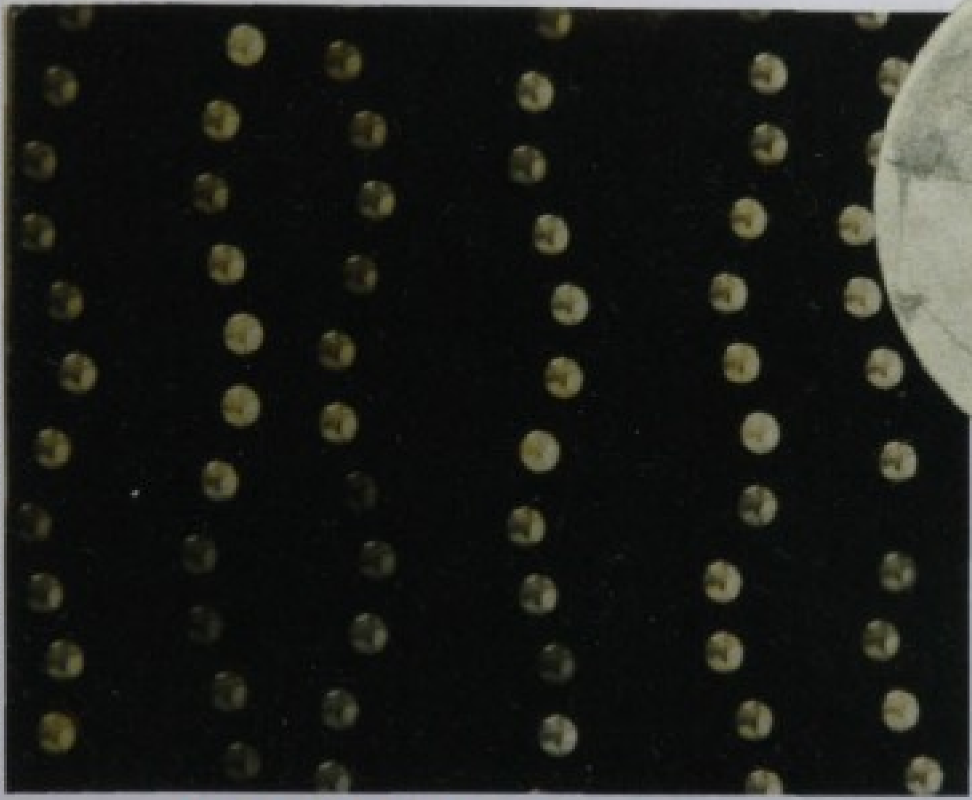
One likely justification turned up in a search of Todd's archives at Yale University. He and his wife enjoyed chasing solar eclipses, and before heading south Todd had calculated that on July 10, 1907, the path of an annular eclipse would cross northern Chile — but not southern Peru.

Eclipse morning, like most every other at Alianza, dawned sunny and "absolutely clear." A visitor named W. Brooke Comber noted that shadow bands were not seen during the eclipse and made detailed sketches of Baily's Beads (seen at left) at the beginning and end of annularity. By all accounts, the expedition team enjoyed a fine view of the eclipse — and then it was back to work observing Mars.



DAVID PECK TODD ARCHIVES / YALE UNIV. LIBRARY

— *J. Kelly Beatty*



CANAL CENTRAL Lowell used Slipher's photos and sketches to update his master map *(upper right)* of Mars's globe-girding canal system. South is up in all views of Mars in this article.

ALL MARS, ALL THE TIME Slipher took 13,000 photographs of Mars during the planet's apparition in 1907, typically recording dozens of images on each sheet of film. *Right:* The tiny images, only 3⁄16 inch across, showed rich detail — but no canals — on the Martian surface.

ting the best possible photographs of Mars, and worked together harmoniously to that end," in fact serious tensions had developed among the members of the group even in Alianza. It seems that Todd was chiefly at fault, and Slipher and Lowell later had frank conversations about "DPT."

Todd's grandiosity and unreasonableness may have been an early sign of a brain disease, probably tertiary syphilis, that was beginning to affect him. He began to entertain increasingly rash ideas, such as a plan, in 1909, to take a balloon above Earth in order to detect radio communications from Mars. After being eased into early retirement from Amherst in 1917, Todd continued making feverish efforts to contact the Martians until he was institutionalized in 1922. He died in 1939.

Much Ado, and Adieu

As remarkable as Slipher's photographs were for their time — and they were regarded as nothing less than miracles of technique in that primitive era of planetary photography — they remained more tantalizing than definitive. The planet's disk was only 3⁄16 inch (less than 5 mm) across on the original plates, and the images proved difficult to reproduce well on the printed page. Thus they disappointed the public who could not, generally speaking, determine what all the fuss was about.

Even astronomers, who had the advantage of viewing the original negatives and prints with trained eyes, could not agree on the details found on them. The great Italian astronomer Giovanni Schiaparelli, whose own observations had started the canal craze 30 years before and who now, with failing eyesight, was reduced to studying Lowell's prints with a magnifying glass, pronounced himself entirely convinced of the canals' reality. But others demurred, and the final consensus — despite the *Wall Street Journal*'s enthusiastic declamation — was that the photographs had failed to settle the matter.

Ironically, the canals' coup de grâce, in the eyes of most professional astronomers, came less than two years after these pioneering images graced the pages of *The Century* and the *Cosmopolitan*. It was delivered not by better photographs but by the eye-brain-hand of Eugéne Michael Antoniadi, who, thanks to periods of ultrasteady air while observing with the 33-inch refractor at Meudon Observatory near Paris, convincingly recorded Mars's irregular (and completely natural-looking) surface details.

Learn more about Percival Lowell and his astronomical legacy at www.lowell.edu.

The Lowell Observatory archives contain a vast correspondence about Mars from a fascinated public. Judging from the volume of letters received there from year to year, it seems that interest in Mars and the Martians peaked in 1907. That's when Lowell came closer than he ever would again to convincing the world that the Red Planet is crisscrossed with a network of canals bearing meltwater from its polar regions to its parched deserts — a dying planet, not yet dead. ✦

By day, ***Bill Sheehan*** *is a psychiatrist and neuro-imaging specialist in Willmar, Minnesota; by night he writes for* Sky & Telescope *and other publications. History sleuth* ***Tony Misch*** *is a support astronomer at Lick Observatory in California.*

DARK BEASTS OF THE TRANS-NEPTUNIAN ZOO

Mark Littmann

NASA / JPL / SPACE SCIENCE INSTITUTE STAR FIELD PHOTO: AKIRA FUJII

The count of dwarf planets and state-size icebergs out beyond Neptune now tops 1,000. And they don't seem to want us to figure them out.

ONCE UPON A TIME, like when the astronomy books in your library were probably written, the solar system ended with Pluto. That was then.

Today one of astronomy's richest areas of discovery is out past the solar system's old limits, in the *Kuiper Belt* (pronounced "KY-per") and the even wider realms beyond. Until 1992 the Kuiper Belt was only theoretical. Now it's as real as its hundreds of known members.

At last count, astronomers had cataloged 1,055 trans-Neptunian objects (or TNOs, the all-encompassing, non-judgmental term) that have well-determined orbits beyond Neptune's. Most of these are likely larger than 100 kilometers (60 miles) across. There are probably a half million others larger than 30 km and millions of smaller ones. They're giving us all sorts of hints about the solar system's formation — including why the giant planets migrated to different orbits, why the Moon got its late cratering, and how Earth got its oceans.

In the September issue (page 22) I described a new theory of how the Kuiper Belt and its related structures may have formed, and what this says about the rest of the solar system's past. Here we'll take a closer-up look at the various species now on display in the trans-Neptunian zoo.

They're an odd lot. There's Eris, usurper of Pluto's title as king of the outer spaces. Slightly bigger than Pluto, and with a moon of its own, Eris currently lurks about three times Pluto's distance from the Sun, following an orbit that's about twice as eccentric and twice as steeply

SCATTERED AND CAPTURED Phoebe, the outermost large satellite of Saturn, was probably a typical Kuiper Belt object before gravitational perturbations flipped it closer to the Sun and a later interaction left it loosely bound to Saturn. It's probably typical of what awaits farther out. In this Cassini orbiter image, white material exposed on cliff slopes and crater walls is probably relatively fresh ice. Mission planners were not expecting such bright material, which is why it's overexposed. Phoebe is about 220 kilometers (140 miles) wide.

inclined to the plane of the solar system.

Then there's "Buffy" (the nickname given to object 2004 XR_{190} while it awaits an official name), whose entire orbit is way out. The Kuiper Belt consists of bodies with mean distances roughly 30 to 48 astronomical units from the Sun — but Buffy never ventures closer to the Sun than 51 a.u. The word "belt" implies a flattened doughnut. But true to its television eponym, Buffy never read the rules. Its orbit is tilted a wacky 47° to the plane of the solar system.

There's Sedna, perhaps weirdest of all. Its orbit is so big and elongated that it loops from 76 to about 900 a.u. from the Sun. Yet its orbit is tilted less than Pluto's.

"This is a very puzzling place," says astronomer Brett Gladman (University of British Columbia), who with Lynne Allen Jones discovered Buffy. "You want me to tell what things are certain in the Kuiper Belt? That won't take very long."

It's an embarrassment of riches. Scientists haven't had so much fun classifying bizarre objects since Alexander Humboldt set foot in South America, venturing into a world with thousands of species he had never seen.

Astronomers have decided that TNOs fit, uncomfortably, into four categories. They're still arguing about what to call those categories, and in some cases, which bodies belong where.

1. Pluto & Company

First there are **resonant Kuiper Belt objects.** These have orbits that are gravitationally linked to Neptune, being trapped in "resonances" with it. The prime example is Pluto. For every two times Pluto orbits the Sun, Neptune completes three revolutions. More than 100 other bodies are also in a 2:3 resonance with Neptune; astronomers call these ones *plutinos*. Other popular resonances are 1:2, 3:5, and 4:7.

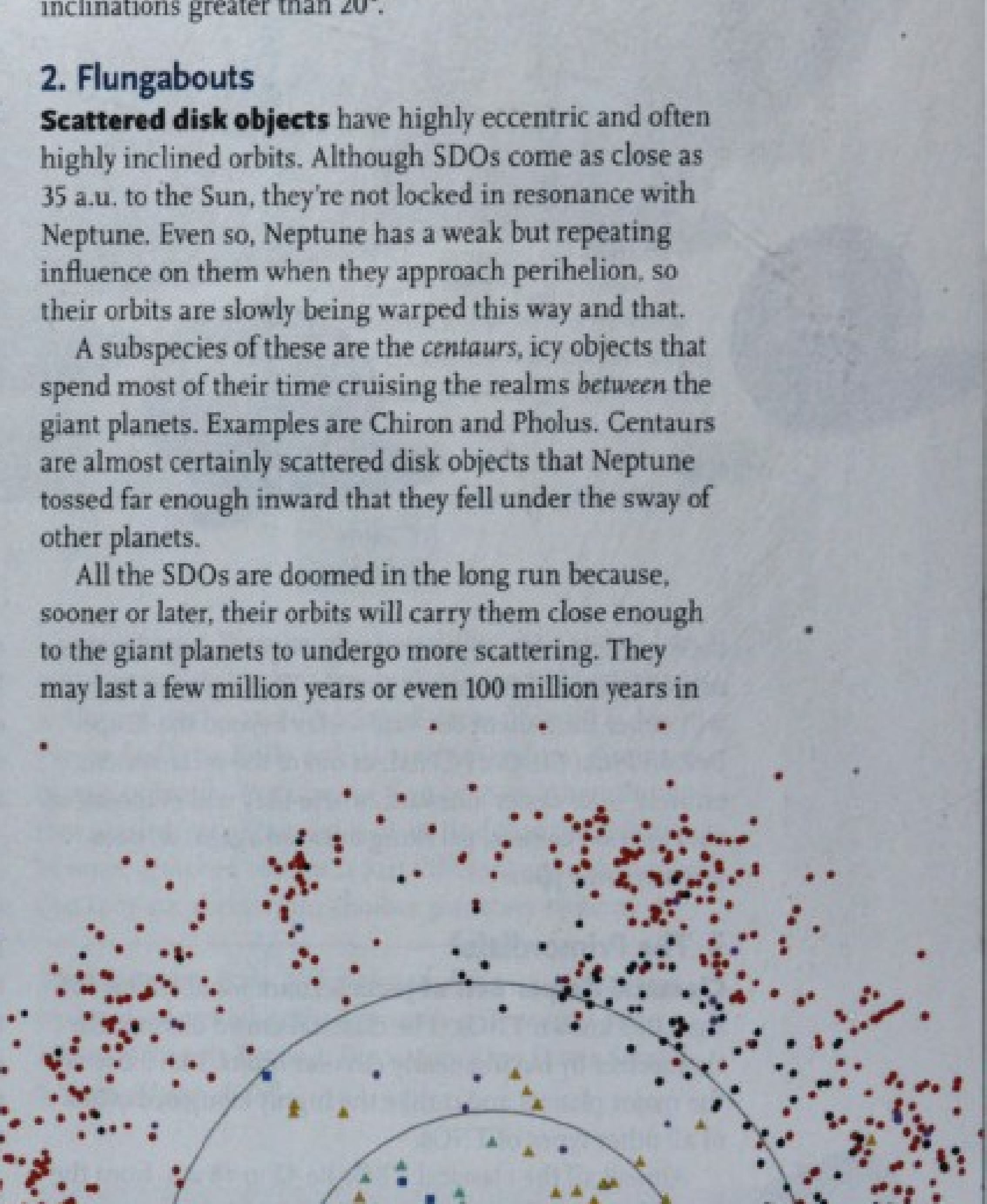
Like Pluto, the resonant objects have orbits more elliptical and more inclined to the plane of the solar system than those of the major planets. However, few have orbital inclinations greater than 20°.

2. Flungabouts

Scattered disk objects have highly eccentric and often highly inclined orbits. Although SDOs come as close as 35 a.u. to the Sun, they're not locked in resonance with Neptune. Even so, Neptune has a weak but repeating influence on them when they approach perihelion, so their orbits are slowly being warped this way and that.

A subspecies of these are the *centaurs*, icy objects that spend most of their time cruising the realms *between* the giant planets. Examples are Chiron and Pholus. Centaurs are almost certainly scattered disk objects that Neptune tossed far enough inward that they fell under the sway of other planets.

All the SDOs are doomed in the long run because, sooner or later, their orbits will carry them close enough to the giant planets to undergo more scattering. They may last a few million years or even 100 million years in



RICH DISARRAY This computer snapshot shows the positions of known bodies in the outer solar system on August 16, 2007. Radial gaps are caused by incomplete search coverage. The view is from the north ecliptic pole. The vernal equinox, in Pisces, is to the right.

MORE TO COME? The six largest objects currently known beyond Neptune are shown (with their moons) with Earth for comparison. "Santa" spins in just 4 hours, so fast that it's flattened into an ellipsoid. New discoveries are almost certain to change this list.

their current orbits, but eventually Neptune will flip them nearer Uranus, Saturn, and Jupiter. These planets in turn will either fling them outward — far beyond the Kuiper Belt and into the Oort Cloud, or out of the solar system entirely — or closer sunward, where they will evaporate as short-period comets, get flung outward again, or, occasionally, hit a planet.

3. The Primordials?

Classical Kuiper Belt objects account for about half of the 1,055 known TNOs. The classical crowd distinguish themselves by having nearly circular orbits, like those of the major planets and unlike the highly elongated orbits of all other types of TNOs.

Almost all the classical KBOs lie 42 to 48 a.u. from the Sun. That puts them farther from the orbit of Neptune than Saturn is from the Sun. The classicals' great distance from Neptune, along with their relatively circular orbits, suggest that they have managed to avoid severe or sustained disturbances by planetary gravitational fields.

Among the larger and better known classical KBOs are 136472 "Easterbunny" (a nickname), also known as 2005 FY_9; 136108 "Santa" (2003 EL_{61}); 50000 Quaoar; and 20000 Varuna. The very first KBO discovered since Pluto, initially designated 1992 QB_1 and now numbered 15760, turns out to be a classical object too. Accordingly, some astronomers refer to classical KBOs as *cubewanos* (pronounced "QB-one-ohs") in honor of the prototype.

Most known classicals have low-inclination, low-eccentricity orbits — dynamically, they're considered "cold." A few objects in highly inclined ("hot") orbits are still considered a subspecies of classicals because their orbits are relatively circular.

Early models of the Kuiper Belt envisioned that all its members would be in nearly circular orbits near the plane of the planets. Only the low-inclination, "cold" classical KBOs fit that description. Might these be undisturbed objects left over from the planet-building phase at the solar system's birth — and hence the least-altered material available for us to study from that distant age?

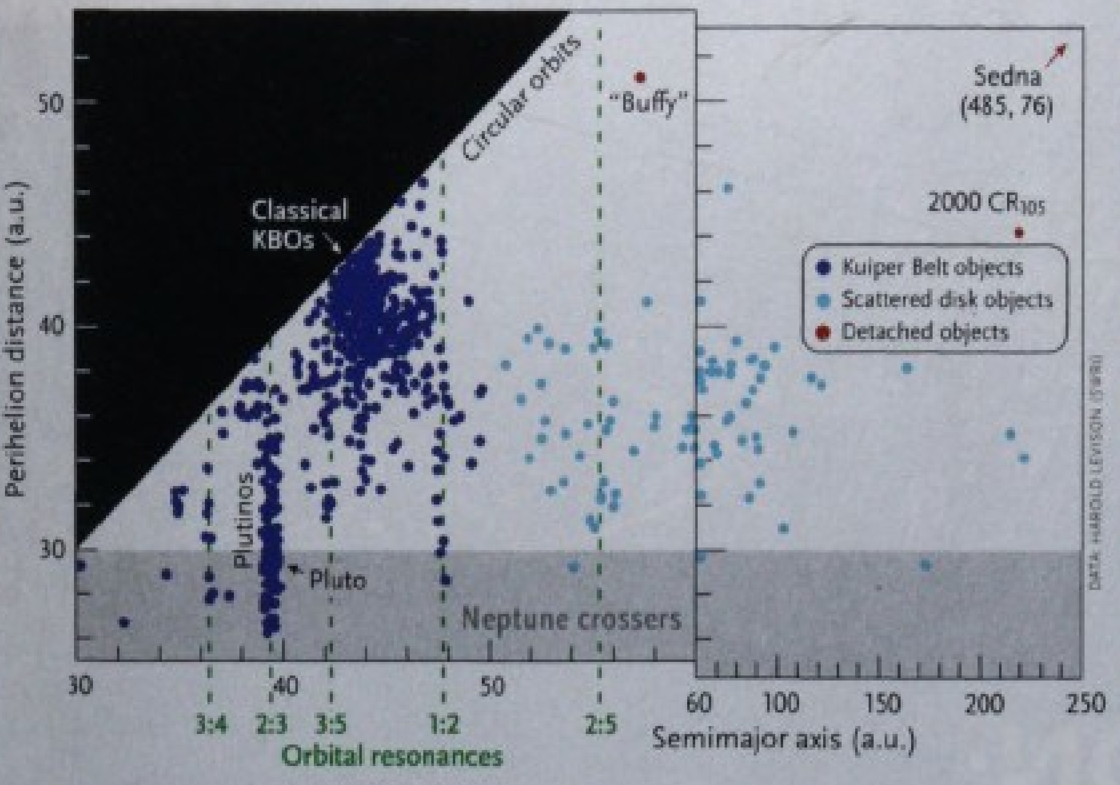
Maybe, says Gladman. Maybe not.

4. The Wild Ones

So far, all of these objects either reside in or venture into the Kuiper Belt proper. They're distinguished largely by their relationships to Neptune's gravitational field. Resonant objects are trapped by Neptune's gravity, scattered objects are disturbed by it, and the classicals are pretty much unaffected by it.

Then there are the **detached objects.** These used to be called "extended scattered disk objects," but Gladman and others weren't happy with the term. "That demeans how strange their orbits truly are," he says. And besides, they don't lie in a disk. Many solar-system dynamicists think the emphasis belongs on *detached* — from Neptune's gravity, and from the Kuiper Belt in general. Detached TNOs have mean distances so far beyond the Kuiper Belt that some astronomers think of them as the innermost members of the distant Oort Cloud, the source of long-period comets.

For astronomers trying to make sense of TNOs, detached objects are the greatest challenge. The other three types fit into the modern picture of the solar system's chaotic, headstrong youth, during which Saturn and Jupiter may have fallen into a temporary 1:2 resonance with each other and Uranus and Neptune migrated outward, as told in the September issue. But many astronomers think the wild orbits of the detached objects can be explained only by invoking a large, massive object that existed in, or blundered through, the outer solar system



NAMING OF PARTS One way to classify trans-Neptunian objects is by their mean distances from the Sun (horizontal axis) and the ellipticity of their orbits (expressed on the vertical axis by how close to the Sun they venture). The farther from the diagonal line an object is, the more elongated its orbit. In the Kuiper Belt proper, note the clustering around orbital resonances with Neptune, especially the 2:3 resonance of Pluto and its fellow plutinos. *Classical* and *resonant* Kuiper Belt objects give way to *scattered disk objects* beyond about 50 a.u. *Detached objects* are especially far out. The definitions, however, are disputed and may overlap.

soon after the planets formed. Two efforts are attracting the most attention.

Gladman and Collin Chan (University of British Columbia) have suggested that a few full-size rogue planets — refugees from the migration of the giants — roamed the trans-Neptunian region early on and stirred up the orbits of millions of planetesimals there. Within some 250 million years, these maverick planets were swallowed up or flung away by gravitational encounters with the giants. But the chaos they wreaked beyond the Kuiper Belt remains.

Second, and perhaps even more intriguing, is a proposal by astronomers including Scott Kenyon (Harvard-Smithsonian Center for Astrophysics) and Ben Bromley (University of Utah) that Sedna, and perhaps Buffy and Eris, owe their orbits to a visit by another star.

Stars generally form in clusters; we see this happening in nebulae throughout the universe today. Our solar system shows plenty of evidence that it formed in a hot, violent nebula along with, presumably, hundreds of other stars. Eventually the newborn stars drift apart. But it's possible — not likely, but possible — that within the first 100 million years, one of the Sun's birthmates wandered through the outer fringe of our solar system.

In their computer simulations, Kenyon and Bromley got a curious but consistent result. Originally, they think, the Sun had a great many planetesimals in a disk extending from the giant planets out to 80 a.u. An intruder star, leisurely cruising past at a minimum distance of 150 to 200 a.u. (0.002 light-year), would disrupt the orbits of planetesimals more than 50 a.u. from the Sun and scatter them in all directions. Kenyon and Bromley's simulations show that no matter what the intruder star's angle of approach or tilt with respect to the solar system's plane, it creates Sedna-like orbits for some of the Sun's planetesimals.

Kenyon and Bromley also found that the passing star may have carried away a few million of our planetesimals in the process — and dropped off some of its own. So maybe Sedna or Buffy or Eris aren't even from our interplanetary family. Perhaps the Sun captured them from that passing star. One day, will we find that the chemistry of some detached objects is just different enough to reveal that they are aliens from another planetary system? ◆

***Mark Littmann** is the Hill professor of science, technology, and medical writing at the University of Tennessee and author of* Planets Beyond: Discovering the Outer Solar System *(Dover, 2004).*

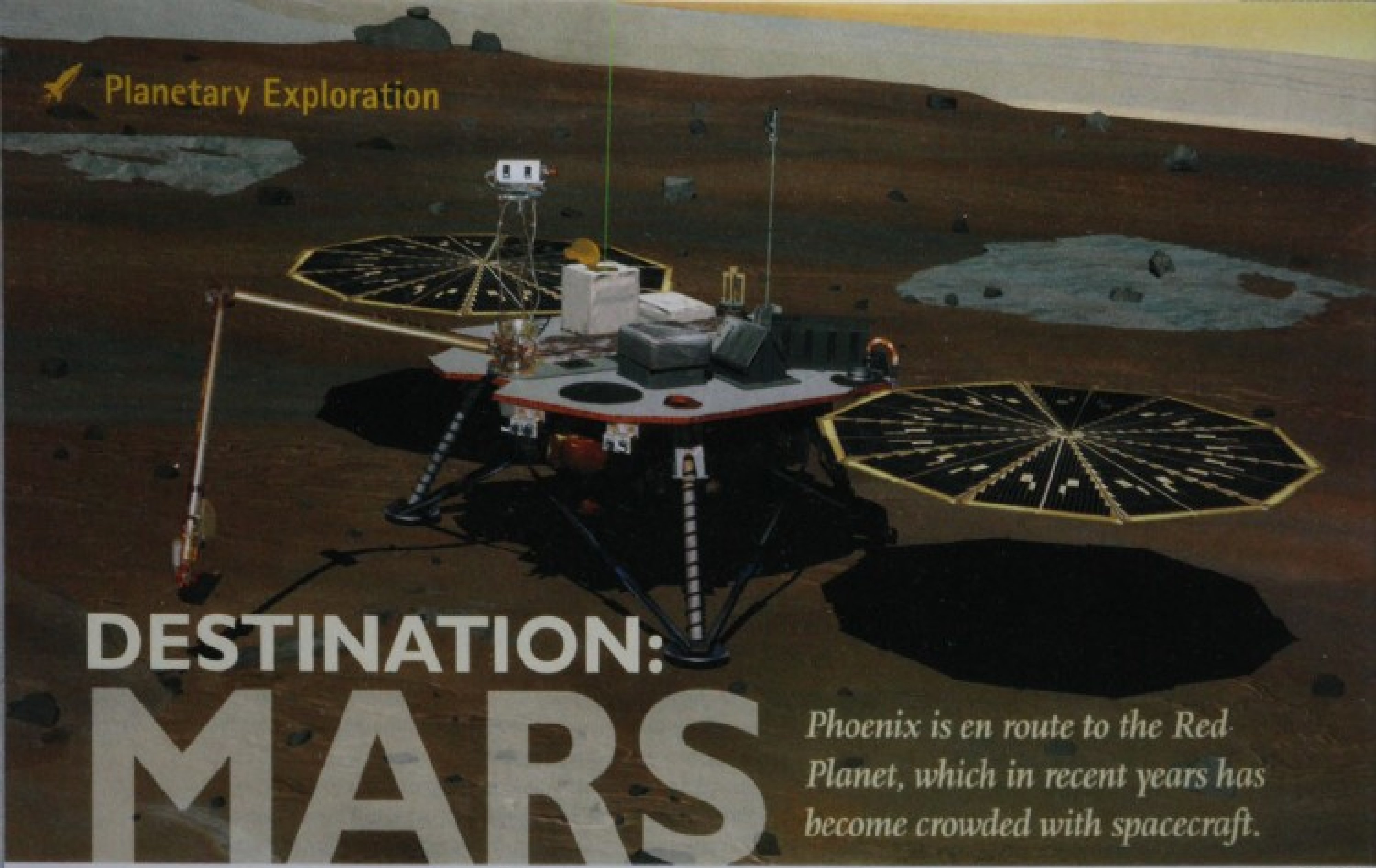
From Theory to Reality

Not one Kuiper Belt object (aside from Pluto) was known before 1992, but generations of astronomers were expecting them.

In 1930, just after Pluto's discovery, UCLA astronomer Frederick Leonard suggested that many more objects would turn up beyond Neptune. In 1943 Irish astronomer Kenneth Edgeworth independently proposed the same thing. In 1951 Dutch-American astronomer Gerard Kuiper suggested that millions of bodies beyond Pluto are the source of short-period comets (as opposed to long-period and once-only comets, which come from much farther out).

In the 1960s, Fred Whipple and Al Cameron demonstrated more mathematically why many solid bodies near the plane of the solar system should exist beyond Neptune. The most extensive theoretical work predicting a belt of outer objects came from Uruguayan astronomer Julio Fernandez in 1980.

So when University of Hawaii astronomers David Jewitt and Jane Luu found 1992 QB_1, the planetary-science world was more than ready. The discovery set off deeper and deeper searches, made possible by modern automation and wide-field electronic imaging, that continue today.



DESTINATION: MARS

Phoenix is en route to the Red Planet, which in recent years has become crowded with spacecraft.

NASA / JPL-CALTECH

KRISTINA GRIFANTINI

THE UNITED STATES completely abandoned sending spacecraft to Mars for two decades following the arrival of twin Viking orbiters and landers in 1976. But it's been a very different story since the mid-1990s.

In fact, exploration of the Red Planet has been going on more or less continuously since Mars Pathfinder thumped onto Ares Vallis in mid-1997. On its heels came Mars Global Surveyor, an orbiter that spent 10 years rewriting the book on Martian geology. It was joined in 2001 by NASA's Mars Odyssey, in 2003 by the European Space Agency's Mars Express, and in 2006 by NASA's Mars Reconnaissance Orbiter. Meanwhile, the Mars Exploration Rovers, Spirit and Opportunity, have been making tracks for more than 3½ years.

ABOVE: After its solar-cell panels fan out to either side, Phoenix will use its long arm to dig into the ice-rich ground. A laser-equipped weather station will monitor dust and clouds in the atmosphere.

RIGHT: NASA's latest mission to Mars rocketed from Florida's Cape Canaveral on August 4th and should land near the Red Planet's north pole next May 25th.

NASA / KENNEDY SPACE CENTER

Each mission has heaped new findings on a growing mountain of data suggesting that our ruddy neighboring world was a busy place in its youth but settled into geologic retirement billions of years ago. With the August 4th launch of the Phoenix lander and more missions in the works, soon we'll know even more about the Red Planet's evolution, particularly whether life once existed there.

The exploration of Mars has gone hand in hand with intrigue about extraterrestrial life, giving birth to the field of astrobiology. The Viking landers (the first spacecraft to function successfully on the surface) stewed, brewed, and incubated scoopfuls of Martian soil, looking for signs of metabolic activity. The results, though contested by a few team members, were negative. The British-built Beagle 2, equipped to look for fossil organisms, hitchhiked aboard Mars Express but mysteriously failed as it descended to its landing site on December 25, 2003.

Since these attempts, NASA has focused on finding evidence of habitability, such as carbon compounds and liquid water, instead of hunting for life directly. Phoenix continues NASA's follow-the-water theme for exploring Mars, which has been "very successful," says NASA associate administrator Alan Stern. "Now it's 'follow the carbon.'"

The Phoenix Rises

Named for the mythological firebird that resurrects itself from its ashes, the $420 million Phoenix utilizes technology from two previous lost or canceled missions and is the first Mars effort run by a university (University of Arizona). On May 25, 2008, the 18-by-5-foot, three-legged, solar-powered lander will touch down near the Martian arctic, where scientists predict sheets of water ice lie just inches beneath the surface. Phoenix will use its nearly 8-foot-long arm — equipped with two blades and a powerful drill — to dig trenches up to 3 feet deep in the hard-as-concrete ice.

The craft carries several novel instruments to analyze what it scoops out. A wet lab will test for properties like acidity and the presence of carbon or sulfur. A high-power microscope will examine the structure of soil particles down to 10 nanometers. And eight tiny, one-use-only ovens will slowly heat pinches of ice and dirt to 1,800°F (1,000°C) and "sniff" for released gases, including any organic compounds, according to mission scientist William Boynton (University of Arizona). All the while, a stereo camera will record the lander's surroundings.

The science team expects Phoenix to carry out its studies for three months before Martian winter sets in and the polar atmosphere freezes, encasing the lander Han Solo–style in frozen carbon dioxide (dry ice).

Six Wheels with Attitude

NASA's next big step is the billion-dollar Mars Science Laboratory, which should launch in 2009. MSL will be a geological and geochemical lab on wheels, the "Rolls Royce of rovers," quips team member Oded Aharonson (Caltech). Nine feet (2.7 meters) long and weighing 1,800 pounds (800 kg), the super rover will hunt for evidence that water — and life — once permeated the Martian soil.

MSL will be bigger than its predecessors, "the size of a Mini Cooper," says Matthew Golombek (Jet Propulsion Laboratory). It will also travel farther, 600 feet or more each day, and be able to climb over large obstacles.

The suite of onboard instruments will be supersized as well. Not only will MSL drill deeply for samples, it will also be packing heat: a laser powerful enough to vaporize rock surfaces up to 10 meters (33 feet) away. The resulting puffs of superheated gas should reveal whether the rocks contain water or organic compounds, such as proteins or amino acids, that may be left over from past living creatures. "That's a dramatic improvement in our ability to characterize habitability," says Golombek.

MSL may also take the first step in bringing samples of Mars back to Earth. Terrestrial laboratories would reveal much more about Martian rocks than rovers and landers could ever tell us. Given just a few grains of grit, scientists on Earth could figure out a rock's exact makeup and, more importantly, the date of its origin. "A sample return would be an amazing exploration achievement and a science bonanza," says Golombek. Such an expensive undertaking, costing $3 to $4 billion, could be attempted before 2020, according to Stern.

While MSL won't be able to send back any rocks, it may be tasked to gather up to a half dozen small rock chips and store them for a later robot to retrieve. "We are working now on a plan to incorporate a small cache, about the size of a hockey puck," says John Grotzinger (Caltech), the project's lead scientist.

All of these missions — Phoenix, MSL, and a sample return — are precursors to human exploration, says Stern. Also in the launch queue are another NASA orbiter (2011) and the European Space Agency's Exo-Mars mission (2013), which will focus on atmospheric studies.

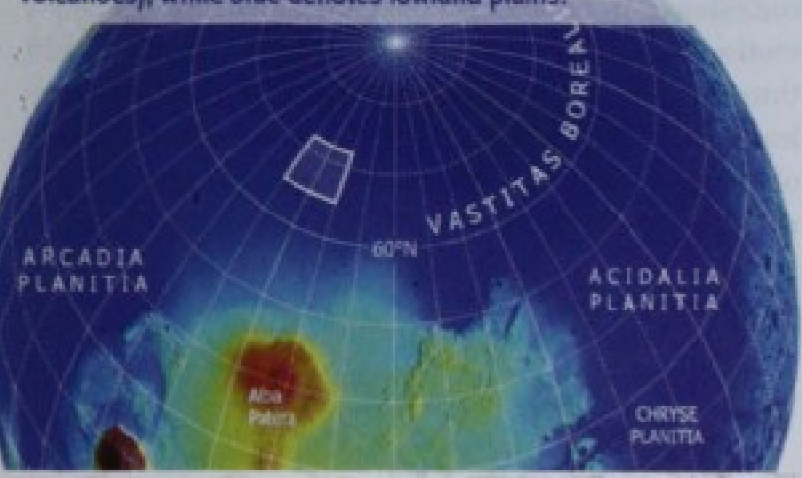
Spirit and Opportunity have demonstrated that there are always surprises when we get to Mars, says Aharonson. "They taught us we need instruments that are versatile and able to analyze the unknown." ✦

Check **SkyandTelescope.com** for updates on Phoenix and other missions to Mars.

SUPER ROVER An engineering prototype of the Mars Science Laboratory, nicknamed the "scarecrow," undergoes mobility testing at the Jet Propulsion Laboratory in Pasadena, California.

NASA / JPL-CALTECH

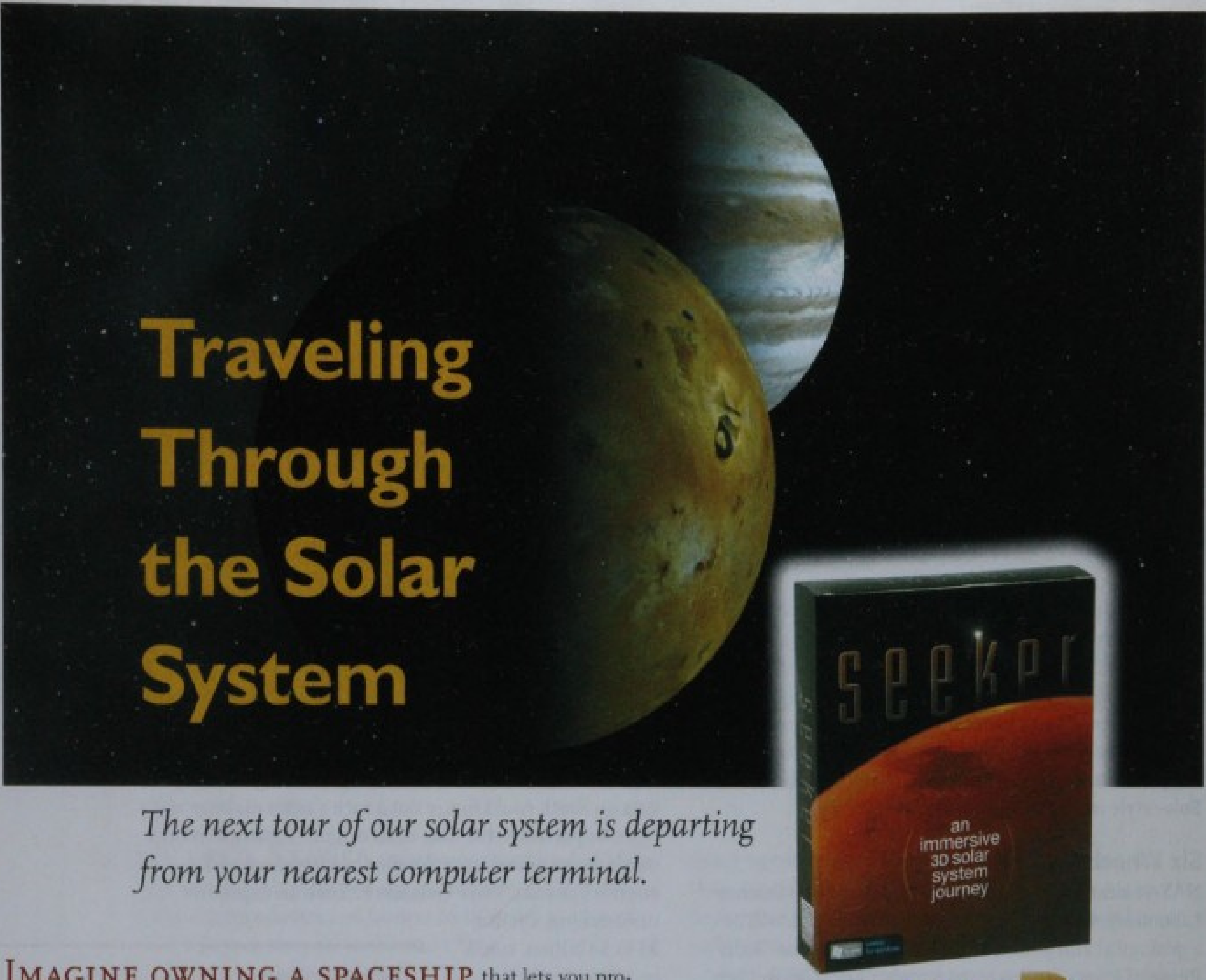
HIDDEN ICE The landing site for Phoenix is a relatively flat area near the Martian north pole, equivalent in latitude to northern Alaska. Red areas indicate high-standing terrain (including large volcanoes), while blue denotes lowland plains.



NASA / JPL-CALTECH / WASHINGTON UNIV. / UNIV. OF ARIZONA

Kristina Grifantini, a student in Boston University's science-journalism program, specializes in biology and astronomy.

 Joe Heafner



Traveling Through the Solar System

The next tour of our solar system is departing from your nearest computer terminal.

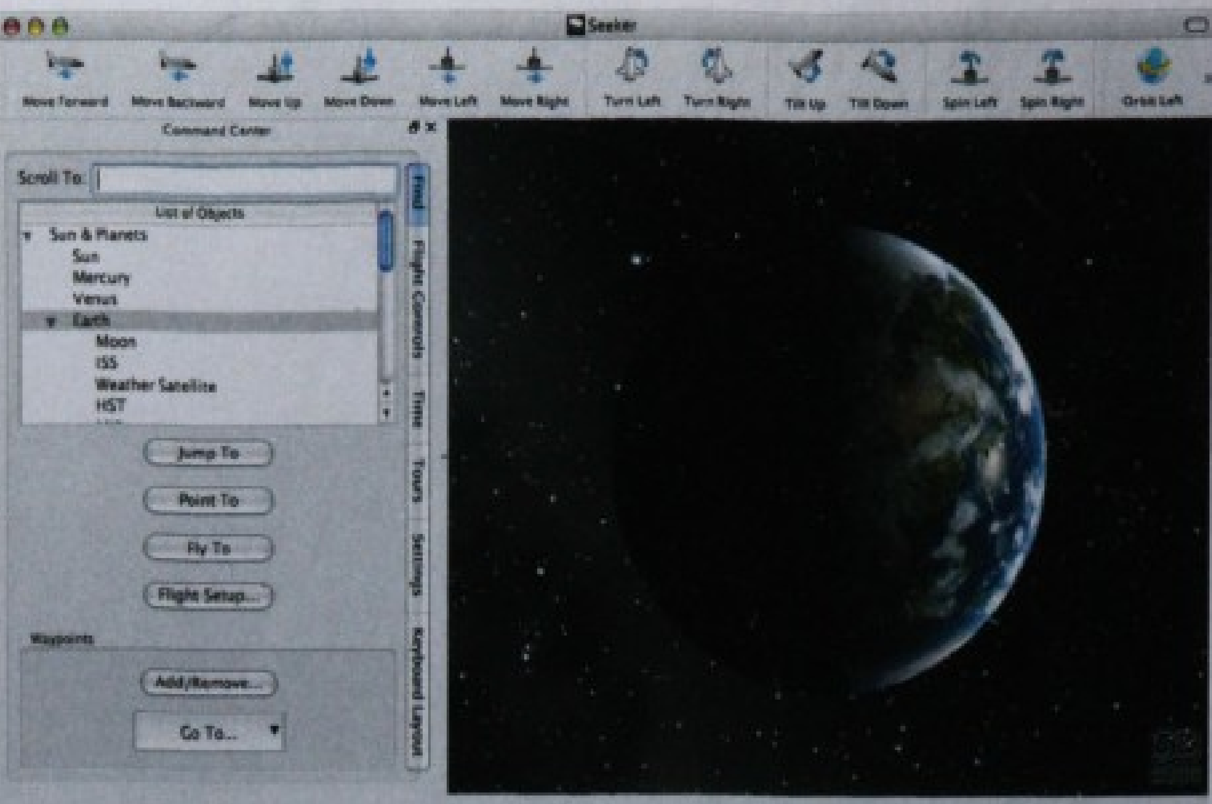
Seeker
US price: $99
Software Bisque
www.bisque.com
Windows and Mac OS X versions sold separately

IMAGINE OWNING A SPACESHIP that lets you program interplanetary trips using waypoints just as you'd plan a hike in the country using a handheld GPS device. You'd be able to travel anywhere in the solar system and park in a low orbit (or a high one for that matter) around an object and do what astronomers do best: observe. Sound like fun? It is, and it's just what Software Bisque's *Seeker* lets you do.

Seeker is available for Windows and Mac OS X, but the two versions are sold separately. I installed the Mac version on my 2.16-GHz MacBook Pro with an Intel Core Duo processor, 2 gigabytes of RAM, and 256 megabytes of video RAM. The complete installation takes up about 2.3 gigabytes of disk space. Software Bisque designed *Seeker* around modern graphics hardware, and the system demands are fairly advanced, so you'll need to heed the graphics requirements or the program will be of no use to you. The good news for Mac users is that any modern Mac should work fine. You'll find details of the graphics requirements at the company's website.

When launched, *Seeker* presents an uncluttered screen with a view of Earth on the right, a Command Center on the left, and a row of large buttons along the top. This is the view out your spaceship's window, and each button corresponds to an aspect of the craft's orientation and motion. You can fly linearly in three dimensions, rotate in three dimensions, and move around an object. I quickly learned that the buttons control the spacecraft and not the object you're visiting. Thus, when I tilted the spaceship's nose up, the view in the window moved down.

JOVIAN VISTA The author parked his virtual spaceship above Jupiter's Galilean satellite Io *(left)* to capture this view. While *Seeker* is not a planetarium program in the traditional sense, it does allow you to witness astronomical events such as eclipses and planetary alignments.



FRONT WINDOW *Seeker* launches with an uncluttered screen offering a view of Earth through the window of your virtual spacecraft. Buttons along the top give you quick access to controlling the spacecraft, while the Command Center at left handles navigation and other functions.

While you can use a computer joystick to control your virtual spaceship, I preferred using my MacBook Pro's trackpad. Dragging both fingertips across the trackpad zooms the viewing window, which also happens when you drag the mouse cursor over the Command Center.

The controls are intuitive and easy to use. A Find function lets you quickly go to planets (and dwarf planets), their major satellites, a handful of asteroids, three comets, and four interplanetary spacecraft. Additional objects can be added.

A Flight Control dialog box lets you do everything the buttons on the toolbar let you do and also control the spacecraft's forward, reverse, and braking thrusts. You'll have to express these forces in newtons, and as a teacher I find this use of the International System of Units (SI) a welcome feature.

The Time dialog controls the rate at which simulated time passes into the future or past. The Tours dialog lists groups of objects to visit along with buttons to initiate the creation of new tours and movies. Settings and Keyboard Layout dialogs control display settings, sound and graphics, mouse/joystick options, and keyboard shortcuts.

Seeker is not a traditional planetarium program. You cannot, for example, fly around the Hyades or among the stars of Orion. Nevertheless, some of the sample tours include astronomical events such as lunar and solar eclipses, which are absolutely stunning to watch. Imagine your spacecraft orbiting the Moon while a total lunar eclipse is in progress! Another excursion shows a spectacular view of Jupiter with three shadows from Galilean satellites cast on the giant planet's cloudtops.

In my opinion, the prettiest sample tour shows the International Space Station (ISS) orbiting Earth. The view, along with the optional background music, is incredible. I literally gasped when I zoomed in on the ISS to see its exterior detail. The view is similar to NASA TV footage; it's that good. Also among the sample tours are movies with background music and voice-overs.

I found two features of *Seeker* to be especially cool. The first allows you to create custom tours, including spacecraft control, using a built-in scripting language. The script can be assembled interactively and includes context-sensitive instructions. The second allows you to create QuickTime movies from existing scripts. These capabilities have tremendous instructional possibilities. Tours can be designed for classroom discussion, or students can be tasked to design their own.

Our local science center is opening a new planetarium, and I can foresee using *Seeker* to quickly "prototype" planetarium shows with solar-system content in much the same way that computer programmers model large projects during the design process.

While using *Seeker*, I found a few things that may need revision in future versions. For example, if you turn off the program's simulated passage of time, the buttons that control the spacecraft's orientation no longer function (but the orbit buttons still work).

Some issues regarding dates should be addressed too. In the Command Center's Calendar dialog, the options Gregorian and Julian merely switch between a format of month/day/year/Universal Time and a Julian Day number rather than between the Gregorian and Julian calendar systems. Page 41 of the printed manual, which is otherwise well done and informative, confuses a date in the Julian calendar with a Julian Day

WHAT WE LIKE:

Can create custom tours and movies, including sound

Outstanding graphics

Available for Mac and Windows

WHAT WE DON'T LIKE:

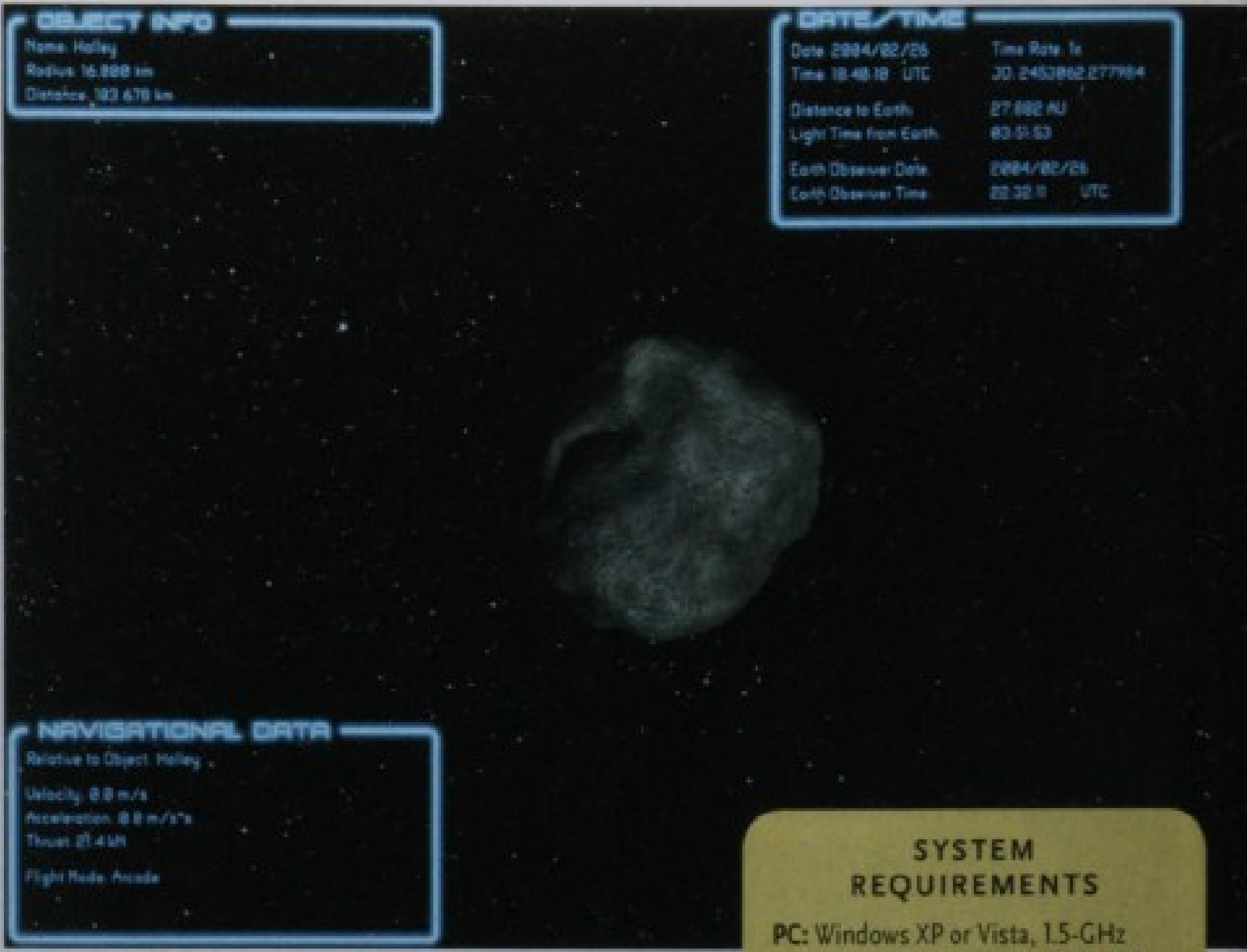
Can't enter dates prior to 1753

Manual uses confusing date terminology

number; the two are not equivalent. The earliest date I could get *Seeker* to accept was January 1, 1753, well after the adoption of the Gregorian calendar system. Initially I thought the program would take dates in either the Julian or Gregorian calendar systems, but it will not. Users should note that *Seeker* uses Coordinated Universal Time (UTC), and beginners may need some help with that.

Seeker reminds me most of *Dance of the Planets*, a program from two decades ago that was unlike anything else then available. Although *Dance of the Planets*, was more of a do-it-all planetarium program, *Seeker* succeeds marvelously in its intended purpose. Software Bisque will no doubt build upon its strong foundation, perhaps even including *Seeker* as part of future versions of the company's highly successful planetarium program *TheSky*. Either way, *Seeker* stands alone spectacularly. ✦

College instructor ***Joe Heafner*** *spends his summers waiting for the return of cool, clear autumn nights to the foothills of North Carolina. He's currently writing an introductory astronomy textbook.*



FAR OUT Several comets and asteroids are included in *Seeker*'s database *(above)*, and more can be added by the user. This view shows some of the information that can be displayed while you fly your virtual spacecraft around the solar system.

SYSTEM REQUIREMENTS

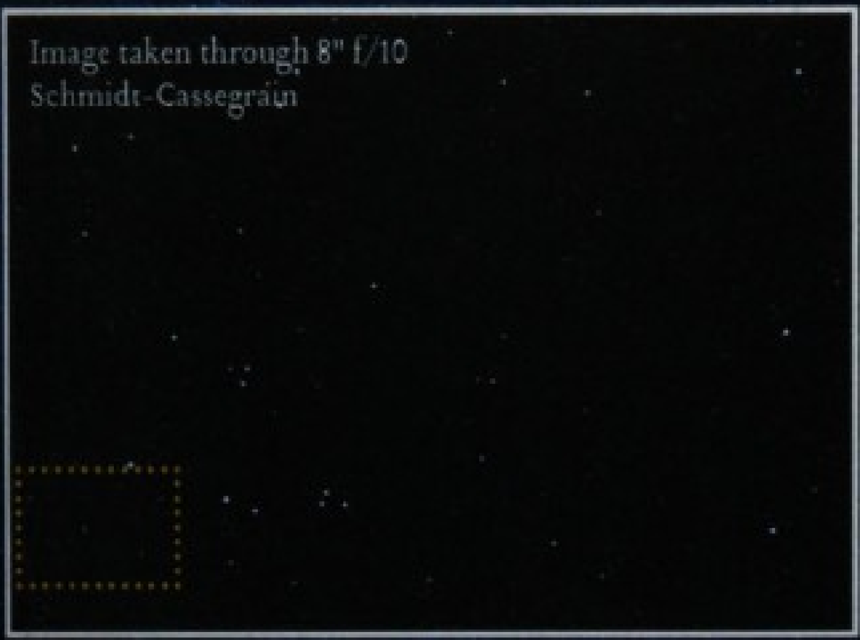
PC: Windows XP or Vista, 1.5-GHz processor, 256 megabytes RAM, 128 megabytes video RAM, OpenGL 2.0 or later.

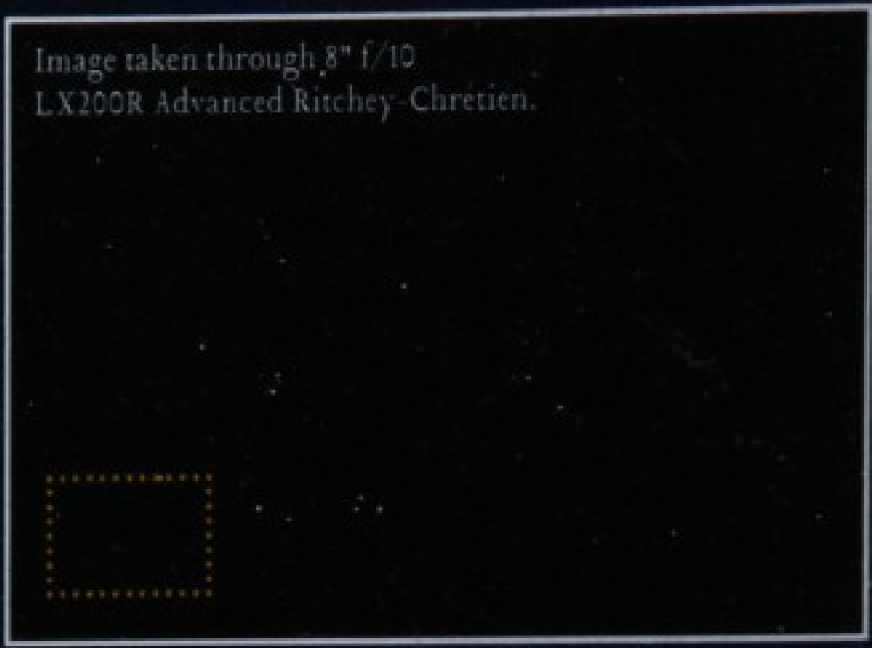
Mac: Macintosh OS 10.4.8 or later, 1.25-GHz G4 PowerPC or Intel Core Duo processor, 512 megabytes RAM, 128 megabytes video RAM, OpenGL 2.0 or later.

See Software Bisque's website for detailed information on the required display hardware for either version.

WOW FACTOR It's not NASA TV, but according to our reviewer *Seeker*'s graphics are good enough to be mistaken for it. The new program from Software Bisque lets you travel throughout our solar system in your own personal spaceship. The stunning views, however, require a computer with a fairly high-end graphics card.

COMA! THE DIRTIEST WORD IN ASTRONOMY. THE COMA KILLER... MEADE'S LX200®R





WHAT IS COMA? It's not some sort of astronomical state of unconsciousness. It's an optical aberration. Precisely defined, coma is a distortion in which the image of a star cannot be focused to a point, but takes on the shape of a comet. Worst yet, the majority of telescope optical systems, including the popular Schmidt-Cassegrain, have it to one degree or another.

THIS SIDE-BY-SIDE COMPARISON TELLS THE TALE. Two images, one camera, one night, and no image processing*. Two very different results. Just look at the magnified view from the Schmidt-Cassegrain on the left. Notice the crescent-shaped distortion of the star images caused by coma. Now look at the magnified image of the same stars from the LX200R Advanced Ritchey-Chrétien** system and you will immediately see advantages of the ARC optical system. Sharp, round stars without coma. Sharp from the center all the way to the edge of this wide field.

Once, you would have had to spend tens of thousands of dollars for an aplanatic optical system (a fancy term for coma-free). Now that Meade has made the coma-free Advanced Richey-Chrétien optical system, this level of performance is affordable to the amateur.

*The camera was a Canon 5D Digital SLR with a full 35 mm sensor. All of the above comparisons were taken using the original full frame images without any processing. The above images of M44 were taken by Jack Newton. See for yourself by downloading the two images and viewing them at 100% screen resolution from Meade.com.

**The Advanced Ritchey-Chretien design is an aplanatic optical system that uses a hyperbolic secondary mirror with a corrector-lens-and-spherical-primary-combination that performs as one hyperbolic element.

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Quick Looks

Atik Instruments ATK-16IC

US price: $645
Available from Adirondack Video Astronomy, 72 Harrison Avenue, Hudson Falls, NY 12839; 877-348-8433; www.astrovid.com

WHAT WE LIKE:

Clean images that reduce the need for calibration frames

Built-in autoguider port

WHAT WE DON'T LIKE:

Complex driver setup when operating as second camera controlled by *MaxIm DL*

S&T RATING:

★★★★½

See SkyandTelescope.com/testreport for an explanation of our star ratings.

S&T: SEAN WALKER (3)

WHETHER YOU'RE in the market for an entry-level CCD camera or a robust autoguider, you'd do well to consider the Atik Instruments ATK-16IC CCD. This thermoelectrically cooled, 16-bit monochrome camera has a Sony ICX424AL CCD chip with a 659-by-494 array of 7.4-micron pixels. Its USB 1.1 computer connection downloads images in less than 3 seconds, and its autoguiding port with a modular jack makes for easy connection to most telescope mounts that conform to SBIG's ST-4 standard. The camera comes with cables, control software, and plug-ins for *MaxIm DL* and *Astroart*.

Setup is straightforward, though you must read the documentation if you plan to use *MaxIm DL* to control this camera simultaneously with another one.

Ten 60-second exposures of a random star field in Vulpecula (lower left) without dark-frame or flat-field calibration produced very clean images. As an autoguider, the camera had no problems tracking faint stars with a 60-mm guidescope operating at f/14. It successfully guided my image of the Ring Nebula, M57, shot through a 12½-inch scope at more than twice the guider's focal length.

Although the camera has no mechanical shutter, the CCD produced no hot pixels (which could have confused the autoguider) in the 3-second exposures I used for my tests. So calibration frames were unnecessary — an extremely desirable feature if you're looking for an autoguider on a remote-imaging setup.

Overall the ATK-16IC performed very well. The camera does exactly as claimed: it produces high-quality images at a low price and will retain its usefulness as an autoguider if you upgrade to another CCD camera in the future.

— *Sean Walker*

Helio Pod Solar Finder

US price: $9.95
FAR Laboratories, PO Box 25, South Hadley, MA 01075; 800-336-9054; www.farlaboratories.com

WHAT WE LIKE:

Fits on any telescope

Makes quick work of aiming at the Sun

Easily modified to increase accuracy

WHAT WE DON'T LIKE:

Can be inaccurate on large-aperture telescopes

S&T RATING:

★★★★★ (on small, wide-field scope)
★★☆☆☆ (on large, narrow-field scope)

DESPITE THE WARNINGS printed on most telescopes, if you place a special-purpose solar filter securely over the front of the tube you can safely observe dark sunspots, bright faculae, and other features on the Sun's face.

Perhaps the biggest challenge in solar observing is getting the ½°-wide Sun into your telescope's field of view. The traditional approach is to aim your scope by

S&T: RICHARD TRESCH FIENBERG

minimizing the size of its shadow on the ground. But this is easier said than done.

Enter the FAR Laboratories Helio Pod, a translucent plastic disk with a rubber gnomon through its middle, set into a triangular plastic base that's held onto your telescope tube via an adjustable elastic cord. With this little device in place, you just turn your scope toward the Sun and find the position where the gnomon no longer casts a shadow on the disk. Voilà!

On a 3⅓-inch (85-mm) f/7 refractor and a 4½-inch f/4 reflector (pictured above), the Helio Pod worked as advertised. With low-power eyepieces, these scopes offered fields of view 3° or wider, and their small tube diameters naturally coaxed the Helio Pod's base into alignment. But on a 14-inch f/8 catadioptric, where the widest field I could muster was 0.8° and the Helio Pod's base twisted sideways on the scope's large tube, the device's "resolution" wasn't quite good enough to reliably put the Sun in the eyepiece.

I found an easy fix: Remove the stubby gnomon and replace it with a longer screw. I used a 2-inch-long 6-32 screw (cost: 9 cents), from which I cut off the head so it wouldn't hide what was left of the shadow as the scope zeroed in on the Sun. This worked fine on the 14-inch as long as I was careful to keep the Helio Pod's base aligned with the scope. ✦

— *Richard Tresch Fienberg*

ECONOMICAL "GO TO" With the overwhelming popularity of Go To telescopes, it's surprising that a product like the Cube (introductory price $199) from iOptron hasn't come along before now. Thanks to its powerful Go To functions and Vixen-style dovetail connector, observers can now add computerized pointing and tracking to small telescopes for an extremely attractive price. Powered by eight internally housed AA batteries or an optional AC power supply, the Cube stands 8 inches (20 cm) tall and comes with a stainless-steel tripod. The mount, which works in altazimuth mode, is rated for loads up to 7 pounds (3 kg) and available in several eye-catching colors. Options include a GPS module for automatic initialization and several advanced hand controllers with more features and larger databases than the standard 5,000-object list. iOptron is also introducing a line of small Go To telescopes and other Go To mounts with capacities up to 30 pounds.

iOptron
6F Gill St., Woburn,
MA 01801; 866-399-4587;
www.ioptron.com

S&T: DENNIS DI CICCO

BRIAN J. GIBSON

CLEAR-SKY GADGET
If you live in North America and have a PC running Windows Vista, you can have Attilla Danko's Clear Sky Clock (CSC) on your desktop 24 hours a day. *The ClearSkyClock Gadget* is a free tool that displays a color-coded hourly forecast of cloud cover and transparency for up to three observing sites. The display is refreshed every 30 minutes, though the forecast itself is updated only twice each day. One click takes you to the CSC website (http://cleardarksky.com/csk), where you can get help interpreting the display (*S&T:* April 2003, page 62). Undocking the gadget increases the display width and level of detail.

ClearSkyClock Vista Gadget
can be downloaded at
gallery.live.com/results
.aspx?bt=1&q=CSC

STELLAR APO Stellarvue adds a new affordable 4-inch apochromat to its line of premium-quality refractors. The SV102ED ($1,095) features a 102-mm f/6.95 ED (extra-low dispersion) doublet objective for color-free performance. As with all Stellarvue telescopes, each unit is assembled and star-tested at the company's headquarters in Auburn, California. The telescope comes complete with a 2-inch dual-speed Crayford focuser, a CNC-machined clamshell tube ring, and a red-dot reflex finder. A Starlight Instruments Feather Touch focuser upgrade is available for $300 at the time of purchase.

Stellarvue Telescopes
11820 Kemper Rd., Auburn,
CA 95603; 530-823-7796;
www.stellarvue.com

STELLARVUE TELESCOPES

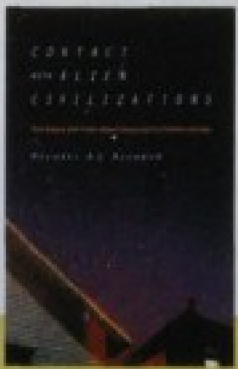
New Product Showcase is a reader service featuring innovative equipment and software of interest to amateur astronomers. The descriptions are based largely on information supplied by the manufacturers or distributors. *Sky & Telescope* assumes no responsibility for the accuracy of vendors' statements.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

STUART J. GOLDMAN

Aliens in Our Midst?

EXTRATERRESTRIALS are fun and mind-expanding to think about, because there are so many aspects to consider. Michael Michaud has collected the past and current ideas on nearly all of them into this book, which is why it's long — but that's not a complaint.

Michaud begins with a chronology of the "plurality of worlds" idea since the 6th century BC and quickly leads the reader through the evolution of the search for extraterrestrial intelligence (SETI) and other modern astronomical developments. Then the fun begins, as Michaud turns to the broad spectrum of optimism and pessimism about the existence, intentions, and potential consequences of aliens, reevaluating the famous Drake equation from several angles as he goes. How hard is interstellar travel, really? How universal, or human-centric, is morality? Religion? Politics? Living machines, billion-year-old minds, planetary defense, the *really* long-term future of humankind — there's a lot to think about. These are issues we don't really need to deal with yet, but that alien signal from space could be found tomorrow, so you might as well prepare yourself with this fascinating book.



Contact with Alien Civilizations

Michael A. G. Michaud (Copernicus Books, 2007). 460 pages. $27.50.

ISBN-13 978-0-387-28598-6

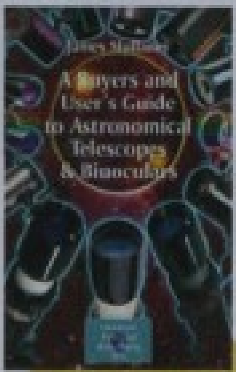
Another inviting aspect of this work is that its topics aren't long and dense. Sections are short and punctuated with boldfaced side thoughts — dubbed "Mind-Stretchers" and "Mirror Images" — that highlight twists worthy of contemplation. Michaud's exposition on any one subtopic is brief, typically a roundup of what others have said; the book finishes with 70 pages of references for anyone wishing to follow up.

The author admits, with apology, that he avoided dwelling on themes from science fiction, which deserve their own book. Sci-fi has arguably explored every extraterrestrial possibility, and Michaud does include a few examples. Nevertheless, there were many times when reading about the possible consequences that the proven existence of aliens could have that I thought, "Hey, just like that episode of *Stargate SG-1*."

*Associate editor **Stuart Goldman** prefers his aliens benevolent and non-reptilian.*

JENNIFER BIRRIEL

For a Powered Eye



A Buyer's and User's Guide to Astronomical Telescopes and Binoculars

James Mullaney (Springer, 2007). 203 pages. $29.95, paperbound.

ISBN-13 978-1-84628-439-7

PURCHASING your first pair of binoculars or first telescope can be an intimidating task. The great variety of instruments available and the range of prices can be overwhelming. Whether you're ready to supplement your naked-eye observations with binoculars or currently own a pair and wish to add a telescope to your equipment, James Mullaney's book is an invaluable guide to aid in your purchase.

Although several similar books have already been published, Mullaney's has a couple of unique traits. While in Part I the author discusses the purchase of both binoculars and telescopes, in Part II he describes how (and what!) to observe. There are also brief but useful discussions in the first chapter about the relative merits of new versus used equipment, homemade versus "home assembled," and optical testing.

Mullaney has been involved in astronomy for more than 50 years as an observational astronomer, planetarium director, writer, and instructor. Drawing on all this experience, he has produced an accurate, well-organized, and nicely illustrated handbook. His style is refreshingly straightforward with some of the best explanations I've seen on concepts such as eye relief and antireflection coatings.

He has compiled comprehensive, up-to-date product and contact information for manufacturers and suppliers of binoculars and telescopes. It's all capped off with three useful appendices: telescope limiting magnitudes and resolutions, a table of constellation names and abbreviations, and a roster of celestial showpieces.

In his preface, Mullaney states that it wasn't his intention to produce an all-encompassing guidebook but rather "a condensed, trustworthy treatment . . . sufficient to make informed decisions on the selection and use of these instruments." In that sense, he has most definitely accomplished his goal. While it's certainly a great book for the novice observer, advanced amateurs will probably find that the book covers too much familiar ground to warrant purchasing.

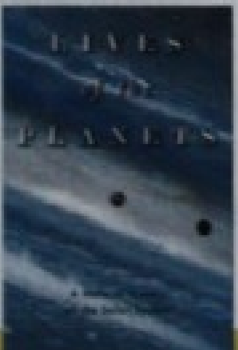
***Jennifer Birriel** is an associate professor of physics at Morehead State University in Kentucky. She writes the Astronomer's Notebook column for* Mercury *magazine.*

KRISTINA GRIFANTINI

World Views

IN HIS THIRD BOOK, British writer Richard Corfield brings life to the story of the planets. Humankind has long been fascinated by those sky "wanderers," and his text documents the many different visions we've had of our celestial neighbors.

This tale of planetary exploration is a friendly, easy-to-read narrative, beginning with impressions of the planets from researchers and dreamers of the past (a Mars teeming with life, for example) to what scientists have gradually learned with each new robotic feeler sent out. Each planet — as well as the Sun and the asteroid belt — has its own chapter, and one even traces the winding trail that led to Pluto's demotion from full planethood.



Lives of the Planets
Richard Corfield (Basic Books, 2007). 268 pages. $27.50.
ISBN-13 978-0-465-01403-3

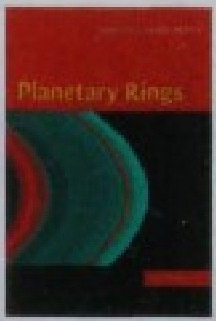
Corfield touches upon the usual suspects (Galileo, Percival Lowell, and Carl Sagan) but also less well-known players who have added to planetary knowledge and fueled the fires of intrigue. Corfield succinctly describes the organizations involved in each endeavor to explore other worlds as well, demonstrating that he knows his stuff when it comes to planetary missions. He was immersed in Britain's Beagle 2 lander mission, which accounts for his extended tribute.

Sometimes explanation of hard science is skimpy or poor, but it's not imposing enough to weigh down the read. Aside from that, the work is an engrossing chronicle that balances politics and science in a history of captivating, "hold-your-breath" attempts at planetary exploration.

After toiling as Sky & Telescope's *summer intern,* ***Kristina Grifantini*** *is now studying science journalism at Boston University.*

Planetary Rings

Larry Esposito (Cambridge University Press, 2006). 214 pages. $110. **ISBN-13 978-0-521-36222-1**



WHENEVER I talk to solar-system experts, they point to the University of Arizona Press title *Planetary Rings* as one of their bibles. But that reference was published the same year Reagan beat Mondale, so it's a little long in the tooth.

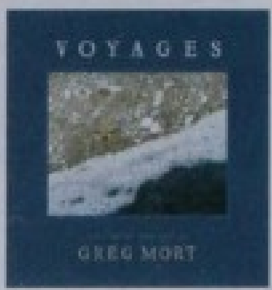
Esposito's *Planetary Rings* fills in many of the gaps by integrating the past two decades of research, covering observations by the Hubble Space Telescope and NASA's Galileo spacecraft, and the ongoing Saturnian ring watches by the Cassini orbiter. This contribution to the Cambridge Planetary Science series is tailored toward advanced undergraduate students or physics-savvy enthusiasts. You don't need to be an expert to learn from it — but you can't be afraid of equations either.

My main reservation about the book is its timing. With advances in ring science appearing in *Science* and *Nature* at breakneck speeds, shouldn't Esposito have waited at least until Cassini's primary mission was complete?

— *David Tytell*

Voyages: Exploring the Art of Greg Mort

Greg Mort (Sea Glass Publishing, 2007). 144 pages. $39.95. **ISBN-13 978-0-9753246-7-7**



AS A FAN of space art, I greatly enjoy the fanciful vistas of alien worlds and vibrant renditions of esoteric cosmic phenomena. Greg Mort (www.gregmort.com) doesn't quite qualify as a "classical" space artist. His work is a melding of water, air, and space created with a more somber palette. Some of his paintings have appeared in *Sky & Telescope*, including the cover of our special November 1988 issue about the state of amateur astronomy. Others are in the collections of President Bill Clinton and the National Air and Space Museum.

This anthology is accompanied by essays about specific paintings. It's here we learn how Mort's celestial interests have inspired aspects of his artistic interpretations, blending still lifes, seascapes, and starscapes in unexpected and appealing ways.

— *Stuart J. Goldman*

Creating and Enhancing Digital Astro Images

Grant Privett (Springer, 2007). 142 pages. $39.95, paperbound. **ISBN-13 978-1-84628-580-6**

THIS RECENT addition to Patrick Moore's Practical Astronomy series is chock-full of helpful tips for anyone considering attaching a camera to a telescope. Author Grant Privett, who obviously spent a great deal of time researching (and practicing) the subject, touches upon every major medium available to amateurs today. He presents you with enough information on each of the disciplines of astrophotography without drowning you in mathematical equations.

Privett introduces various digital cameras and explains their strengths and weaknesses. He then describes the techniques for image processing, dividing the steps (and the book) into two distinct categories: data reduction, the essential procedures to apply to digital astrophotos; and enhancement, which encompasses virtually everything else done to an image.

Privett wisely avoids discussing specific software packages, choosing instead to describe the important functions common to most, thereby extending the usefulness of the book in this rapidly evolving hobby. I highly recommend it for beginners or for advanced imagers who concentrate on one photographic discipline and need an introduction to the other ones. ✦

— *Sean Walker*

Exploring Earth at Night

Use Google Earth *to find the darkest spots near you.*

I APOLOGIZE if you're tired of hearing about it, but *Google Earth* (earth.google.com) keeps adding new features too cool not to mention.

Every few months *Google Earth* updates its main data sets that make the program so fun to explore: the detailed aerial and satellite imagery of our planet. A new overhead view is now available: Earth's surface at night.

It turns out we can thank *S&T* executive editor J. Kelly Beatty for the inclusion of the Earth-at-night view in *Google Earth*. He's the one who suggested to Ross Beyer (NASA/Ames Research Center) that satellite imagery showing the pervasiveness of light pollution belongs in *Google Earth*. Beyer and his colleagues have been molding NASA's vast sets of data into formats easily accessible to the public; this is their first step to make layers for outreach.

The global view of Earth at night has been around for years, available on posters and even a Google Maps "mashup" that I noted in this column (*S&T*: July 2006, page 96). But the Earth City Lights version is a marked, fascinating improvement. By turning on other layers as well, such as roads, cities, and geographic features, you get clear context to the patterns of surface illumination. This lets you locate the best patches of darker sky nearest your home and find the roads that will let you reach it.

The night-view layer doesn't have nearly the resolution of the aerial and satellite imagery, so you can't zoom into cities and see individual buildings glowing. And you can't find secret patches of darkness in the suburbs quite as clearly as I'd like. The imagery — based on the US Air Force's Defense Meteorological Satellite Program and rendered into maps by the National Oceanic and Atmospheric Administration (www.ngdc.noaa.gov) — has a resolution of a few kilometers.

Wouldn't it be cool if you *could* peer closer? Some scientists think so, and they have an idea for boosting the resolution by orbiting a camera dedicated to photographing the Earth at night. In the January *International Journal of Remote Sensing*, NOAA's Christopher Elvidge and 10 colleagues, including astronaut Donald Pettit, offered their rationale for a "NightSat." Their goal is to provide 50- to 100-meter resolution for the darkened globe, mapping the entire planet once a year. It wouldn't be merely a "light-pollution satellite." The data could benefit fields from environmental sciences to urban planning.

Pettit's involvement stems from experience photographing Earth at night. During his stay aboard the International Space Station in 2002–03, he made a point to photograph major cities at night. He even built a special motion-compensating mount for the camera to improve the views. Some of these photos are featured in the sub-level of *Google Earth's* NASA layer highlighting orbital photos by astronauts, a compilation from NASA's Earth Observatory program (earthobservatory.nasa.gov). For the motherlode of orbital images, however, see the Gateway to Astronaut Photography of Earth at eol.jsc.nasa.gov.

Beyer notes that there's more to come: "We will hopefully be rolling out the Moon in the *Google Earth* client early next year." After that, he says, they'll turn to Mars.

As a final note, after reading my August 3rd blog entry about these new NASA data layers, solar observer Greg Piepol wrote to me about his wishful idea for a "Google Sun." He has it mapped out at www.googlesunshine.com. ✦

GOOGLE, INC.

DARK SIDE OF THE EARTH
***Google Earth* software now includes data layers straight from NASA. You can get a new perspective on light pollution with the Earth City Lights layer.**

Read associate editor ***Stuart Goldman****'s blog at SkyandTelescope.com.*

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• XLT Coating Optional
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Going Like Sixty

Going down for the count, Mesopotamian style.

WITH 60 MINUTES consigned to every hour and 60 seconds to every minute, time goes like 60. We should take five and thank ancient Mesopotamia for that.

The presence of 60 in our timekeeping conventions and in the way we subdivide angles is the legacy of the sexagesimal, or base-60, number system first devised by the Sumerians. Their habit of counting in 60s is documented from the 3rd millennium BC in cuneiform bookkeeping on clay tablets from Uruk, in what is now southern Iraq. The Sumerians' innovative use of place-value notation — in which the position of a number indicates its value — made basic arithmetic easy.

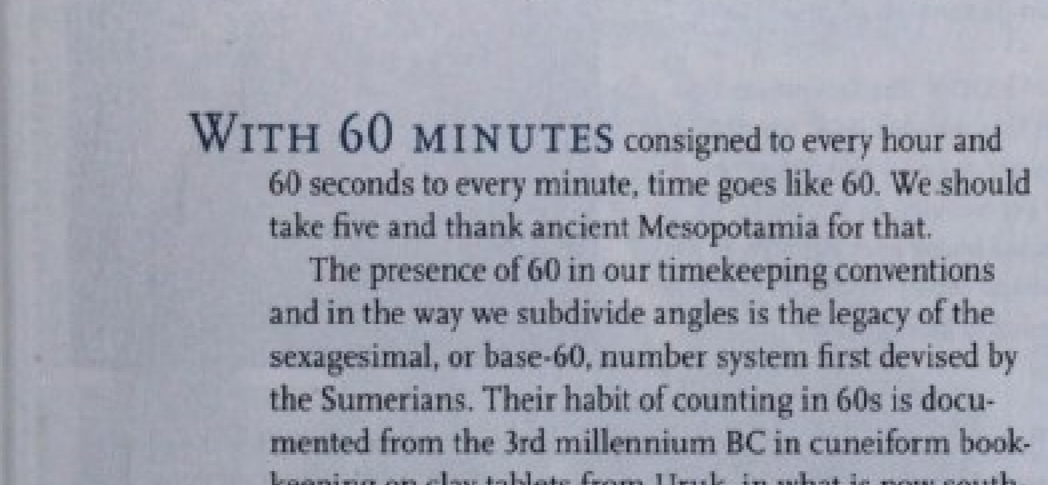
To our decimally regimented brains, manipulating multiples of 60 doesn't sound convenient. We manage numbers in powers of 10, and in our integers, the figure farthest to the right represents values from 0 to 9. The next position to the left indicates how many multiples of 10 comprise the amount. One more shift to the left registers hundreds, and greater powers of 10 follow suit.

Mesopotamia introduced similar place-value to its sexagesimal numbers, but the count goes from 1 to 59 in the first position. Each numeral was a combination of two different strokes: one stood for 10 and the other for 1. When the count reached 60, the symbol for 1 was used in the position reserved for multiples of 60, and higher powers of 60 were expressed in adjacent sequence.

We don't know what prompted the Sumerians to go sexagesimal. The number 60 is conveniently divisible by 2, 3, 4, 5, 6, 10, 12, 15, 20, and 30, and its attraction is often attributed to all of these factors. In *The Exact Sciences in Antiquity* (1951), Otto Neugebauer, an expert on ancient mathematical astronomy, argued that the sexagesimal system wasn't a singular and deliberate invention but an accretion over time of various conventions and manipulations.

In the time before writing was invented, tokens used for counting likely played a key role as well. When arithmetic processes are handled through objects like clay tokens, numbers that can be partitioned easily in many ways are favored. The number 60 outperforms 100.

The language of Babylonian arithmetic appears to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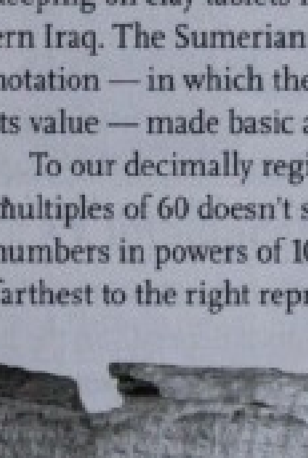
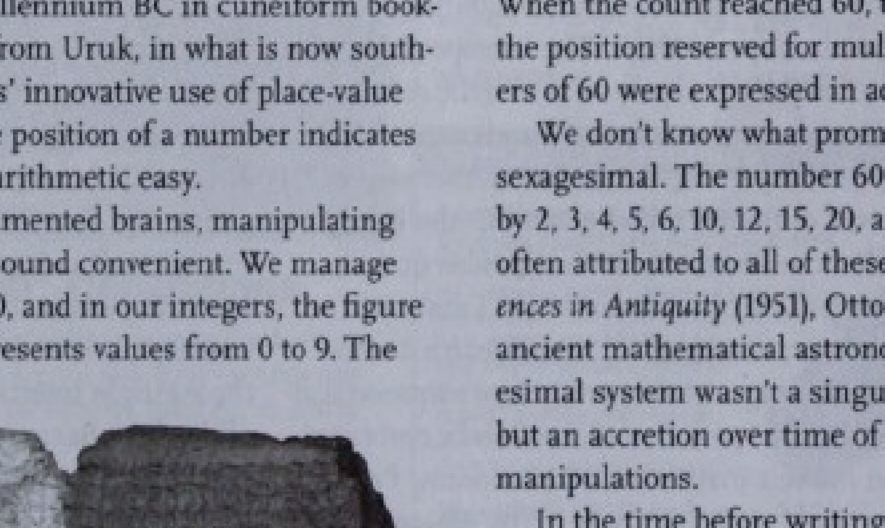
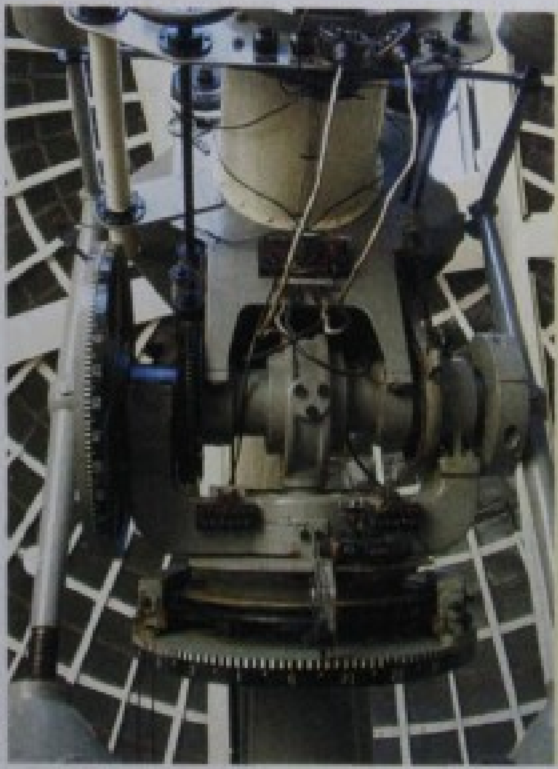



GRIFFITH OBSERVATORY

SET IN STONE Record keepers in ancient Mesopotamia used cuneiform notation to specify numbers in sexagesimal, or base-60. The tablet in the British Museum *(upper left)* was reassembled from fragments. The document tabulates sexagesimal data on the position and progress of the Moon during a three-year period in the Seleucid era, beginning in March 104 BC. Teachings by a Chaldaean astronomer *(left)* include asking if his students think he's sexagesimal as he draws circles graduated in Mesopotamian style with 360°. Illustration from *Astronomical Myths* by John Blake (1877).



E. C. KRUPP

SCOPE MATH Telescopes have sexagesimal appeal, but they don't necessarily flaunt it. Each subdivided hour on the horizontal ring of Griffith Observatory's 12-inch Zeiss refractor *(left)* actually contains 60 minutes, and each minute has 60 seconds. The declination circle's degrees (on the vertical ring) contain 60 arcminutes, and each arcminute conceals 60 arcseconds.

HIGH NOON The Sun moves 1° in about four minutes (360° per day ÷ 24 hours per day ÷ 60 minutes per hour = $\frac{1}{4}$° per minute). As it transits, its projected image goes like 60 over the *meridiana (right)* inside San Petronio cathedral in Bologna, Italy.

E. C. KRUPP

be rooted in words more applicable to the handling of counters than to abstract numbers. The Mesopotamian way of handling fractions is clearly related to the concept of subdividing a fundamental measure. Commerce and the use of clay tokens likely inaugurated the number system.

By the first half of the 1st millennium BC, the Babylonians had divided the circle into 360° and subsequently divided each degree into 60 arcminutes (60′) and each arcminute into 60 arcseconds (60″). Chaldaean astronomers incorporated sexagesimal notation into astronomical tables in the Hellenistic period, and the Greeks embraced this convention in their mathematical astronomy. Ptolemy specified sexagesimal angles this way in the *Almagest*. The practice was transmitted to Islamic astronomers and was in time incorporated into Medieval European computation.

The setting circles on telescopes, the tables in *The Astronomical Almanac*, and the celestial positions specified in this magazine each month all preserve an archaic Mesopotamian inclination to count by 60.

The Chinese also relied on 60, but only for a calendrical day count — traditional Chinese arithmetic isn't sexagesimal. Each day in the tally is designated through a sequential pairing of what the Chinese call 10 celestial *gan* (stems) and 12 terrestrial *zhi* (branches). There are 60 possible combinations, and this system is attributed to Da nao, the advisor of the legendary Yellow Emperor, Huang di, who is said to have inaugurated it in 2679 BC.

By the Han dynasty and the 1st century BC, the system was extended to a 60-year cycle that is, in turn, linked to the 12-year cycle of talismanic animals and the 12-year cycle of the planet Jupiter (*S&T:* February 1998, page 72).

A 60-year interval acquired personal meaning for me on November 18, 2004 — my 60th birthday. I was in Bologna, Italy, for that milestone, leading a tour. Late that morning we headed to San Petronio cathedral.

Begun in the 14th century, the brick Gothic basilica was never actually completed, but it has had an astronomical career. Egnatio Danti, a Dominican calendar reformer, turned the church into an observatory in 1575. He installed a *meridiana*, a north-south line inscribed on an interior floor and accompanied by an aperture on a vertical wall rising beyond the south end of the line. The aperture permits a pinhole image of the Sun to cross the meridian line each day at local noon, and the point where the sunlight intercepts it depends on the noon elevation of the Sun. Because that angle depends on the date, a *meridiana* operates as a calendar.

Danti's instrument was replaced in 1655 by a grander *meridiana* designed by the astronomer Gian Domenico Cassini, and Cassini's 68-meter-long (220-foot) meridian is still embedded in the cathedral's stone floor.

In November, Bologna typically experiences only three sunny days, and in 2004, my 60th birthday was one of them. Soon after entering San Petronio, a member of the tour noticed a spot of sunlight high on one of the columns. I realized that in a moment the Sun's image would drop to the floor and intercept the line.

I was surprised by this opportunity to see Cassini's *meridiana* in action, but others were obviously better informed. A small crowd of locals had already gathered at the north end of the line and was waiting for the Sun. I hurried down and began photographing the ellipse of sunlight. In a moment, I realized the obvious: the Sun was marking my birthday on the meridian.

The spot moved quickly. The whole show was over in a few minutes, and I realized that at my age life seems to go like 60. ◆

E. C. Krupp places value on astronomy at Griffith Observatory in Los Angeles.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Just Passing Through

IMAGE BY AKIRA FUJII

IN SEPTEMBER 1990 Mars was drifting through Taurus near the distinctive V of the Hyades star cluster, outshining the similarly hued star Aldebaran. Last August the Red Planet passed the same spot en route to Gemini, farther east, where it lingers through opposition to the Sun in late December; see our observing guide on page 66. In January Mars slips westward back into Taurus, pairing with Beta (β) Tauri, or Elnath, the bright blue-white star at upper left. The eye-catching Pleiades star cluster is at upper right. The field shown is about 30° (three fist-widths) wide, with north up.

November 2007
Sky at a Glance

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	29	30	

PLANET VISIBILITY

EVENING	LATE NIGHT	MORNING
Mercury	Mercury	Mercury (Low, ESE)
Venus	Venus	Venus (SE)
Mars (Rising)	Mars (E to S)	Mars (W)
Jupiter (Low, SW)	Jupiter	Jupiter
Saturn	Saturn (Rising)	Saturn (High, SSE)

A gray entry indicates that the planet isn't visible at mid-northern latitudes.

CELESTIAL ALMANAC

Nov. 1 Last-quarter Moon (5:18 p.m. EDT).

3 The Moon occults Regulus for viewers across Mexico and the southern US; see page 70.

3–4 Daylight-saving time ends at 2 a.m. Nov. 4th (for most of the US and Canada).

4 The Moon passes 1½° from Saturn in the morning sky for viewers in Asia. It's 6–7° below Saturn by dawn in North America.

S&T: Sean Walker

4–16 Mercury is at its best low in the east-southeast; look about 60 minutes before sunrise. This is an unusually good showing, and Mercury may be visible for most of November if the air is very clear; see page 58.

5 The Moon is 3–4° to the right of Venus in early dawn for the Americas. A beautiful pairing!

9 New Moon (6:03 p.m. EST).

13 Venus passes just 2′ north of 4th-magnitude η Virginis around 5:30 a.m. EST. Best through a telescope.

15 Mars begins retrograde (westward) motion against the background stars; see page 66.

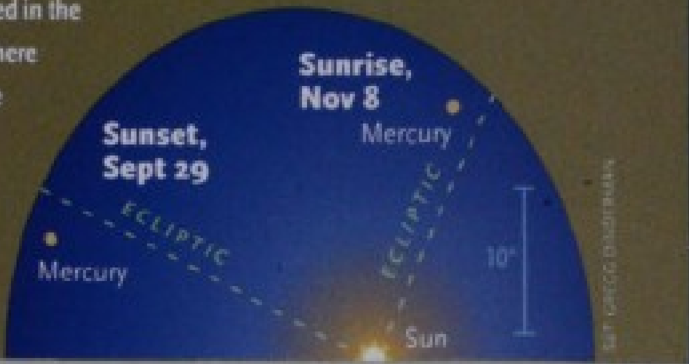
17 First-quarter Moon (5:32 p.m. EST).

17–18 The weak Leonid meteor shower peaks tonight. Activity starts around midnight, when Leo rises, but you'll likely see the most meteors 2–3 hours before sunrise on the 18th. Expect about 10 meteors per hour under ideal conditions.

A MATTER OF PERSPECTIVE

People in the Northern Hemisphere get a much better view of Mercury before dawn in November than during its evening apparition in September and October. That's because in autumn the ecliptic (the path of the planets against the stars) runs high across the sky in the morning but hugs the horizon in the evening.

The situation is reversed in the Southern Hemisphere, where it's spring now. There, the September-October evening apparition was superb, but Mercury is barely visible at dawn in November.



S&T: Gregg Dinderman

24 The Moon is exactly full at 9:30 a.m. EST (6:30 a.m. PST). Just a bit earlier, around 4–5 a.m. PST, it skims the Pleiades for observers in western North America. Use binoculars or a telescope.

26–27 The Moon passes 1½° north of Mars around 11:30 p.m. EST.

S&T: Sean Walker

Check **SkyandTelescope.com** for details as each event approaches.

Novelties of November

You don't need to travel the globe or stand on your head to enjoy the constellations in new ways.

MYTHOLOGY, MYSTERY, lovely geometries — the November sky has them all. With the right hints, beginning skywatchers will take to this sky like iron filings to a magnet. And what if you're a seasoned amateur, looking to renew your sense of wonder? You can do it by studying the November sky from novel angles.

Constellation themes. Among the constellations of autumn, the message seems to be "join the club." No fewer than 14 constellations on our evening sky map at right are members of two topical groups.

The first group illustrates the Greek myth of Andromeda and Perseus. Its members are the chained damsel in distress, Andromeda; her rescuer, Perseus; her parents, King Cepheus and Queen Cassiopeia; Perseus's flying horse, Pegasus; and evil Cetus, the Whale or Sea Monster. They're contiguous save for Cetus, who rightfully should be as far as possible from Andromeda.

The second constellation group is water related. Its five central members are the sea-goat Capricornus, the water carrier Aquarius, the two fish of Pisces, Piscis Austrinus (the Southern Fish), and Cetus again. They touch each other, as do four fringe members. Delphinus is a dolphin and Eridanus a river. Grus, the Crane, is a shore bird peeking up from below Piscis Austrinus. Finally we have Taurus, the Bull, who's traditionally missing his back half among the stars because it's submerged in seawater. This ocean is the one across which Zeus swam — in bull form — to carry off the maiden Europa. While Europa isn't a constellation, she makes up for it by having a continent of Earth, a major moon of Jupiter, and an asteroid named for her.

MESSIER'S MARK
Although he discovered a dozen comets, French comet hunter Charles Messier is much better known, two centuries later, for his "M number" list of more than 100 star clusters, nebulae, and galaxies.

A mysterious Milky Way backwater. Between the main patterns of Cygnus and Cassiopeia is a weird section of the Milky Way that crosses parts of Cygnus and Cepheus. It is nearly cloven through by a dark cloud of dust and gas northeast of Deneb. It also passes over Mu (μ) Cephei, popularly called Herschel's Garnet Star for its deep color, and the star cluster Messier 39, which is nowadays neglected but was familiar to ancient observers. Not far from M39 lie the Cocoon Nebula and the spooky dark nebula Barnard 168, which *S&T*'s Gary Seronik calls "the Road to the Cocoon." Here too is Pi¹ (π^1) Cygni, which has one of my favorite preposterous names: Azelfafage ("ah-ZEL-fuh-fahj," a medieval corruption of the Arabic name "the Tortoise").

Geometries of beauty and use. Finally, consider the patterns arrayed in the November heavens. The big, elegant Summer Triangle of Deneb, Vega, and Altair has sunk halfway down in the western sky. Almost bisecting the triangle is the Northern Cross. The Great Square of Pegasus, bristling with outward lines of stars, sits high in the south. If we extend the Square's west side a long way down we hit Fomalhaut, the lone 1st-magnitude star of the traditional autumn constellations. Following the Square's east side south takes us toward Beta (β) Ceti, or Diphda, the 2nd-magnitude star at the tail of Cetus. ✦

The sky between Cygnus and Cepheus features a huge dark nebula, the large smudge just right of center here. French astronomer Guillaume Le Gentil first called attention to it in the mid-18th century.

Fred Schaaf welcomes your mail at fschaaf@aol.com.


Facing North
Facing NE
NW
Facing East
Facing SE
Facing South
URSA MAJOR
Big Dipper
Mizar & Alcor
M81
M82
LYNX
BOOTES
Thuban
URSA MINOR
Little Dipper
Polaris
AURIGA
Capella
M36
M38
M37
CAMELOPARDALIS
Page 53
Double Cluster
DRACO
M13
M92
CEPHEUS
CASSIOPEIA
M52
PERSEUS
Algol
M34
TRIANGULUM
Moon Nov 24
Aldebaran
Hyades
Pleiades
TAURUS
ORION
ECLIPTIC
Page 55
ANDROMEDA
Zenith
LACERTA
M39
Deneb
CYGNUS
Northern Cross
M29
LYRA
Vega
M57
Albireo
61
VULPECULA
M27
SAGITTA
ARIES
Hamal
M33
M31
Great Square of Pegasus
PEGASUS
M15
Page 74
DELPHINUS
EQUULEUS
Altair
AQUILA
EQUATOR
Moon Nov 21
PISCES
Circlet
CETUS
Mira
ERIDANUS
M2
Water Jar
AQUARIUS
Moon Nov 17
Moon Nov 14
M30
CAPRICORNUS
Fomalhaut
SCULPTOR
PISCIS AUSTRINUS
GRUS
2h
20h
23h
-1
0
1
2
3
4
Star magnitudes

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

Using the Star Chart

WHEN

Late November	7 p.m.
Early November	8 p.m.
Late October	10 p.m.*
Early October	11 p.m.*
Late September	Midnight*

*Daylight-saving time

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 label for the direction you're facing (such as west or northeast) is at the bottom, right-side up. The curved edge is the horizon, and the stars above it on the map now match the stars in front of you in the sky. The center of the map is the zenith, the point directly overhead. Ignore all parts of the map above horizons you're not facing.

Example: Turn the map around so the "Facing NE" horizon is right-side up. About a third of the way from there to the map's center is the bright yellowish star Capella. Go out, face northeast, and look about a third of the way up the sky. There's Capella!

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. No bright planets are visible at chart time in November.

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

Binocular Highlight: Seeking Stock 2

YOU MIGHT EXPECT that every good binocular target is in the Messier catalog or at least has an NGC or IC number. Stock 2, a pretty but obscure cluster on the Perseus-Cassiopeia border, shows that this isn't the case.

In the 1950s, German-born astronomer Jürgen Stock discovered a handful of clusters on photographs taken of a 12° stretch of sky along the northern Milky Way. Because Stock used an objective prism, these plates yielded the spectra and magnitudes needed to pick clusters out from the teeming masses of field stars. He identified 24 clusters this way, including the one now called Stock 2.

Being listed in an obscure catalog is only one reason why Stock 2 is usually overlooked — it also lies near the much showier Perseus Double Cluster. But if you follow an arc of 6th- and 7th-magnitude stars running 2° north-northwest from NGC 869 (the western component of the Double Cluster), you'll end less than 1° south of Stock 2.

Under dark skies, my 10 × 50 binoculars show it as a big, dim, sprawling haze spanning about 1°. The cluster's brightest stars shine around 8th magnitude and form a distinctive stick-figure man with arms and legs spread wide and his feet to the northeast. The rest of the cluster's star mist appears elongated north-south. The extra light grasp and magnification of my 15 × 70s pulls in a few more stars and gives the cluster a little more definition. ✦ — *Gary Seronik*

Snowball Sighting

One of the sky's brightest planetary nebulae crests overhead on autumn evenings.

FUN WITH FILTERS
A narrowband "nebula" filter (particularly an O III type) will transmit most of a planetary nebula's "oxygenated" luminosity while dimming the light of neighboring stars and blocking light pollution. The increased contrast should speed your identification of the Blue Snowball and improve your chances of detecting its dusky middle.

The Constellation

Andromeda hangs high on November nights. Best known for its namesake galaxy, Messier 31, Andromeda is also home to a fine planetary nebula, **NGC 7662,** called the Blue Snowball.

If you're intrigued by celestial misnomers, consider "planetary nebula." English astronomer William Herschel first coined the term in 1785. Having found numerous spherical nebulae during his pioneering survey of the night sky, Herschel commented that their telescopic appearance resembled that of the planet Uranus, which he'd discovered in 1781. This little puffball in Andromeda was typical of the species. Herschel described it as "bright, round, a planetary [with a] pretty well defined disk."

Herschel couldn't have known that a planetary nebula symbolizes the death of a star. When a star similar to our Sun grows old, it expands to become a red giant. This phase of its existence is relatively brief and ends when the star sheds its immense but tenuous atmosphere. A wind of fast-moving particles from the star's exposed core then smashes into the ballooning sphere of gas and squeezes it into a thin shell. As ultraviolet light from the white-hot core reaches the shell, it energizes the atoms in the gas and makes them glow. The result is a luminous planetary nebula.

VOLKER WENDEL & BERND FLACH-WILKEN

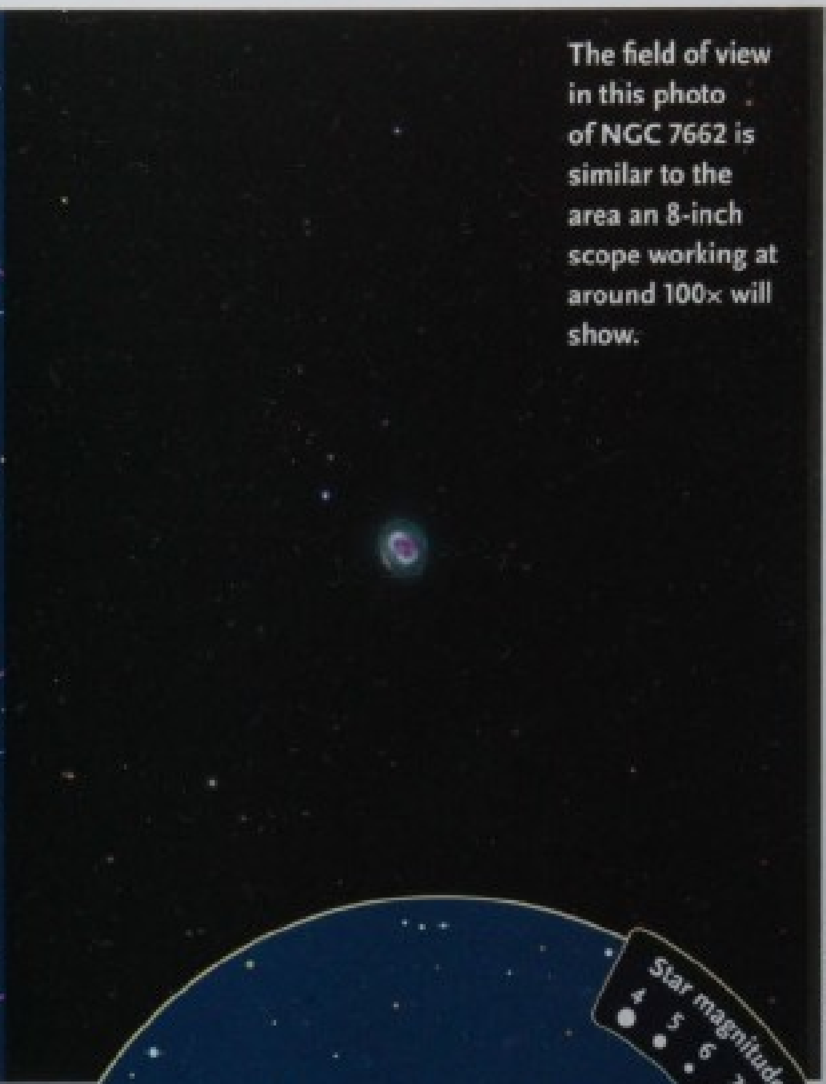
This portrait of the Blue Snowball reveals the nebula's aqua hue and double-shelled structure. The central star looks prominent here, but it glows at 13th magnitude and is beyond the range of small telescopes.

Check out our foldout evening-sky map. The Blue Snowball is located (but not plotted) directly above the letter "i" in the word "Zenith" near the center of the chart. Guiding your telescope to that spot is easy, especially when Andromeda and neighboring Pegasus are near the meridian.

1 Begin your star-hop at 2.5-magnitude Beta (β) Pegasi, or Scheat, which marks the northwest (upper-right) corner of the Great Square of Pegasus. From Scheat, shift your scope northward toward 3.6-magnitude Omicron (ο) Andromedae.

Slightly more than halfway to Omicron lies a pretty double star,

2 **h975,** situated in Lacerta, the Lizard. The 5.7- and 9.0-magnitude components shine blue-white and orange, respectively, and are 52 arcseconds apart — an easy split even at low power. The "h" in h975 stands for John Herschel (William's son), who


The field of view in this photo of NGC 7662 is similar to the area an 8-inch scope working at around 100× will show.

cataloged this star early in the 19th century.

Resuming our journey to the Blue Snowball, when you reach **3** Omicron, turn eastward in the direction of 4.3-magnitude Iota (ι), nearly 7° away. Two-thirds of the way toward Iota, your finderscope will sweep up 6th-magnitude 13 Andromedae. **4** Our celestial snowball floats less than ½° southwest of that star.

NGC 7662 glows at magnitude 8.3 and is a scant 32 by 28 arcseconds in size. Observing with my 4¼-inch f/6 reflector at 27×, I see the nebula as almost stellar, but its true nature becomes apparent when I compare it with a star of similar luminosity 8 arcminutes to the east. Pushing the scope to 93× produces a fuzzy "pixel" but no detail.

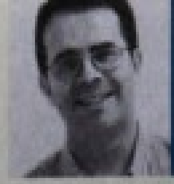
Bigger scopes do better. My 10-inch f/5.5 reflector at 200× reveals that the planetary's disk is slightly elliptical with a hint of a darker middle. The hazy annulus looks brighter on its northeast side (facing 13 Andromedae) than it does on its southwest side. This structure is surrounded by a dim outer shell, but it isn't visible in my city-based scopes. The promised "blue" in the Blue Snowball is elusive as well.

Perceiving color in deep-sky objects is a rare treat. The spectra of planetary nebulae are dominated by emission lines, from doubly ionized oxygen atoms, that we perceive as blue or green; consequently, planetaries often display an aqua tint. John Herschel was the first to notice the bluish cast of NGC 7662, though in small scopes the pale hue is subtle at best.

For tips and tricks on using star maps with your telescope, visit SkyandTelescope.com/howto/visualobserving.

To wrap up your visit to the Blue Snowball, aim your telescope at Uranus, the remote world that William Herschel chanced upon 226 years ago. Currently, Uranus is a 6th-magnitude dot about 2½° west-southwest of 4th-magnitude Phi (φ) Aquarii, and it crosses the meridian around the same time that NGC 7662 does. Use high magnification and see if Uranus's teensy aqua disk reminds you of the Blue Snowball at low power. ✦

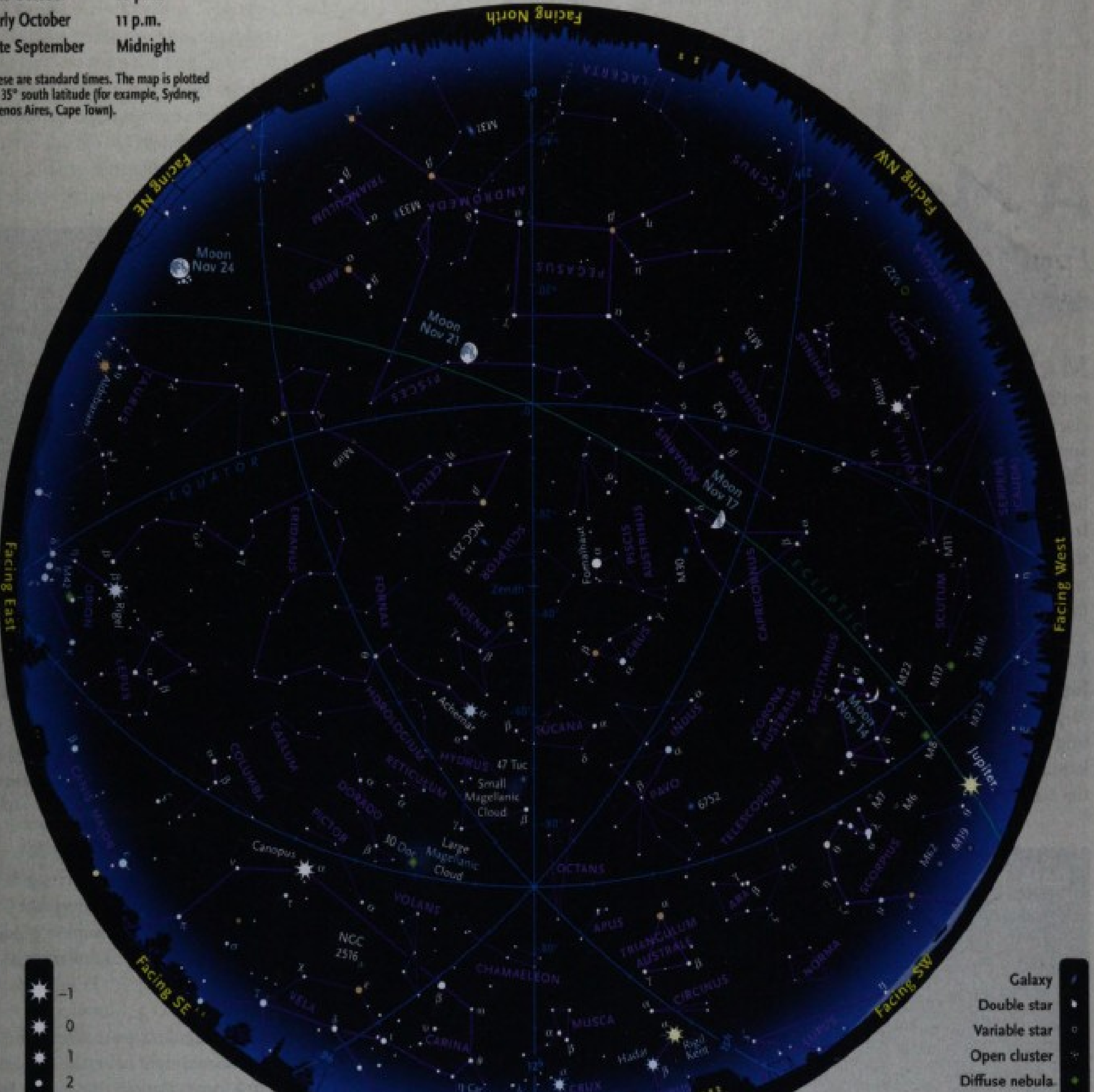
Ken Hewitt-White found his first planetary — the Ring Nebula in Lyra — more than 40 years ago using a 60-mm refractor bought with the profits from his newspaper route. You can reach Ken by e-mail at kwhite@SkyandTelescope.com.



When to Use the Map

Late November	Dusk
Early November	9 p.m.
Late October	10 p.m.
Early October	11 p.m.
Late September	Midnight

These are standard times. The map is plotted for 35° south latitude (for example, Sydney, Buenos Aires, Cape Town).



THE CONSTELLATION Tucana (the Toucan) flies high in November's evening sky. Named for the colorful bird of the American tropics, Tucana has some very remarkable deep-sky objects around its nest.

Foremost among them is the Small Magellanic Cloud (SMC), which is easily visible to the unaided eye. The "lesser" of the two Magellanic Clouds, the SMC is a satellite galaxy that orbits our own Milky Way at a distance of about 200,000 light-years.

Also visible to the eye as fuzzy "stars," the globular star clusters NGC 362 and 47 Tucanae lie just north and west of the SMC, respectively. Although 47 Tuc is the night sky's second-brightest globular (after Omega Centauri), many observers consider it the finest in appearance. ✦

A Month for Planets

From Mercury to Neptune, all the planets are on display.

MARS DRAWS ALL EYES to its vivid brightness and color after it rises in the evening. The Red Planet is approaching its December opposition and closest approach to Earth. Saturn comes up around midnight, Venus several hours later, and they're both high in the east to southeast before sunrise. And for the first weeks of November, Mercury glimmers far below them at dawn's first gleaming.

EVENING

Jupiter shines at magnitude –1.8 but lurks very low in the southwest at dusk, getting lower every week. At mid-northern latitudes, Jupiter sets almost 2½ hours after the Sun as November begins but only about 70 minutes afterward at month's end.

POINT OF VIEW Unless noted otherwise, sky diagrams and descriptions in *Sky & Telescope* are calculated for latitude 40° N, longitude 90° W, in the US Midwest. The positions of stars and planets are fairly accurate anywhere at mid-northern latitudes, but the Moon positions are valid only for North America.

Pluto is too low to be observed this month, but **Neptune** and **Uranus,** in Capricornus and Aquarius, respectively, are still nicely accessible in the southern sky right after the end of evening twilight. See page 60 of the July issue for finder maps.

LATE NIGHT

Mars is a campfire-colored radiance noticeable as soon as it rises in the early evening: about 8:30 p.m. as November opens and 6:30 p.m. at month's end. Only for a few months every two years does the Red Planet flame up as bright as this. In fact it doubles in brightness during November, from magnitude –0.6 to –1.3, greatly outshining even the brilliant winter stars until Sirius rises much later in the evening.

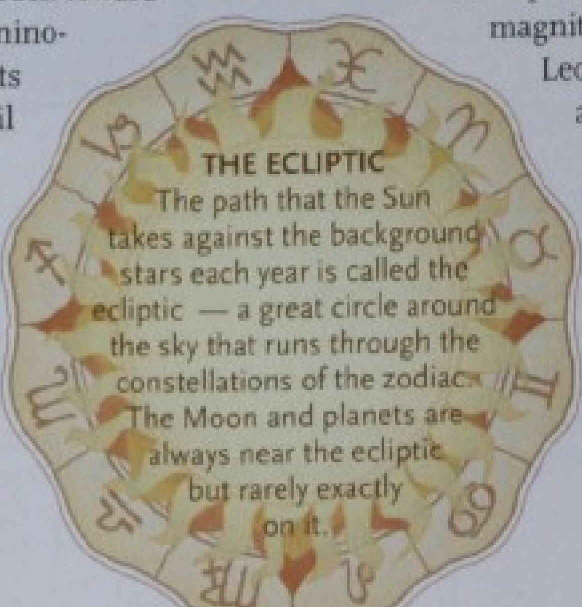
One pleasure of following Mars with naked eye or binoculars is to watch it stop its normal eastward motion through the stars and begin a dramatic period of *retrograde* (westward) motion. This halt happens on November 15th, with the planet burning brightly in the middle of Gemini. It then begins to drift back toward nearby Epsilon (ε) Geminorum. Mars continues its retrograde motion until January 30, 2008.

In a telescope the planet swells from 12″ to 14″ wide during November, large enough to show a lot of surface features on very good nights once Mars gets high in the east late in the evening. See the article on page 66 for a complete guide to observing Mars these next few months.

MOON GREETS MARS On the night of November 26th, North Americans are perfectly placed to see a spectacular pairing of the Moon and Mars. When closest, around 11 p.m. to midnight EST, their centers are just 1½° apart.

MORNING

Saturn follows Regulus up over the horizon around the midnight hour; the two are 7° or 8° apart. Saturn shines at only magnitude +0.8 in central Leo. If you view it through a telescope, you'll find that the rings appear closer to edge-on than they've been in a decade. You'll get the clearest image as morning twilight begins, when the planet is highest.



THE ECLIPTIC The path that the Sun takes against the background stars each year is called the ecliptic — a great circle around the sky that runs through the constellations of the zodiac. The Moon and planets are always near the ecliptic but rarely exactly on it.

Venus is the dazzling "Morning Star." It reaches *greatest elongation* (appearing farthest from the Sun in the sky) on October 28th. In November it remains gloriously high, rising nearly four hours before the Sun as seen from mid-northern latitudes. Its altitude a half hour before sunrise declines only a little during November for mid-northern viewers, from about 37° to 32°. Venus is still magnitude –4.2 at month's end, when in telescopes it displays an 18″-wide gibbous disk.

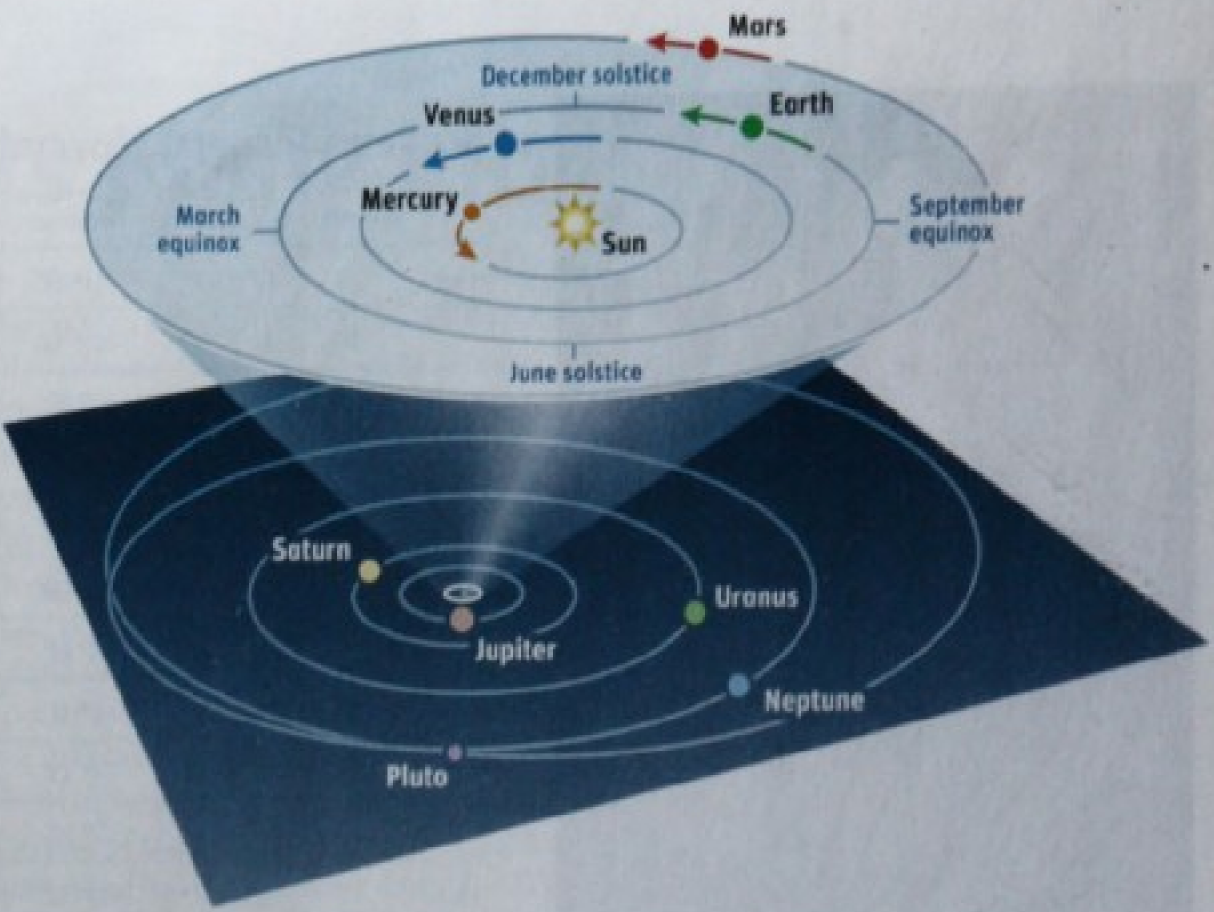
Binoculars or a small telescope will give fine views of Venus passing close to three fairly bright stars in Virgo during the first three weeks of the month. At dawn in Europe on November 6th, Venus is 0.2° north of Beta Virginis, magnitude 3.8; the two are still just 0.3° or 0.4° apart by the time of dawn in North America. On November 13th at 5:30 a.m. EST, Venus passes only 2′ north of Eta Virginis, magnitude 4.0. On the morning of November 18th, Venus is 1° lower right of the close double star Gamma Virginis (Porrima).

Venus appears 8° above 1st-magnitude Spica on November 24th. The two close to a minimum distance of 4° on the mornings of November 29th and 30th.

You can find each week's observing highlights at SkyandTelescope.com/ataglance.

Mercury climbs into good view far below Venus at dawn for the first two or three weeks of November. This is a fine apparition of the swift little planet for mid-northern latitudes. On November 1st Mercury already rises about 1½ hours before the Sun, but it's a little dim at magnitude +0.7 (just 24% illuminated in telescopes). That's a bit brighter than Spica, situated about 4° to Mercury's lower right then. The hot world flares up quickly though, shining at –0.5 by the time it reaches greatest elongation on November 8th. That morning Mercury shows a globe 6.7″ wide and 58% lit.

If you're at mid-northern latitudes you'll find that Mercury is at least 8° high in the east-southeast a half hour before sunrise from November 1st to the 19th.

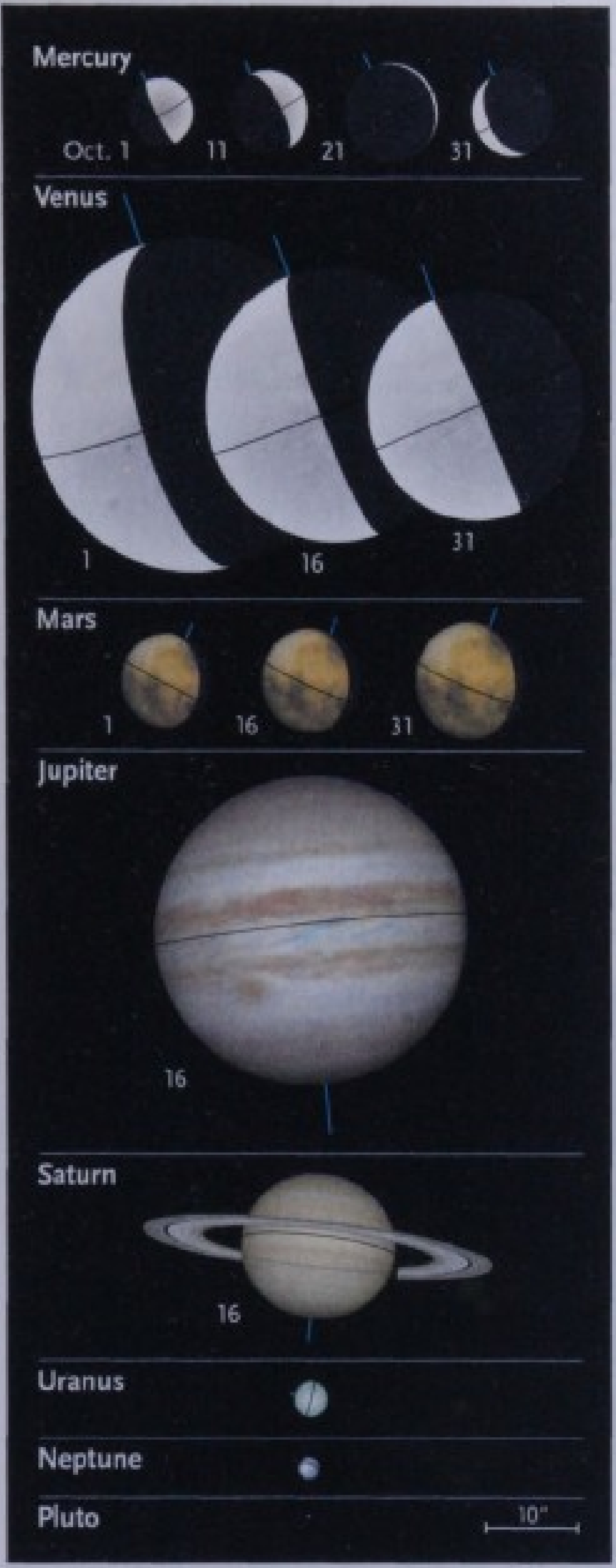


ORBITS OF THE PLANETS

Curved arrows indicate each planet's movement during November, as if you were looking down on the solar system from the constellation Ophiuchus. The outer planets don't change position enough in a month to notice at this scale.

MORNING MOON

The Moon occults Regulus before dawn on November 3rd for observers in parts of North America; see page 70 for details. The Moon is in Saturn's vicinity on November 4th, beautifully close to bright Venus on the 5th, and somewhat above Mercury and Spica on the 7th.

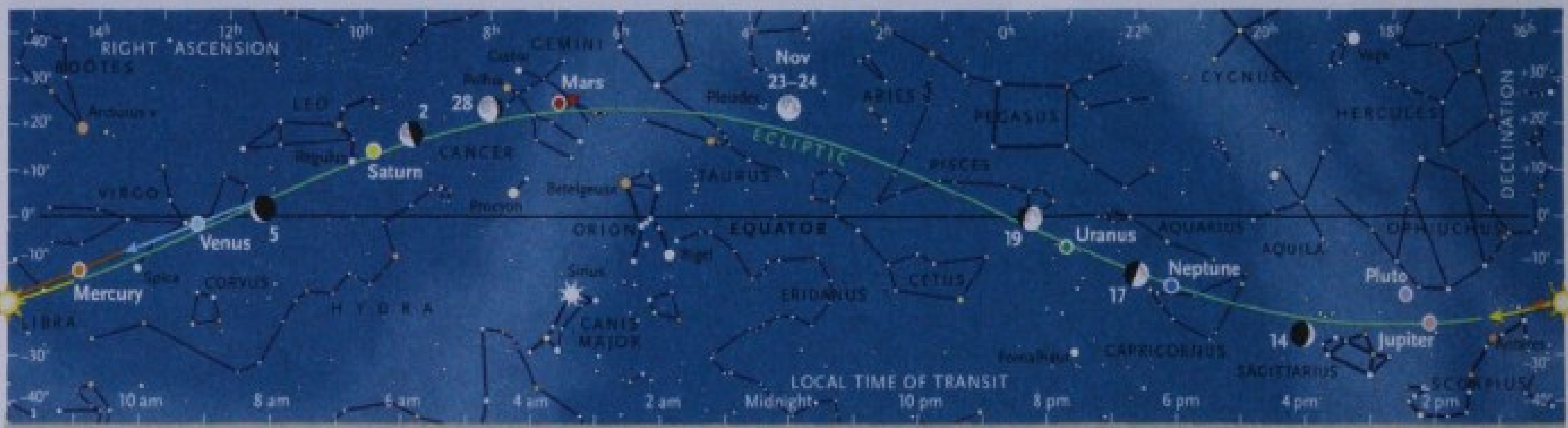


Sun and Planets, November 2007

	November	Right Ascension	Declination	Elongation	Magnitude	Diameter	Illumination	Distance
Sun	1	14^h 23.2^m	−14° 14′	—	−26.8	32′ 14″	—	0.993
	30	16^h 22.3^m	−21° 33′	—	−26.8	32′ 26″	—	0.986
Mercury	1	13^h 28.9^m	−7° 49′	15° Mo	+0.8	8.6″	22%	0.786
	11	13^h 53.2^m	−9° 13′	19° Mo	−0.7	6.4″	66%	1.047
	21	14^h 46.6^m	−14° 28′	15° Mo	−0.7	5.3″	88%	1.258
	30	15^h 41.9^m	−19° 08′	10° Mo	−0.8	4.9″	96%	1.376
Venus	1	11^h 30.4^m	+3° 41′	46° Mo	−4.5	23.2″	52%	0.717
	11	12^h 10.3^m	+0° 14′	46° Mo	−4.4	21.0″	57%	0.793
	21	12^h 51.8^m	−3° 35′	45° Mo	−4.3	19.2″	62%	0.867
	30	13^h 30.3^m	−7° 10′	44° Mo	−4.3	17.9″	65%	0.932
Mars	1	6^h 48.6^m	+23° 57′	117° Mo	−0.6	12.2″	91%	0.770
	16	6^h 54.8^m	+24° 30′	131° Mo	−1.0	13.7″	94%	0.685
	30	6^h 48.4^m	+25° 19′	146° Mo	−1.3	15.0″	97%	0.624
Jupiter	1	17^h 14.9^m	−22° 46′	41° Ev	−1.9	33.0″	100%	5.973
	30	17^h 41.4^m	−23° 09′	18° Ev	−1.8	31.9″	100%	6.186
Saturn	1	10^h 35.1^m	+10° 28′	62° Mo	+0.8	17.2″	100%	9.680
	30	10^h 41.8^m	+9° 56′	89° Mo	+0.7	18.0″	100%	9.219
Uranus	16	23^h 05.2^m	−6° 43′	112° Ev	+5.8	3.6″	100%	19.710
Neptune	16	21^h 27.3^m	−15° 18′	86° Ev	+7.9	2.3″	100%	30.095
Pluto	16	17^h 49.6^m	−17° 02′	35° Ev	+14.0	0.1″	100%	32.180

The table above gives each object's right ascension and declination (equinox of date) at 0^h Universal Time on selected dates, and its elongation from the Sun in the morning (Mo) or evening (Ev) sky. Next are the visual magnitude and equatorial diameter. (Saturn's ring extent is 2.27 times its equatorial diameter.) Last are the percentage of a planet's disk illuminated by the Sun and the distance from Earth in astronomical units. (Based on the mean Earth–Sun distance, 1 a.u. equals 149,597,870 kilometers, or 92,955,807 international miles.) For other dates, see SkyandTelescope.com/almanac.

Planet disks at left have north up. Ticks indicate the pole currently tipped toward Earth.



The Sun and planets are positioned for mid-November; arrows show motion during the month. The Moon is plotted for evening dates in the Americas when waxing (right side illuminated) or full, and for morning dates when waning (left side). "Local time of transit" tells when objects cross the meridian at mid-month; transits occur an hour later on the 1st and an hour earlier at month's end.

Saturn and Its Many Moons

IN NOVEMBER SATURN BEGINS rising in the middle of the night, becoming a telescopic target for stay-up-late observers as well as for set-the-alarm-clock observers. It's in Leo, not most people's idea of a November constellation. You'll find the planet highest up and looking sharpest in a telescope just before dawn.

Saturn is best known not for its 95-Earth-mass globe, but for the baubles and bangles around it: the rings and moons. These add up to less than 0.03 Earth mass, nearly all of it in Titan. Almost any telescope will reveal this big moon, magnitude 8½ and tinted slightly orange due to its smoggy atmosphere. Titan spends most of its time well separated from the planet — by up to four times the width of Saturn's rings.

Handy utilities that display the observable moons of Jupiter, Saturn, and Uranus for any time and date are at SkyandTelescope.com/javascript.

The next easiest to spot are Rhea, Dione, and Tethys, working inward in that order. They're about magnitude 10, 10½, and 10½, respectively, and become increasingly difficult to see as they get nearer Saturn's glary disk. Next in is challenging, 12th-magnitude Enceladus.

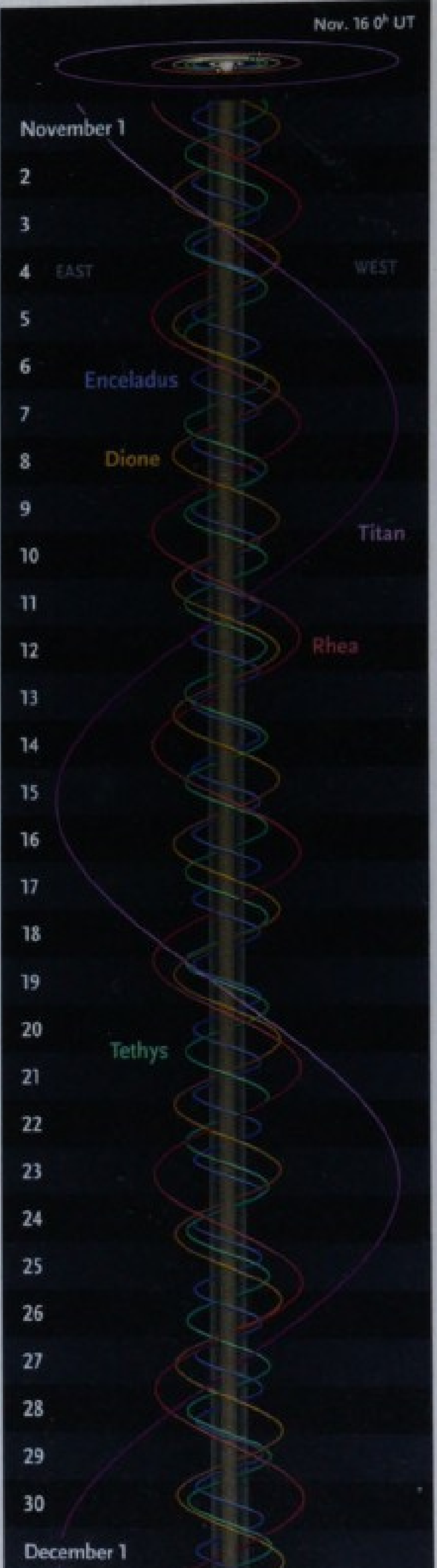
Wide-ranging Iapetus orbits outside them all (and is omitted from the diagram at right). It varies from 10th magnitude when west of Saturn to 12th when east of it; that's because one side of Iapetus is dark-chocolate colored, while the other is mostly coated with something white. With a 79-day orbit, this yin-yang moon spends early November far to Saturn's east, showing us its chocolate side. Iapetus then swings back and passes a couple of Saturn-diameters south of the planet on November 23rd, heading west and brightening all the while.

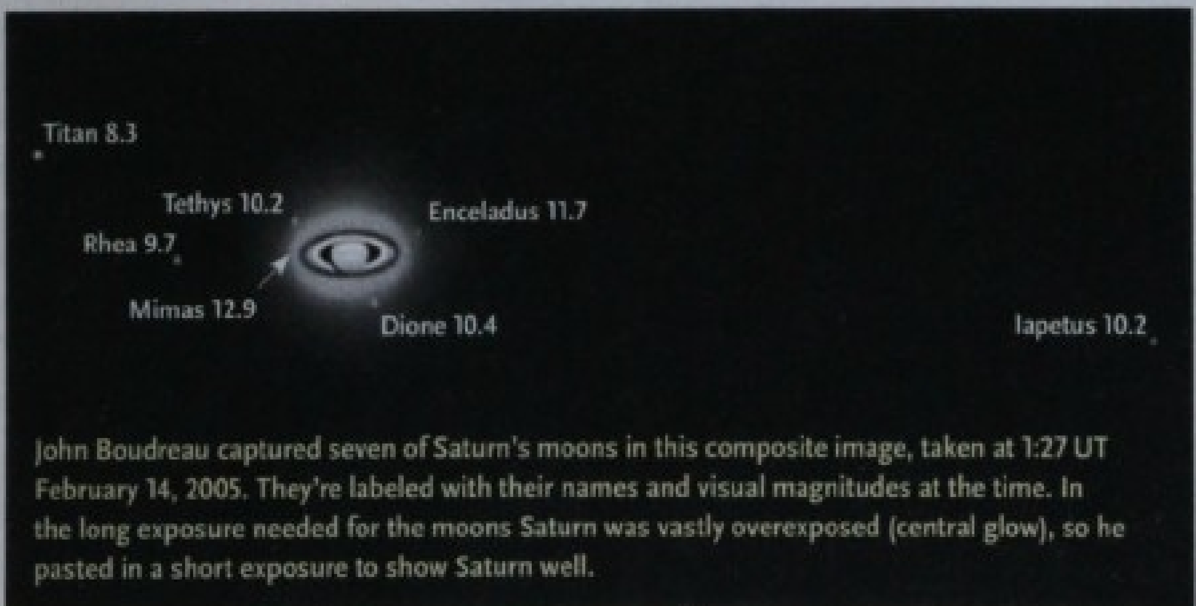
You can locate Iapetus anytime in November judging by its separation east or west of the planet, in seconds of right ascension, on the following dates (0^h UT): Nov. 1, 35^s east; Nov. 8, 33^s east; Nov. 14, 23^s east; Nov. 18, 14^s east; Nov. 22, 3^s east; Nov. 24, 2^s west; Nov. 28, 14^s west, Dec. 2, 24^s west.

To measure the distance, just turn off your telescope's drive (if it has one) and let the sky drift in the field of view for the correct number of seconds. When Iapetus is *east* of Saturn, it *follows* the planet as they drift across your field of view. ✦

— *Alan MacRobert*

Right: **The curving lines represent Saturn's brightest moons. The vertical bands represent the planet's disk and rings. Each horizontal black or gray band represents a full day, from 0^h (top of band) to 24^h Universal Time. The wavy lines show only the satellites' east-west displacement. Refer to the ellipses at top to estimate each satellite's location north (above) or south of the ring extension.**





John Boudreau captured seven of Saturn's moons in this composite image, taken at 1:27 UT February 14, 2005. They're labeled with their names and visual magnitudes at the time. In the long exposure needed for the moons Saturn was vastly overexposed (central glow), so he pasted in a short exposure to show Saturn well.

Reading the Moon

Lunar history can be understood with a telescope and a little stratigraphy.

IN LAST MONTH'S column I wrapped up the Lunar 100. That long-running series let me describe the list's individual entries in detail, and it also allowed me to get into some of the underlying mechanisms that shaped our Moon's fascinating surface. Starting this month, I'm going to delve more directly into how you can learn to read lunar landscapes and figure out the Moon's complex history.

Classical lunar observers were so obsessed with finding evidence for ongoing change that they didn't notice that they were staring at the entire history of the Moon in their telescopes. It wasn't until the 1960s, when geologists began to examine the lunar surface in preparation for the Apollo landings, that the forces that shaped the Moon finally emerged. Eugene Shoemaker and Robert Hackman, both of the US Geological Survey, led the way. They found that the lunar landscape revealed a sequence of events that *could* be deciphered as a geologic chronology.

Shoemaker and Hackman pioneered their approach by mapping features in a rectangular area that stretches across eastern Mare Imbrium from Copernicus to the northern Apennine Mountains. As these geologists knew, one of the best ways to determine an age sequence was by noting how rocks are layered — their *stratigraphy*. In general, the oldest rocks are found at the bottom and the youngest on top. But how can stratigraphy be applied simply by examining the Moon and its cratered landscape telescopically?

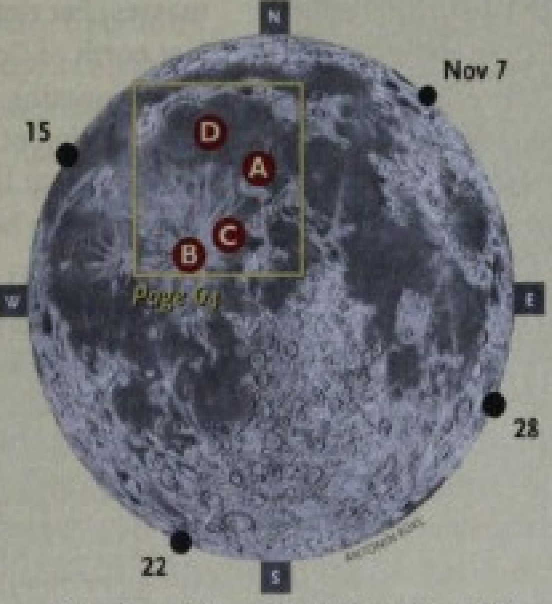
The striking rayed crater **Copernicus** provides a good

Highlighted Features

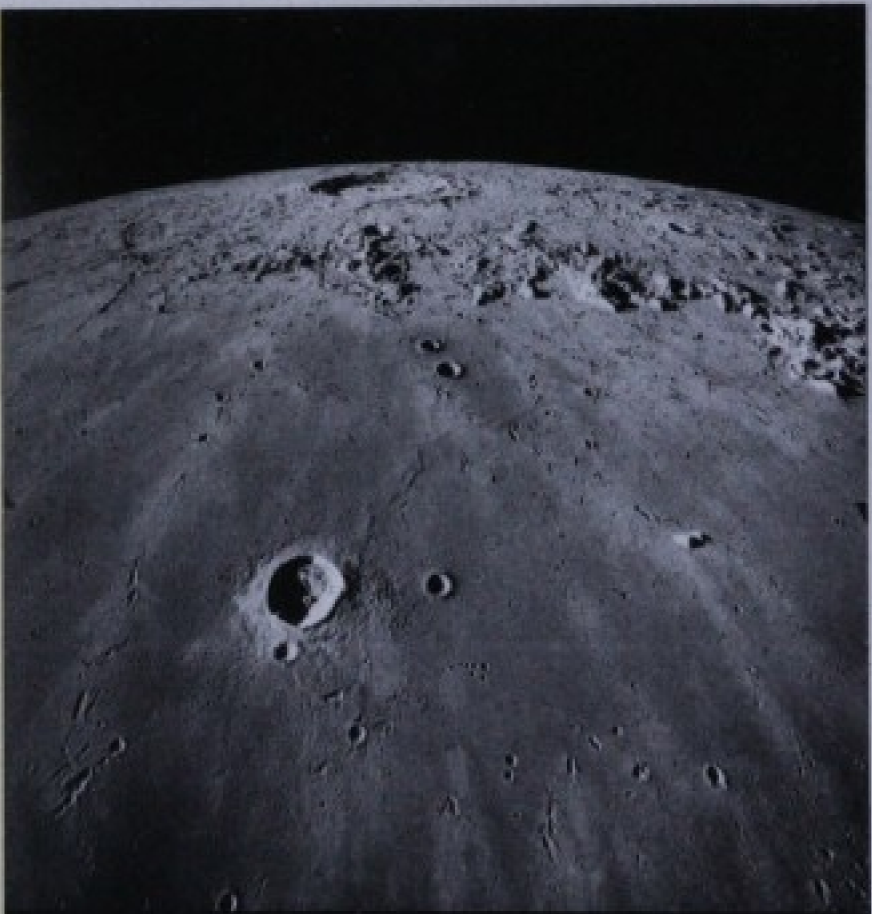
	Name	Diameter/ Size (miles)	Description
A	Archimedes	52	Lava-flooded crater
B	Copernicus	58	Impressive, young crater
C	Eratosthenes	36	Crater with faint rays
D	Imbrium	720	Huge, lava-filled impact basin

Moon, November 2007

Last quarter	Nov. 1, 21:18 UT
New Moon	Nov. 9, 23:03 UT
First quarter	Nov. 17, 22:33 UT
Full Moon	Nov. 24, 14:30 UT
Apogee (dist. 252,694 miles; diam. 29′ 23″)	Nov. 9, 13^h UT
Perigee (dist. 221,950 miles; diam. 33′ 27″)	Nov. 24, 0^h UT
Min. libration	5.4°, Nov. 7, 2^h UT
Max. libration	7.6°, Nov. 15, 13^h UT
Min. libration	6.2°, Nov. 22, 19^h UT
Max. libration	8.3°, Nov. 28, 13^h UT

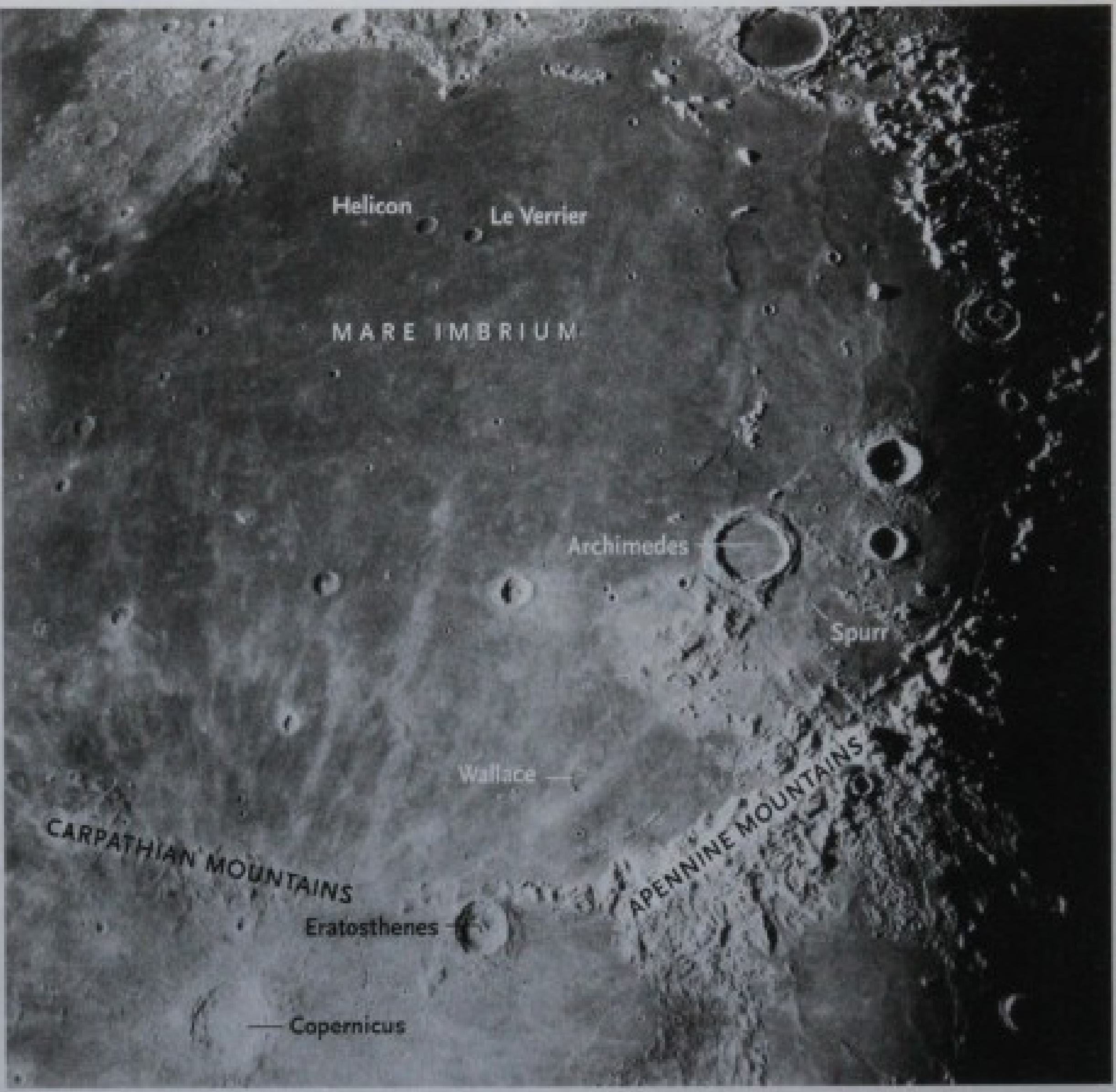


For key dates, red dots on the map indicate what part of the Moon's limb is tipped the most toward Earth by libration. Amounts are listed at left.



NASA

This Apollo 17 orbital view shows the magnificent ray crater Copernicus on the horizon. Its impact ejecta and secondary craters blanket the region of Mare Imbrium near 12½-mile-wide Pytheas in the foreground.



MOUNT WILSON & PALOMAR OBS.

example of how lunar stratigraphy works. If craters were simply holes punched in the ground, it would be difficult to determine their relative ages. But if you train your telescope on Copernicus, you'll quickly see there's far more to this feature than a simple depression. Impact craters not only excavate a hole, but they also distribute the displaced debris (collectively called *ejecta*) far and wide, and produce rays and secondary craters. Notice that Copernicus's rays drape across nearby maria, other craters, and the surrounding bright highland areas. Some of the rays even blanket the neighboring crater Eratosthenes. This means Eratosthenes must have already existed when Copernicus formed.

Eratosthenes itself is situated on the skeletal western end of the Apennine Mountains. Look closely when the Moon is near full and you'll see that the crater's faint rays and small secondary craters lie atop nearby Mare Imbrium. Clearly, the Imbrium lavas and the Apennines were already in place before Eratosthenes showed up.

So what is the age relationship between **Mare Imbrium** lavas and the Apennines? In some places it's apparent that Imbrium lavas flowed around and between individual Apennine mountain masses. For example aim your telescope just north of Copernicus at the Carpathian Mountains (which are really a continuation of the Apennine arc), and you'll see that the mountains must have been in place before Imbrium's lavas

BASIN & MARE BASICS

There's often confusion about the relationship between impact basins and the dark volcanic eruptions (the maria) that fill them. Take Imbrium, for example. This mountain-rimmed basin formed 3.9 billion years ago when a giant projectile slammed into the Moon. Millions of years later, a succession of lavas oozed to the surface, filling the basin. The resulting plain is known as Mare Imbrium.

erupted onto the surface. This also supports the idea that the Apennines, Carpathians, Caucasus, and Alps are parts of the Imbrium basin's rim.

A number of craters and hills within Imbrium must be younger than the basin itself but older than Copernicus. With careful observation you can be even more specific. For example, the crater **Archimedes** in eastern Imbrium has no observable rays or secondary craters. Shoemaker and Hackman realized that because Archimedes lies within Imbrium, it must be younger than the basin and its mountainous rim — but its lack of rays and secondary craters means it's older than the mare lavas surrounding it.

This significant observation led the two scientists to propose that Mare Imbrium didn't form as part of the powerful basin-forming impact, but rather long afterward. The Archimedes impact must have occurred after the Imbrium basin was excavated but before mare lavas flooded the region surrounding the crater.

Other nearby craters, such as Wallace and Spurr, are much smaller — 16 and 8 miles across (26 and 13 km), respectively — and nearly covered by lava. These probably didn't form on Imbrium's original floor, but instead were gouged into early mare flows before the basin filled completely. This implies that Mare Imbrium's massive covering didn't erupt in a single episode. Indeed, the radiometric ages of Apollo samples from other maria suggest that lavas rose to the surface over hundreds of millions of years.

To review the Lunar 100 list, visit SkyandTelescope.com/lunar100.

The next time you view the Moon in your telescope, try using stratigraphy to understand what you see. Begin with the Imbrium craters Helicon and le Verrier. What can you deduce about their relative ages? Next month I'll fill you in on the details. ✦

*Geologist **Charles A. Wood** is author of* The Modern Moon: A Personal View *(available from Sky Publishing).*

Your Telescopic Guide to Mars

Here comes your last chance to see Mars so big for the next nine years.

ALAN MACROBERT

MARS IS APPROACHING EARTH, and if you have a telescope, you'll want to make the most of the opportunity in the coming months. It'll be a long time before we get another chance this good.

Not often do we get a close look at Mars. It's a small world to begin with, about half the diameter of Earth, and it spends most of the time far away on the other side of its orbit from us. Mars usually ranks as one of the most disappointing objects in amateur astronomy — a tiny, featureless orange blob. The only time we get a decent look at its surface markings, clouds, dust storms, and changing polar caps is during the months around *opposition*, when Mars comes closest. Oppositions of Mars happen a little more than two years apart, but not all of them are equal. The best come in bunches of two or three that repeat in a cycle averaging 16 years long.

We're currently on the downswing of that cycle. In August 2003 Mars grew to a record-breaking apparent diameter of 25.1 arcseconds, and in October 2005 it reached 20.2″. This time around, Mars will max out at 15.9″ when it passes closest to Earth on December 18th. Even so, that's bigger than it will appear again until four oppositions later, in 2016.

This October, Mars enlarges from 9.8″ to 12.1″ as it shines in the east late at night. It takes till the end of November to reach 15.0″ across.

But there's good news too. This year's observing season finds Mars riding the northernmost part of the ecliptic, in Gemini and Taurus above Orion. This means it passes very high overhead every night for observers at mid-northern latitudes — far above the thick layers of air and poor atmospheric seeing that troubled northern observers during the previous few close-ups.

Then again, Mars underwent major dust storms in July and August. How much surface detail you see depends on the quality of not only Earth's atmosphere but Mars's too. Will the dust settle out fast enough to allow good, high-contrast views? Or will remaining dust paint a yellow wash over everything? Only time will tell.

Mars is already shining brightly in the early-morning sky, inviting observers to see what they can see. By early November you'll catch the planet high up by midnight. Mars reaches opposition on December 24th, Christmas Eve, when it rises around sunset and shines high in late evening. It will be an early-evening object during the months thereafter as it recedes into the distance.

How to Observe

To both casual and serious observers, Mars offers challenges and, with a little luck, delights. In a high-quality 4- or 6-inch telescope on a night of excellent steady air, you may be able to make out the north polar cap or cloud hood, dark surface markings (depending on which side of Mars is facing Earth at the time), limb hazes, occasional white clouds, and possibly the bright patch of a fresh dust storm moving from day to day.

But Mars is never easy to study visually; every bit of what you see is a hard-won prize. Don't expect impressive views unless you have a large scope with first-rate optics in perfect collimation (optical alignment). Even then the limiting factor is usually Earth's atmosphere. Studying the planets means spending a lot of time watching and waiting for glimpses of detail when the seeing steadies. Moreover, the longer you watch, the more familiar with the scene and the better trained your eye becomes. Plan to spend lots of time at the eyepiece.

Color filters are a useful aid. They improve the delicate contrast of Martian features and sometimes help in diagnosing their nature. Red and orange filters show Mars's surface markings best and may even steady the seeing slightly. As you move away from the red end of the spectrum toward the blue, you see less of the surface and more of the Martian atmosphere and clouds. Some visual observers swear by a magenta filter as a general-purpose Mars-watching tool, especially for small scopes.

But the real excitement these days is in electronic imaging. A backyard amateur with a good 8-inch scope, a lightweight webcam, and a portable computer can match or beat the best ground-based Mars photography by professionals a generation ago. For how to do it, see last January's issue, page 129. Complete packages — including camera, filters, adapter, software, and instructions — now sell for less than the price of a premium eyepiece (for example, see the October issue, page 36). If you get halfway-good images, you're urged to submit them to the Mars database of the International Mars Watch, as described at the end of this article. And at that site you can see what everybody else is getting too.

Even when Mars was still small and gibbous last August (diameter 7.2″), imagers were seeing lots going on. Here, Mare Tyrrhenum appears at center and Syrtis Major at upper left. The Hellas Basin at lower left is unusually bright; it's well known for dust activity. Note the north and south polar clouds. North is up, and celestial east is left.

Using the Map

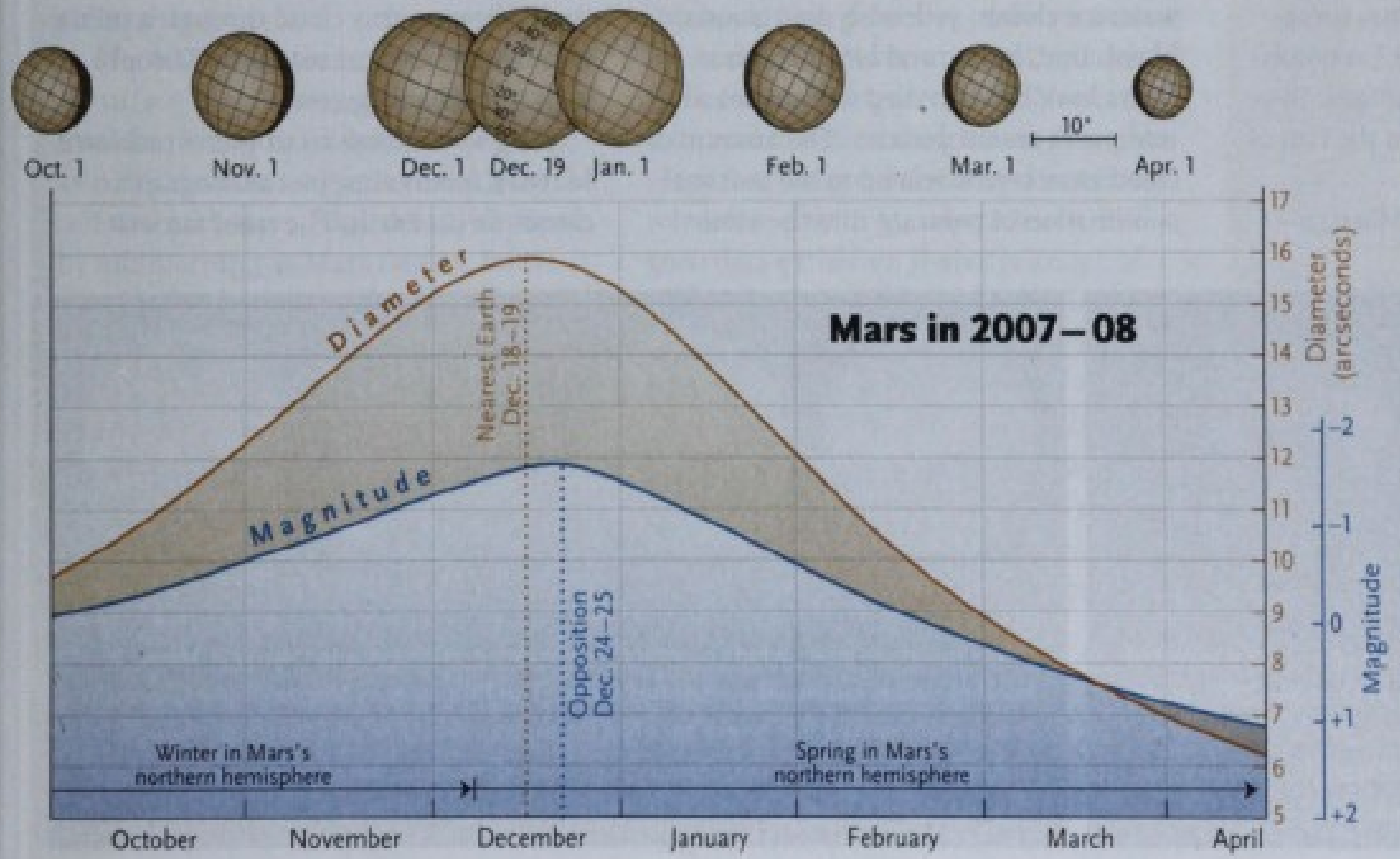
It's one thing to detect a tiny, vague smudge on a small, shimmering disk. But the smudge becomes much more exciting if you can identify and name it. The Mars map on the next page will allow you to identify features you see by referring to the globes just under it. Below, the grid on the globes shows how the map's latitude and longitude lines project onto Mars's apparent disk as it changes its tip and tilt this observing season.

To find which side of Mars is visible at the time you observe, find the longitude of Mars's central meridian (CM) using the box on page 69. The CM is the imaginary line crossing the center of Mars's disk from pole to pole. Once you find its longitude, locate this on the scale along the top of the map. Features near this part of the map will be facing you on the planet's disk.

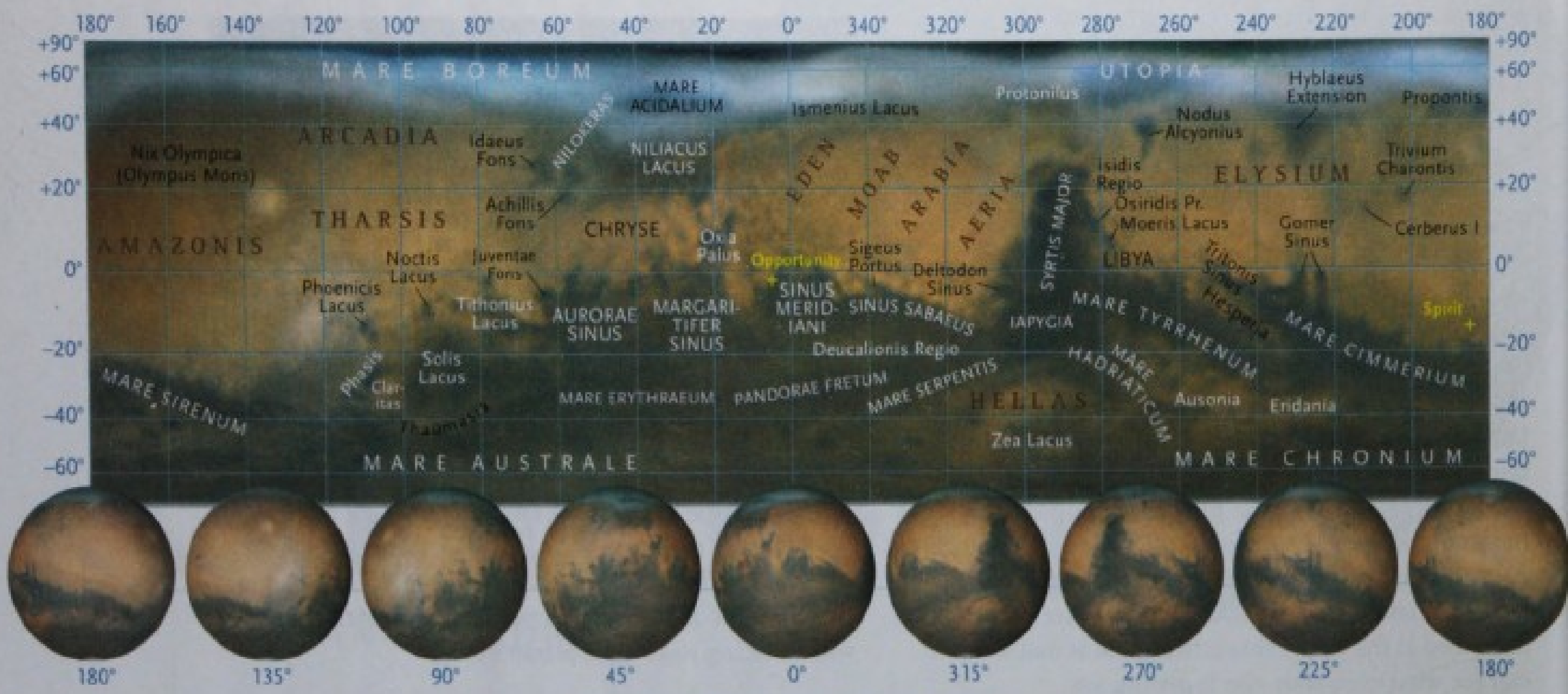
What to Look For

The polar caps. We see Mars nearly equator-on this year, as shown below. The south polar cap has been shrinking in the southern hemisphere's summer. That, combined with the planet's slight tilt, may make the cap undetectable. In contrast, the wintry north polar cloud hood should be large in October and November. Watch for it to start breaking up in December with the coming of northern-hemisphere spring — perhaps revealing the smaller, brighter north polar cap underneath the clouds.

Albedo features. The Martian surface markings — the dark "maria" and bright "terrae" picturesquely



Here at a glance are observing prospects for Mars for the coming months. On the globes, celestial north is up (but remember that many telescopes show south up), and celestial east is left. The celestial east side is Mars's morning side, and celestial west is the evening side. When your telescope's drive is turned off and the planet drifts across your field of view, celestial west is "preceding" — the direction the planet drifts toward — and celestial east is "following." For easy comparison with the map grid on the next page, lines of latitude and longitude are drawn on the globes every 20°.



Use this map to identify what you see. North is up; west longitude is labeled along the top. Most telescopes will show only the largest dark regions. Damian Peach assembled the map and virtual disks from images he took in 2005. Each disk corresponds to the central-meridian longitude above it on the map. In 2005 Mars's southern hemisphere was tipped toward us, and the far-northern latitudes were covered by the north polar cloud hood. This time you'll have a nearly equal view of both the northern and southern hemispheres.

named by Mars mappers more than a century ago — are merely differences in the *albedo*, or reflectivity, of the surface rock, sand, and dust. Windstorms sometimes move the dust, resulting in both seasonal and long-term changes.

Syrtis Major, the planet's most prominent dark marking, has undergone a dramatic widening since the 1950s. It has also shown seasonal variations in its breadth: widest in the southern hemisphere's midwinter and narrowest during southern summer (the season currently).

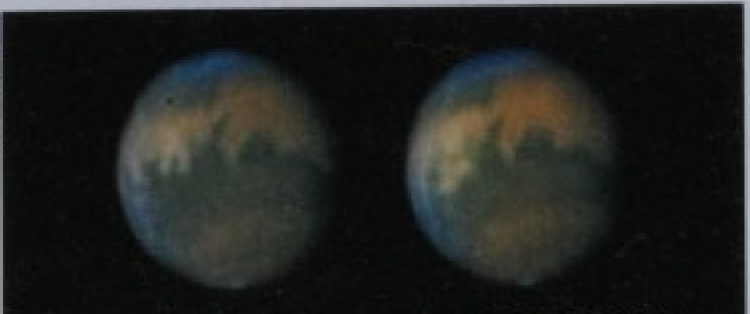
The area around Solis Lacus, sometimes called the "Eye of Mars," is notorious for undergoing major changes. So is the Trivium-Cerberus area on the rim of Elysium.

Clouds and hazes. The Martian atmosphere is ever-changing. White water-ice clouds, yellowish dust clouds, bluish limb hazes, and bright surface frosts have been studied with increasing interest in recent decades. The amount of cloudiness seems related to the seasonal sublimation of polar ice into the atmosphere, especially from the northern cap. The Mars Section of the Association of Lunar and Planetary Observers (ALPO) has found that clouds and surface fogs are more abundant during the spring and summer of the northern hemisphere. So this time around, we may see little cloud activity until perhaps February.

Discrete clouds recur at the same Martian sites, notably Libya, Chryse, and Hellas. The "Syrtis Blue Cloud" circulates around the Libya basin and across Syrtis Major; it's best seen near the planet's limb. Viewing this cloud through a yellow filter sometimes causes Syrtis Major to appear distinctly green.

Orographic clouds recur over windblown Martian mountains, just as orographic clouds do on Earth. The most famous

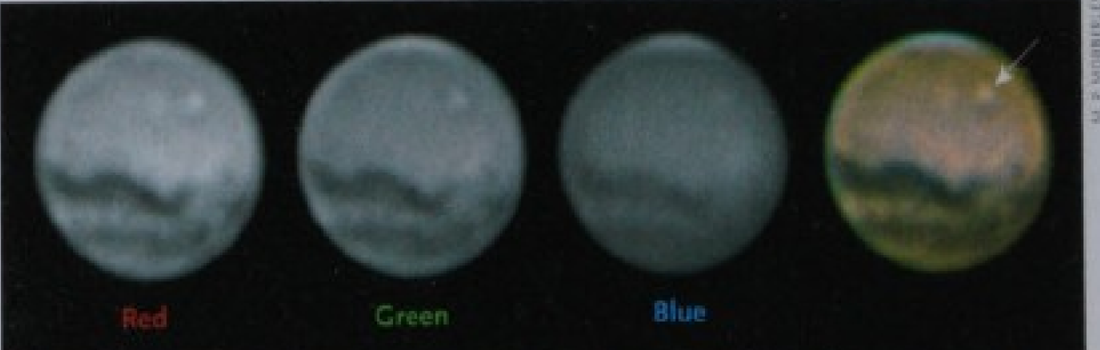
S&T: SEAN WALKER



Oct. 18, 2005 3:04 UT   Oct. 19, 2005 3:15 UT

Amateurs watched as a dust storm (the bright inverted V left of center) evolved rapidly in October 2005. Note how much it changed in 24 hours. *Sky & Telescope*'s Sean Walker took these images through a 7-inch scope at f/50 with a ToUcam Pro webcam.

M. P. MOBBERLEY



When moisture-laden winds blow across the broad, high volcano Olympus Mons, a hood of clouds (arrowed) sometimes forms. The 19th-century Mars mapper Giovanni Schiaparelli named this bright spot Nix Olympica, "the snow of Olympus," though he knew nothing of its origin. It was pure coincidence that the spot turned out to be a mountain. Dark Mare Sirenum is below. North is up in all images.

Which Side of Mars Are You Looking At?

What are the markings you're seeing on Mars? Is that darkish thing Sinus Meridiani, the plain where Opportunity is roving? If Mars looks bland, is it because your atmospheric seeing is poor or because we're facing Mars's bland side?

To compare what you see to the map and disks at left, you need to know which side of Mars you're looking at — in other words, the longitude of the disk's *central meridian*, the imaginary line down the center of the disk from pole to pole.

The table at right gives the Martian longitude on the central meridian at 0:00 Universal Time every day through the end of March. Read across the top to the month, and down to the date (which is also in Universal Time).

To find the central-meridian longitude at any other Universal Time, *add 14.62° for each whole hour, plus 0.244° for each minute,* since 0:00 UT. If you get 360° or more, subtract 360°. The result is accurate to about 1°. (To convert Eastern Daylight Time into UT, add 4 hours; CDT 5 hours; MDT 6 hours; PDT 7 hours. When you're on standard time, add 1 more hour to these values).

For example, suppose you're out at 11:30 p.m. EST November 14th (which is 4:30 UT November 15th). The central-meridian longitude works out to 290°. The map shows that big, dark Syrtis Major will be centered on the planet's disk at that time.

Alternatively, you can use our Mars Profiler at SkyandTelescope .com/javascript. (Orient the Mars map there to match your scope.)

You'll soon notice that Mars shows nearly the same face from one night to the next. This is because the Martian day is only about 40 minutes longer than Earth's. To see other parts of Mars, you must view at a different time of night or wait for a week or more to pass. If viewed at the same time every night, Mars takes somewhat more than a month to complete one retrograde (backward) "rotation."

Longitude of Mars's Central Meridian at 0:00 UT

UT date	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
1	276°	344°	71°	158°	241°	332°
2	266°	335°	62°	149°	231°	322°
3	257°	326°	53°	140°	222°	313°
4	247°	317°	44°	132°	213°	304°
5	237°	307°	36°	123°	204°	294°
6	228°	298°	27°	114°	195°	285°
7	219°	289°	18°	105°	186°	275°
8	209°	280°	9°	96°	176°	266°
9	200°	270°	0°	87°	167°	257°
10	191°	261°	351°	79°	158°	247°
11	181°	252°	342°	70°	149°	238°
12	172°	243°	334°	61°	140°	228°
13	162°	234°	325°	52°	130°	219°
14	153°	224°	316°	43°	121°	209°
15	143°	215°	307°	34°	112°	200°
16	134°	206°	298°	25°	102°	190°
17	125°	197°	290°	16°	93°	181°
18	115°	188°	281°	7°	84°	172°
19	106°	179°	272°	358°	75°	162°
20	96°	170°	263°	349°	65°	153°
21	87°	161°	255°	340°	56°	143°
22	78°	152°	246°	331°	47°	134°
23	68°	143°	237°	322°	37°	124°
24	59°	134°	228°	313°	28°	115°
25	50°	125°	219°	303°	19°	105°
26	40°	116°	211°	295°	9°	96°
27	31°	107°	202°	286°	0°	86°
28	22°	98°	193°	277°	351°	77°
29	12°	89°	184°	268°	341°	67°
30	3°	80°	176°	259°		58°
31	354°		167°	250°		48°

Martian case is the W-shaped cloud formation sometimes caused by wind passing over the high peaks of Olympus Mons and the other volcanoes of the Tharsis plateau. Other orographic clouds can show up in Elysium.

Limb brightenings ("limb arcs") are caused by scattered light from dust and dry-ice particles high in the Martian atmosphere.

Morning clouds are isolated patches of surface fog or frosty ground near the morning limb (the planet's trailing edge as it drifts across an eyepiece field; the celestial east edge). Fogs usually dissipate by midmorning as Mars rotates. Frosts may persist for most of the Martian day.

Evening clouds really are clouds. They have the same appearance as morning clouds but occur on the planet's preceding limb. They tend to be larger and more numerous.

Dust storms. These can occur almost anytime, but they peak during the warmest season for Mars's southern hemisphere, meaning roughly June to September this year. The critical diagnostic of a dust storm is movement of a relatively bright patch that obscures dark features that were previously well defined.

For More Information

At each apparition, the ALPO Mars Section receives thousands of observations, now mostly webcam images; see www .lpl.arizona.edu/~rhill/alpo/mars.html. Also see the International MarsWatch site, at elvis.rowan.edu/marswatch. Both have more on observing and imaging the planet, detailed maps, what to expect as this apparition proceeds, and instructions for submitting observations of your own.

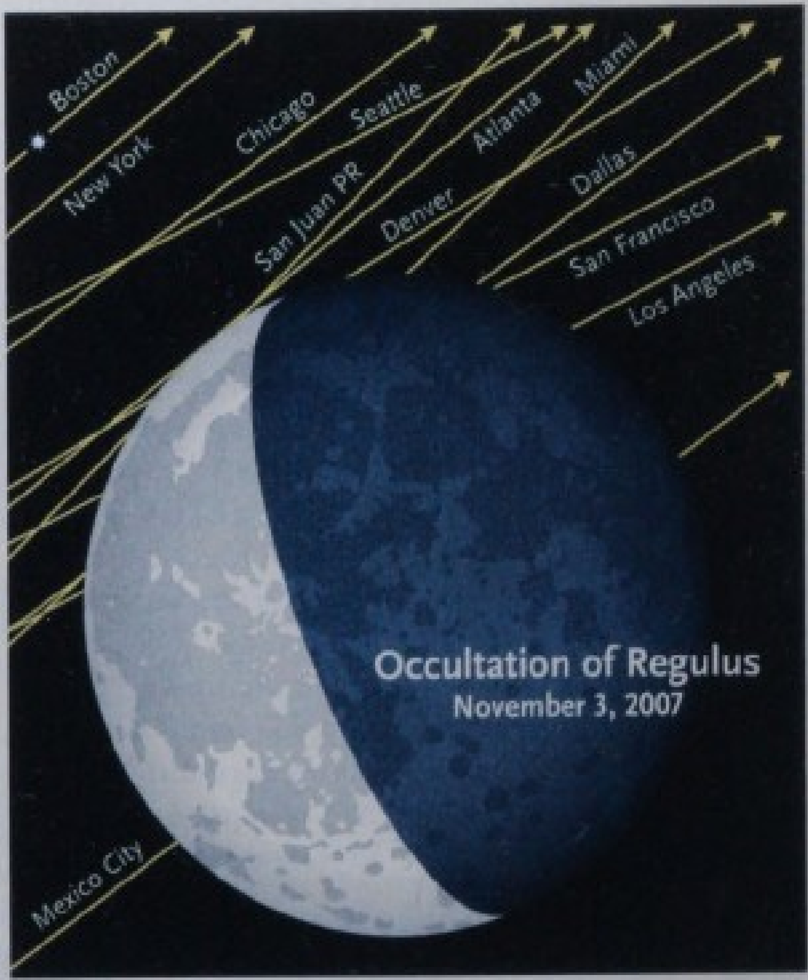
In this age of spacecraft in Martian orbit and rovers on the ground, it might seem that backyard amateurs have little role left to play in Martian science. But good data-gathering is always an act of faith; you never know what seemingly trivial item might someday become important. And continuing to do traditional, Earth-based observations in parallel with the on-site observations serves to correlate the two — helping to reveal the meanings of the century and more of Martian observations in the world's astronomical archives. ◆

*By luck, **Alan MacRobert** experienced first light in his 12.5-inch Newtonian reflector on September 21, 1988, when Mars appeared its largest (23.8") between 1971 and 2003.*

Alan MacRobert

Watch the Moon Occult Regulus

Late-night spectacle or daytime challenge? It'll depend on where you are.



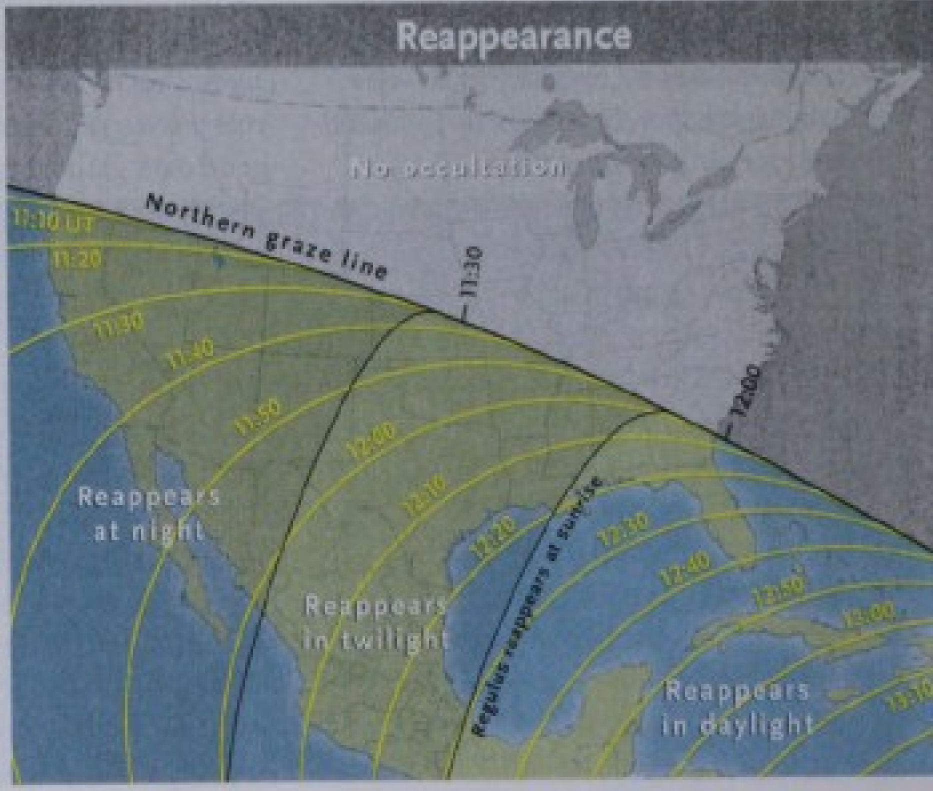
On Sunday morning, November 3rd, telescope users in much of the southern and western US have a chance to watch the bright edge of the waning gibbous Moon creep up to and snuff out the 1st-magnitude star Regulus, or Alpha (α) Leonis. The occultation happens in the dark of night for the Southwest, in the glow of dawn for much of the Southeast, and barely after sunrise for the east coast of Florida.

Detailed predictions for many cities, including in Mexico and the Caribbean, are on the website of the International Occultation Timing Association at www.lunar-occultations.com/iota/bstar/1103zc1487.htm.

Trickier to observe will be Regulus's reappearance just as suddenly out from behind the Moon's dark limb. This happens roughly an hour later, when the sky will be brighter in Texas and the Southeast. And you'll have to be looking at the right spot at exactly the right moment.

At upper right is the star's path behind the Moon as seen from various cities. The maps below tell when Regulus will disappear and reappear at your location. Interpolate between the yellow lines to get the Universal Time (GMT) of each event. Subtract 8 hours from this to get Pacific Standard Time, 7 hours to get MST, 6 hours for CST, or 5 hours for EST. (Daylight-saving time will have ended earlier that morning.)

Also indicated on each map is whether the occultation happens in a dark night sky, morning twilight, or daylight. The Moon will be well up in the east or southeast.



S&T: CASEY REED (3)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We'll sell you the right telescope.™
At astronomics, our family-owned business has been helping people choose the right telescope since 1979. We'll use our staff total of over 150 years of experience using and selling telescopes to help you pick the scope that fits your needs (and your budget).
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The AT90EDT from Astro-Tech is a 90mm f/6.7 triplet apochromatic refractor that uses all premium Ohara glass, including FPL-53.
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Does the competition stack up to the 90mm Astro-Tech AT90EDT apo triplet? Doesn't sound like it.
The AT90EDT is one of six great-value Astro-Tech ED refractors – including the $349 AT66ED that Astronomy magazine said "everyone should own."
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The Astro-Tech dielectric 1.25" star diagonal is a Sky & Telescope Hot Product for 2007! It has 46-layer 99% reflectivity dielectric mirror coatings. Its soft brass compression ring eyepiece holder won't scratch your valuable eyepieces.
At only $69⁹⁵, the Astro-Tech is a best buy. It's one of five great-value dielectric diagonals from Astro-Tech.
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. . . at a fraction the price of a true R-C.
Sky & Telescope said the Meade RCX400 f/8 catadioptric "does indeed perform like a Ritchey-Chrétien." And Astronomy said it "delivers Ritchey-Chrétien-like performance at a fraction the cost."
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14" LX200R, tripod, UHTC optics 6499
16" LX200R, no tripod, UHTC optics 11,999
16" LX200R, tripod, UHTC optics 12,999
16" LX200R, altaz pier, UHTC optics ... 12,999
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The sky doesn't get any easier than this.
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An optional cable lets you connect the GPS-based Meade mySky to your Meade AutoStar-equipped scope for point and click go-to viewing, or add GPS to your non-GPS computerized Meade scope.
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TMB-80CF carbon fiber triplet apo
$1395
TMB-80 triplet apo
$995
Like all TMB refractors, the TMB-80 uses premium FPL-53 ED glass in its fully multi-coated apochromatic triplet lens. The aluminum tube TMB-80 has a rotating 2" Crayford focuser, 1.25" and 2" compression ring eyepiece holders, and a free $120 value Astro-Tech 2" dielectric star diagonal. A true TMB apo for under $1000? Wow!
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The very compact 92mm f/5.5 TMB-92 triplet apo, below, fills the void left by the discontinued 90mm Astro-Physics Stowaway (a legendary scope that sells for up to $6000 on the used market). But you won't pay $6000 for the TMB-92. This fast focal ratio TMB apo is only $1999. The TMB-92 has a collimatable lens cells and a famous Feather Touch 2.7" dual-speed rotating rack and pinion focuser.
TMB-92 triplet apo
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C6 S-GT, 6" Schmidt-Cassegrain 999
C8 N-GT, 8" reflector 1019
C8 S-GT, 8" Schmidt-Cassegrain 1514
C9¼ S-GT, 9¼" Schmidt-Cassegrain 1999
C10 N-GT, 10" reflector 1199
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This GPS-based non-magnifying handheld personal planetarium locates and identifies all of the 6,000 sky objects visible to your unaided eye. Earbuds tell you their stories, or you can read the information on the scrolling 5-line text and graphics display.
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Pentax XO high performance eyepieces have exceptional sharpness and contrast for lunar, planetary, and binary star observing. They reveal a universe of subtle details that lesser eyepieces miss.
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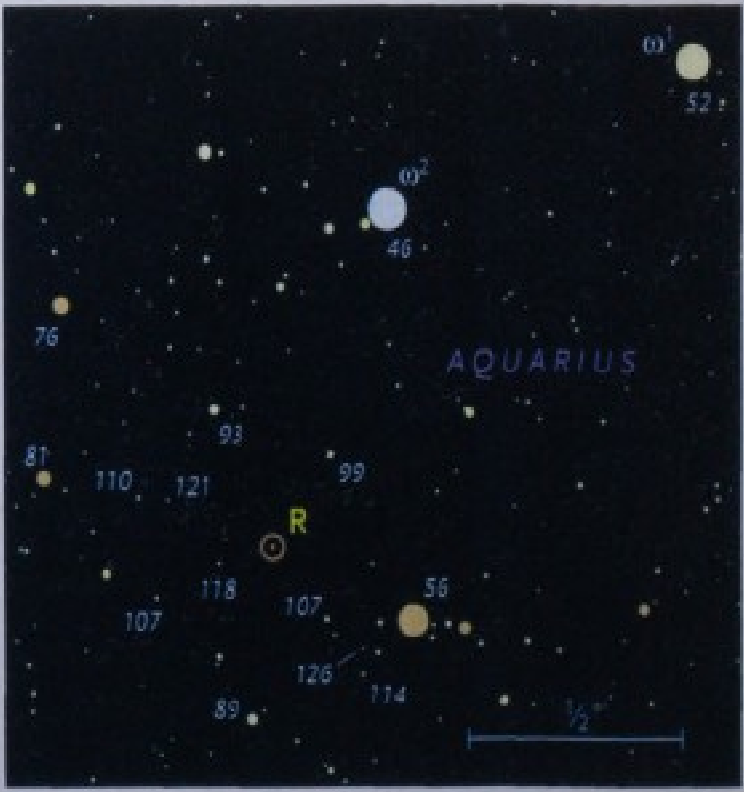
A Symbiotic Star

THE RED long-period variable star R Aquarii contains more than meets the eye. It seemed like any other Mira-type variable when German asteroid hunter Karl Ludwig Harding discovered it in 1810. But spectra taken in 1922 revealed signs of a tiny, hot dwarf in the system, with red-giant wind cascading onto it. Such systems were named *symbiotic stars* for their odd, hot-and-cool combined spectra. In the case of R Aquarii, the red giant and hot dwarf are in a wide, 18-year-long orbit around each other.

Even now there's more going on here than we understand. Normally the combined light of the system cycles every 13 months from magnitude 6 to 11 and back. So why did the entire cycle dim down to a range of magnitude 8 to 12 in the 1980s? And why do faint loops and jets of nebulosity surround the system?

R Aquarii's next maximum is predicted for late November, as listed in the table below, left. Using binoculars or a small telescope, watch for it brightening in October and November using the comparison-star chart at right. ✦



Above: **R Aquarii lies in one of the faint "spilling water" asterisms in southeastern Aquarius, at the center of the triangle formed by Fomalhaut, Beta (β) Ceti, and the Circlet of Pisces. The brightest star plotted above appears there on the evening constellation chart facing page 52. Comparison-star magnitudes are given in italics to the nearest tenth with the decimal points omitted.**

Variable-Star Maxima

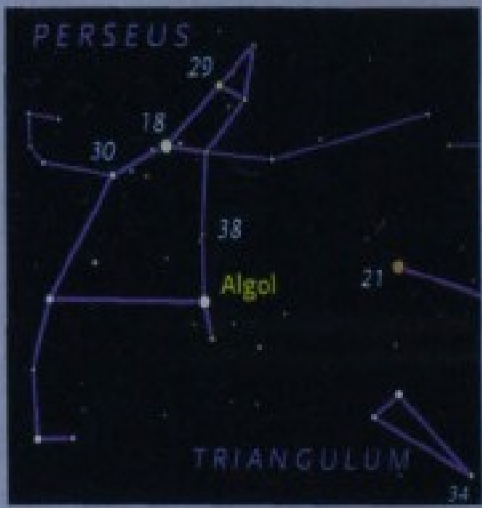
2007	Star	Mag.	RA	Dec.
Oct. 1	S CrB	7.3	15^h 21.4^m	+31° 22′
Oct. 1	RS Lib	7.5	15^h 24.3^m	−22° 55′
Oct. 7	R Dra	7.6	16^h 32.6^m	+66° 45′
Oct. 8	V Cnc	7.9	8^h 21.7^m	+17° 17′
Oct. 12	R Hya	4.5	13^h 29.7^m	−23° 17′
Oct. 15	S Car	5.7	10^h 09.4^m	−61° 33′
Oct. 17	R Cas	7.0	23^h 58.4^m	+51° 23′
Oct. 28	RT Sgr	7.0	20^h 17.8^m	−39° 07′
Oct. 29	R Ser	6.9	15^h 50.7^m	+15° 08′
Nov. 2	RU Sgr	7.2	19^h 58.6^m	−41° 51′
Nov. 7	T Cen	5.5	13^h 41.8^m	−33° 36′
Nov. 16	R Hor	6.0	2^h 53.8^m	−49° 53′
Nov. 16	RV Cen	7.7	13^h 37.5^m	−56° 29′
Nov. 20	R CVn	7.7	13^h 49.0^m	+39° 32′
Nov. 22	V Cas	7.9	23^h 11.7^m	+59° 42′
Nov. 23	T Col	7.5	5^h 19.3^m	−33° 42′
Nov. 27	R Aqr	6.5	23^h 43.8^m	−15° 17′

Listed for each of these long-period variable stars are the expected date of peak brightness, the star's typical visual magnitude at peak, and its right ascension and declination (equinox 2000.0). The actual maximum may be brighter or fainter and many days early or late. Courtesy Elizabeth Waagen, American Association of Variable Star Observers (www.aavso.org).

Minima of Algol

Oct.	UT	Nov.	UT
1	21:09	2	10:15
4	17:57	5	6:54
7	14:46	8	3:43
10	11:35	11	0:31
13	8:23	13	21:20
16	5:12	16	18:09
19	2:01	19	14:58
21	22:50	22	11:47
24	19:38	25	8:36
27	16:27	28	5:25
30	13:16		

These geocentric predictions are from the heliocentric elements Min. = JD 2,452,253.567 + 2.867321*E*, where *E* is any integer. Derived by Marvin Baldwin (AAVSO), they are based on 17 timings collected from 1999 to 2003 and on the star's average period during the previous 35 years. For more about Algol, visit SkyandTelescope.com/algol.



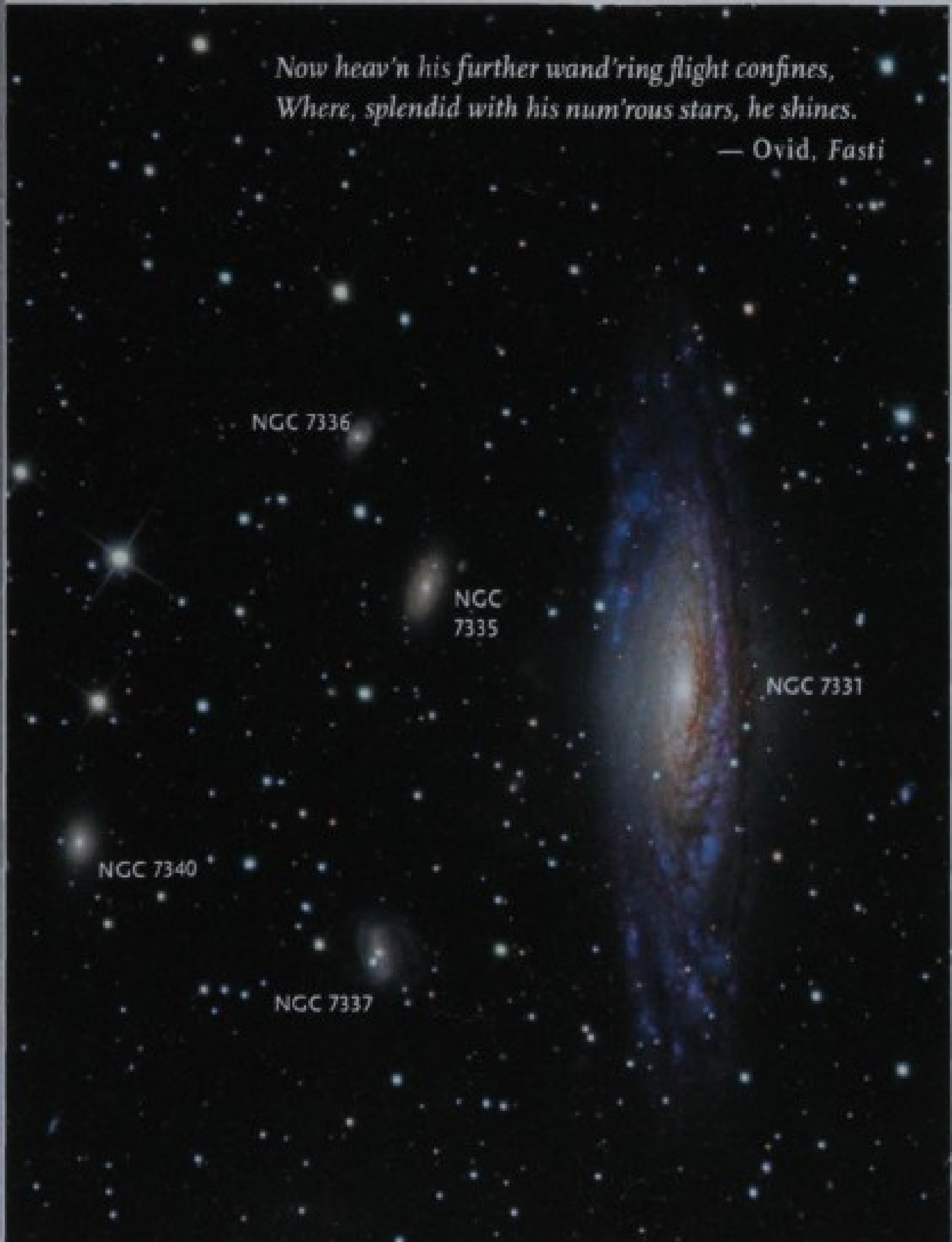
See for Yourself

Every 2 days 20 hours 49 minutes, the famous eclipsing variable star Algol (Beta Persei) fades from magnitude 2.1 to 3.4. The change is obvious to the unaided eye. Algol stays near minimum brightness for two hours, and the fading and rebrightening each take several additional hours.

Predicted eclipse dates and times, in Universal Time, are listed at left. The chart above gives magnitudes of comparison stars to the nearest tenth, with the decimal points omitted. Algol usually matches Gamma Andromedae (labeled *21*), but at minimum it resembles Alpha Trianguli (labeled *34*).

The Winged Horse

Here are some fascinating deep-sky objects in Pegasus that'll delight you and challenge you at the same time.



RUSSELL CROMAN

BRIGHT SPIRAL Moderately large and bright enough to show in binoculars, the spiral galaxy NGC 7331 (Caldwell 30) in Pegasus is a popular destination for deep-sky observers of all experience levels. Four nearby galaxies, collectively know as the Fleas, are far more challenging but still within reach of modest-aperture telescopes. The field is ¼° wide with north up.

ACCORDING TO GREEK MYTH, Pegasus is the winged steed that sprang from the blood of the hideous Gorgon Medusa when she was slain by Perseus. This beauty born from ugliness was involved in many tales, including the great feats of the hero Bellerophon.

Bellerophon grew overly proud of his accomplishments and tried to fly Pegasus to the abode of the gods. Zeus, angered by this display of audacity, sent a gadfly to sting Pegasus. Bellerophon was thrown from his steed and fell back to Earth, but Pegasus was accepted into the heavens, where we see him today.

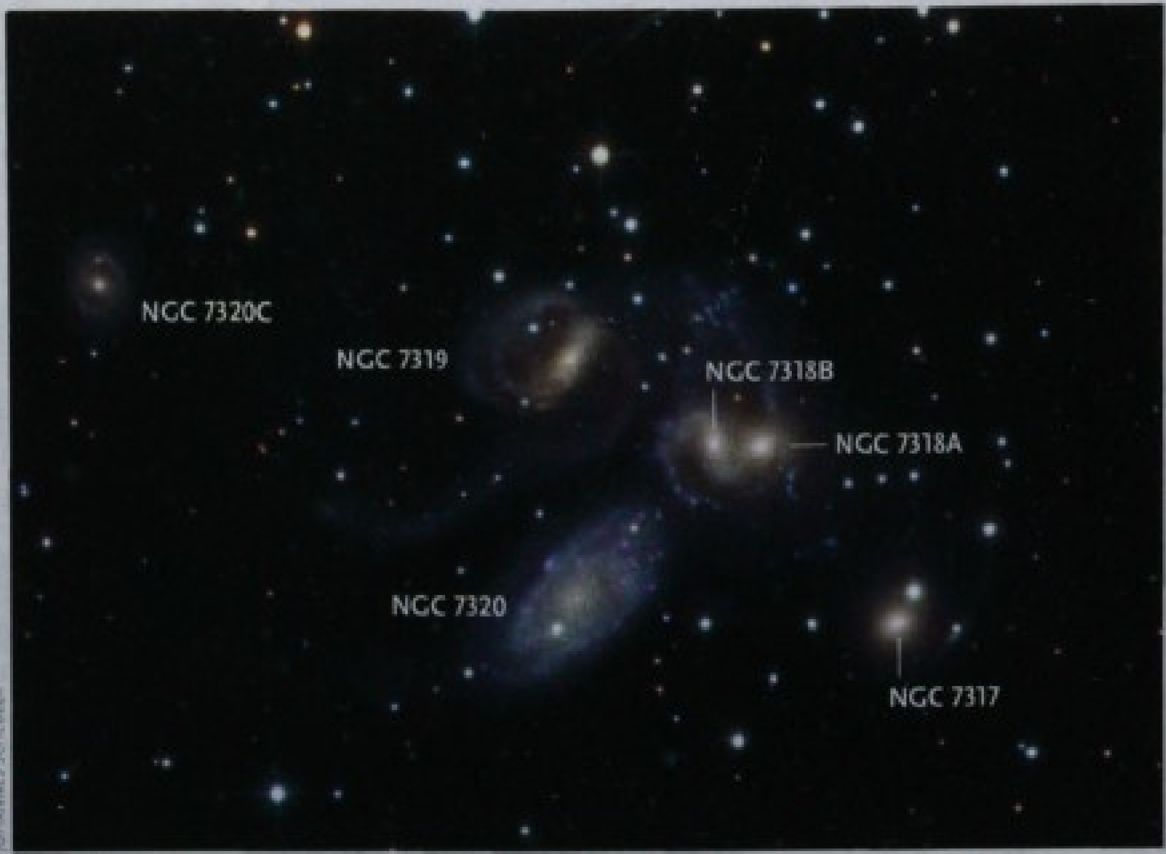
Our flying horse seems intent on the celestial sugar ball suspended before him, **Messier 15,** one of the most beautiful globular clusters in the northern sky (October issue, page 59). An imaginary line from Theta (θ) Pegasi, the horse's ear, through Epsilon (ε) Pegasi, his nose, points right to it. From my semirural home, M15 is easily visible in 12 × 36 image-stabilized binoculars as a hazy orb. An 8th-magnitude star sits just off one edge, and a ½° box with two or three stars at each corner rests east of the cluster.

My 4.1-inch (105-mm) refractor at a magnification of 17× shows M15 with an intense nucleus, a small bright core, and a large halo that weakens outward. At 87× the core looks mottled, and many stars glimmer in the halo. Several sugar grains sweeten the core at 153×, and the nucleus reveals a brighter center but remains unresolved. The halo's stragglers stretch the globular to a diameter of 9′.

M15 is positively gorgeous in my 10-inch reflector. At 166× it boasts a brilliantly blazing center from which it fades sharply outward to a diameter of 12′. The most obvious stars of the sparsely populated halo seem to fill four or five starfish-like arms.

Inward, where the cluster's brightness starts to soar, M15 is very rich in stars that grow more and more crowded toward its luminous heart. M15 is one of the most densely packed clusters in our galaxy. It lies 33,600 light-years from Earth and 15,400 light-years below the midplane of our Milky Way Galaxy.

Another aspect of M15 that sets it apart from the ordinary is a planetary nebula that is visible in amateur telescopes. **Pease 1** is buried deep within M15 and tough



CONTROVERSIAL CLUSTER
Stephan's Quintet is one of the sky's best-known galaxy groups, thanks to a controversy involving discordant distance estimates of the members. The field is 8′ wide with north up.

POWER UP
While observers often find that large faint nebulae and galaxies are seen to advantage in a low-power, wide-field eyepiece, the faintest stars and small diffuse objects are usually easier to see with high magnifications. Try using a high-power eyepiece if you can't find your target in a low-power view.

to locate among the globular's myriad stars. Fortunately, detailed charts are available on the Planetary Nebulae Observer's website (www.blackskies.org/peasefc.htm). With these charts and an hour of invested time, I identified the little clump of stars that includes Pease 1.

At 284× through my 15-inch reflector, I couldn't isolate the planetary until I added an oxygen III nebula filter. This left just one object standing out well, no doubt the planetary. Don't worry — you don't need a 15-inch scope to try for Pease 1. Experienced observers under better skies than mine have reported success with telescopes as small as 8 inches.

If the planetary is too much of a tease, pass the Pease and try for **NGC 7094.** Located 1.8° east-northeast of M15, this planetary nebula is rather faint through my 10-inch reflector at 115×. But its 13.6-magnitude central star is easily spotted, and I occasionally glimpse an extremely dim star within its edge. Using either a narrowband or O III filter greatly improves the view. The 1½′ nebula appears roundish, somewhat uneven in brightness, and vaguely annular (ring-shaped).

Now, for a bit of extragalactic excitement, we'll zoom up to the pretty galaxy pair **NGC 7332** and **NGC 7339** near Lambda (λ) Pegasi in the horse's leg. The duo dwells 2.1° west of Lambda, where it's sandwiched between a north-south pair of 7th-magnitude stars.

In my little refractor at 87×, NGC 7332 is a thin spindle tilted north-northwest with an elongated core and stellar nucleus. Also slender, but requiring averted vision, NGC 7339 lounges 5′ east of its companion's southern tip and runs east-west. A faint star lies between the galaxies. At 122×, NGC 7339 is visible with direct vision, has a uniform surface brightness, and spans about 2¼′. NGC 7332's halo extends farther south than north of its nucleus and bridges 2¾′.

A dozen degrees northward, a gold and orange pair of 6th-magnitude stars decorates the Pegasus-Lacerta border. Magnificent **NGC 7331** rests 1.2° south of these stars. The galaxy is easily visible in my 4.1-inch scope at 47×. Its elongated core and halo lean slightly west of north and envelop an intense, starlike nucleus.

The galaxy is quite pretty at 87× and measures about 6′ × 1½′. The light along the eastern side diminishes gradually outward, whereas an abrupt falloff on the opposite side indicates the presence of a dust lane.

The dark lane is lovely through my 10-inch scope at 166×, and the galaxy covers about 9′ × 2½′. The 3′ core brightens markedly toward its tiny nucleus. Four dim galaxies, collectively nicknamed the Fleas, harry the eastern flank of NGC 7331. The most prominent is **NGC 7335,** which measures 1¼′ × ½′ and tips north-northwest. This galaxy presents a fairly uniform surface brightness with a scumbled edge. Look for it 3.5′ east of the northern end of NGC 7331's core.

A pair of 10th- and 11th-magnitude stars 4′ farther east point southward to **NGC 7340,** a smaller and rounder version of NGC 7335. A north-south line of four 12th- and 13th-magntitude stars runs between NGC 7340 and NGC 7331. **NGC 7337** sits 1′ west-southwest of the southernmost star. Only the galaxy's very small but relatively bright core is visible, and a faint star bedecks its southeastern edge.

NGC 7336 is also petite and is seen only with averted vision. It lies in the four-star line two-thirds of the way from the northernmost star to the next one down.

While preparing this article, I wondered if any of the

Fleas could be seen through my little refractor. Studying the region carefully on the next clear night, I was delighted to discover that, though challenging, all except NGC 7336 were visible with averted vision.

The Fleas aren't true neighbors of NGC 7331, but rather reside deep in the background. NGC 7331 is about 50 million light-years from Earth, while three of the Fleas belong to a group nearly six times as distant. NGC 7336 is yet another 100 million light-years farther away.

NGC 7331 is, however, generally thought to be associated with **NGC 7320,** one of the galaxies in nearby **Stephan's Quintet.** Look for an east-west pair of 10th-magnitude stars 24′ south-southwest of NGC 7331. Stephan's Quintet huddles 6′ south of the western star.

In my 10-inch reflector at 311×, the Quintet's **NGC 7318A** and **NGC 7318B** are so snug that they seem to share an east-west halo, but close inspection reveals separate cores. To the southeast, NGC 7320 is about the same size and brightness as the combined glow of the conjoined twins. This galaxy is elongated northeast-southwest and appears somewhat brighter toward its core.

Due north, elusive **NGC 7319** shows a similar slant, which indicates that I'm only seeing this spiral galaxy's core and bar. West of NGC 7320, tiny **NGC 7317** is nestled against a 13th-magnitude star north-northwest.

Encouraged by my success with the Fleas, I turned my 4.1-inch scope toward Stephan's Quintet. At 203×, I could spot NGC 7318A/B as a single patch of mist. NGC 7320 was also discernible, but more subtle. I'm a great fan of small telescopes for deep-sky observing, but their capabilities still surprise me from time to time.

Most astronomers place NGC 7320 at roughly the same distance as NGC 7331, whereas the remaining galaxies of Stephan's Quintet are thought to inhabit the same region as the more distant Flea trio. A vocal minority of researchers, though, maintains that all five galaxies in Stephan's Quintet are related, and they cite this as one piece of evidence indicating that redshifts (recessional velocities) may not be reliable indicators of extragalactic distances. There a nice up-to-date history of this astronomical controversy in Jeff Kanipe and Dennis Webb's *Arp Altas of Peculiar Galaxies* (Willmann-Bell, 2006), reviewed in the September issue, page 74. ◆

Longtime amateur astronomer ***Sue French*** *observes year-round from her home outside Schenectady, New York.*

Flying with the Horse

Object	Type	Magnitude	Size	RA	Dec.	MSA	U2
M15	Globular cluster	6.2	18.0′	21h 30.0m	+12° 10′	1238	83R
Pease 1	Planetary nebula	14.7	1″	21h 30.0m	+12° 10′	1238	83R
NGC 7094	Planetary nebula	13.4	94″	21h 36.9m	+12° 47′	1238	83L
NGC 7332	Galaxy	11.1	4.1′ × 1.1′	22h 37.4m	+23° 48′	1187	64R
NGC 7339	Galaxy	12.2	3.0′ × 0.7′	22h 37.8m	+23° 47′	1187	64R
NGC 7331	Galaxy	9.5	10.5′ × 3.5′	22h 37.1m	+34° 25′	1142	46R
NGC 7320	Galaxy	12.6	2.2′ × 1.1′	22h 36.1m	+33° 57′	1142	46R

Angular sizes are from recent catalogs. The visual impression of 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. The columns headed *MSA* and *U2* give the appropriate chart numbers in the *Millennium Star Atlas* and *Uranometria 2000.0 Deep Sky Atlas*, respectively. All the objects this month are in the area of sky covered by Charts 74 and 75 of *Sky & Telescope's Pocket Sky Atlas*.

Flight to the Future

It took two trips to Florida, but the author finally got to witness a shuttle launch.

TWO SUMMERS AGO my wife, Wendee, and I planned to watch a Space Shuttle launch. We traveled to Florida and settled into a hotel with a direct view of *Discovery* on its pad. But the weather didn't cooperate, and the liftoff was delayed. At first we waited, even catching a magnificent fireworks display at Epcot Center after narrowly escaping being hoodwinked into buying a timeshare unit in Orlando. *Discovery*, on the other hand sat under fog, clouds, and the threat of a hurricane that never materialized. In the end we had to return home before the flight got under way.

We didn't even think about traveling to see another launch until *Atlantis* was sidelined last spring after a hailstorm damaged its external fuel tank. Once the repairs were completed and the launch was rescheduled for June 8th, we decided to head back to Florida.

Launch morning dawned rainy, and I awoke with a sense of déjà vu. This started me thinking about why we are repeatedly going into orbit around Earth to build a space station of questionable science value. Wouldn't it be better to invest in robotic probes instead? This argument is simple and certainly not new. Robotic spacecraft like Voyager, Galileo, and Cassini have explored the biggest worlds in our solar system, Deep Impact released a wealth of data when it slammed into Comet Tempel 1, and New Horizons is on its way to study Pluto and the Kuiper Belt. Their value? Priceless. Together they offer us an unprecedented understanding of the solar system.

But interplanetary exploration is not the only reason I am an unabashed NASA fan. Having gone through high school during NASA's golden years in the 1960s, I followed every launch and every mission as a personal odyssey. By the time the shuttle program began I was utterly locked into NASA's beating heart. During the early 1980s, however, I became involved with the Planetary Science Institute, many of whose employees are audaciously against human spaceflight because it reduces funds available for their dreams of exploring the solar system remotely.

Nevertheless, as the years passed I found it unnecessary to abandon one view in

LIFTOFF Just before sunset last June 8th, the Space Shuttle *Atlantis* rocketed from Florida's Kennedy Space Center toward a rendezvous with the International Space Station.

NASA

favor of another. A good space program, I believe, must have room for a significant human presence in space *and* robust robotic exploration of the solar system. And whatever anyone perceives as shortcomings of our current program, it's the one we have. Our growing space station provides a constant human presence in space. We are also at the dawn of commercializing human spaceflight, with several companies actively competing to provide service in the near future. It is not a perfect space program, but it *is* exciting.

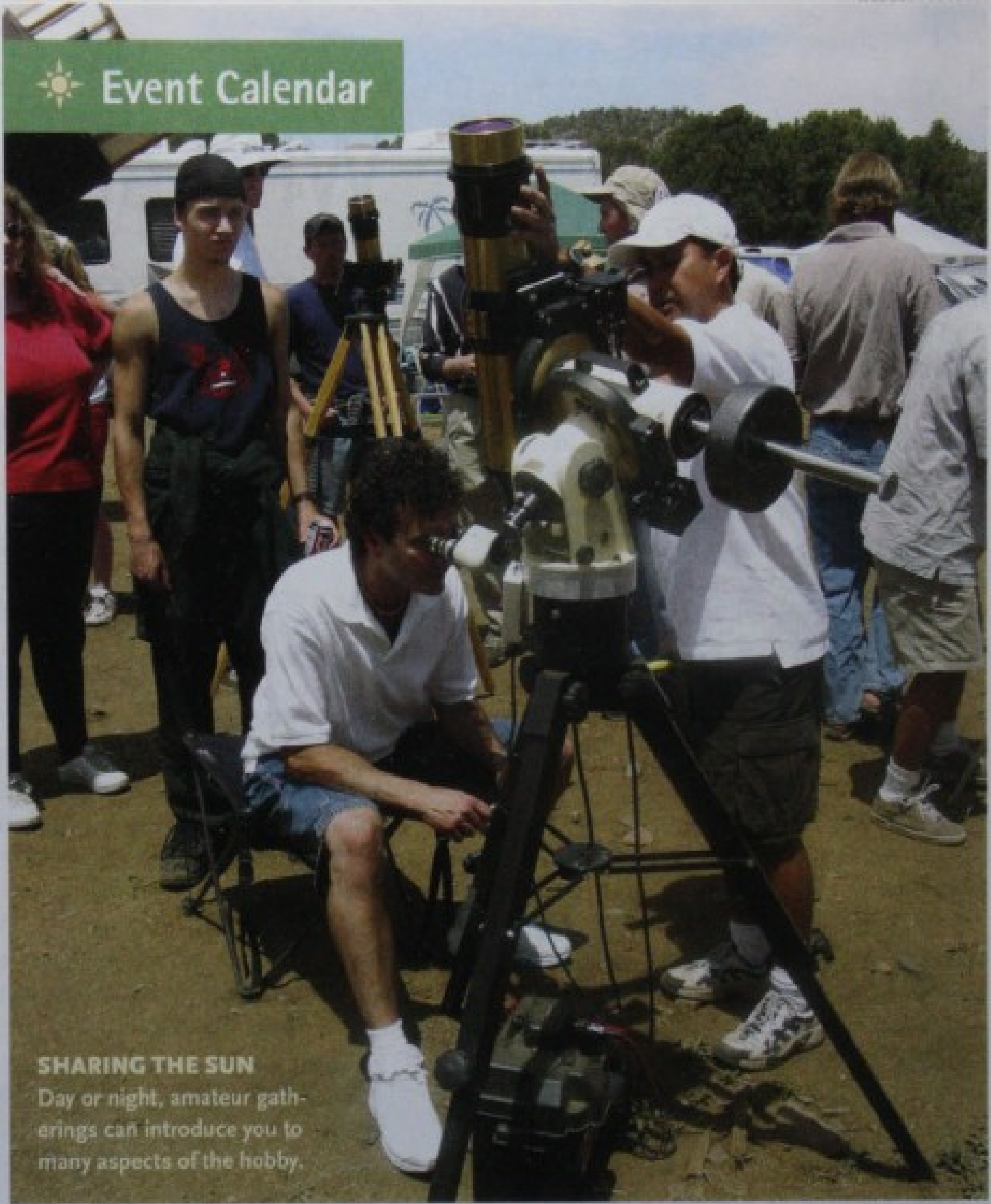
Friday, June 8, 2007, was just one day in the life of that space program. After our experience last year we knew there were no guarantees, but the rain and clouds were diminishing as we gathered our group together to watch the launch. Jack "Triple" Nickel, the NASA pilot who flew our zero-g mission last year (*S&T:* November 2006, page 91), arranged a wonderful viewing site for us along the causeway at Kennedy Space Center. Sid Leach, chairman of the Sharing the Sky Foundation, his wife, Gloria, Peter Jedicke, and Ann Micklos joined us as the count went on.

By 7 p.m. the Sun was setting in an almost completely clear sky. We had a few moments of concern when Ann told us that transatlantic landing sites (needed if the mission had to be aborted before the shuttle reached orbit) were clouded out. But the weather in Spain soon cleared enough for the countdown to continue.

At 7:37 p.m. *Atlantis*'s three main engines lit up. The next seven seconds seemed like an eternity, since five launches have been aborted within seconds of liftoff. But then the solid-fuel rocket boosters ignited and 1½ million pounds of shuttle seemed poised in the air atop a column of fire. Within seconds the rocket pirouetted like a ballet dancer as it soared toward the stars and soon vanished from sight. Hours later the still-present smoke plumes encircled Venus in a darkening evening sky. It was a successful launch for the shuttle — and for us. ✦

*Author **David Levy** and his wife, Wendee, travel frequently to astronomical venues around the world.*

Event Calendar



SHARING THE SUN
Day or night, amateur gatherings can introduce you to many aspects of the hobby.

S&T: DENNIS DI CICCO

OCTOBER 12–14
Jersey Starquest
Hope, New Jersey
www.princetonastronomy.org

OCTOBER 26–28
Advanced Imaging Conference
San Jose, California
Steve Mandel
steve@galaxyimages.com
www.aicccd.com

NOVEMBER 6–11
Deep South Regional Star Gaze
Norwood, Louisiana
www.stargazing.net/DSRSG

NOVEMBER 9–12
VicSouth Desert Spring Star Party
Nhill, South Australia
vicsouth@internode.on.net
www.vicsouth.com

For more astro events, go to SkyandTelescope.com/community/calendar

NOVEMBER 9–11
International Festival for Astronomy
Bunnik, The Netherlands
M. R. Haas, +31 71-527-8436
haas@strw.leidenuniv.nl
www.sterrenkunde.nl/jwg/ifa

NOVEMBER 10
Saturday Star Party
Paris, Virginia
Sean O'Brien, 540-592-3556
www.nasm.si.edu/events

To list an event, e-mail your announcement and contact information (with complete details) to info@SkyandTelescope.com at least three months in advance. Late or incomplete submissions will not be considered. Not all events will be listed.

ATMentoring

Amateur telescope making is easier with a little help from a friend.

I MET MY telescope-making mentor on January 13, 1987. That evening, during an informal get-together after a meeting of the Vancouver Centre of the Royal Astronomical Society of Canada, I overheard a guy describing how he was putting the finishing touches on three 12½-inch telescope mirrors. All I knew about mirror making in those days was that it was difficult and that anyone who tackled a piece of glass that big was probably nuts. And anyone who made three at a time had to be *seriously* nuts! This particular nut was Lance Olkovick.

Every astronomy club has a Lance. He's the first guy you call when your scope needs repairs. He's the guy you check in with before buying a new piece of gear. He's the guy who gets roped into setting up a mirror-making demo at the local shopping mall on Astronomy Day. And he's the guy you should seek out if you're planning to make your own telescope.

I struck up a conversation with Lance, and when he offered me one of his big mirrors for only a couple hundred dollars, I suddenly found myself caught up in the world of serious ATMing. A couple of days later I visited his house and toured his telescope workshop, known locally as the Krell Lab (a *Forbidden Planet* reference).

Together we set to work on building a housing for my new 12½-inch mirror. As my project grew from a pile of plywood and cardboard tubing into something resembling a telescope, my friendship with Lance also took shape. That 12½-inch became my main telescope, and Lance became my observing companion.

Join in on the telescope-making discussions at Cloudy Nights forums (www.cloudynights.com) and Yahoo Groups (groups.yahoo.com).

When the day came for me to tackle my first mirror, I knew I could turn to Lance for guidance. When I felt the mirror was done, I took it to the Krell Lab for testing. I'll never forget the thrill of discovering that Lance's test results closely matched my own. The mirror was an excellent one — something of a rarity for a first attempt. Having a mentor helped make that possible.

You can make an excellent telescope guided only by books, but it's much easier, and more rewarding if you have hands-on help. But even if there isn't an astronomy club nearby, these days help is only a few mouse clicks away thanks to the online ATMing community. You can have "virtual" mentors to guide you through the ins and outs of telescope making. No one need grind alone.

Lance died suddenly last June 21st. On that sad day, I lost not only an inspiring teacher, but also a close friend. When I look at the scopes I've built over the years, I see a little of Lance in each of them. They stand as tokens of our friendship and of the virtues of mentoring. And now, when I scan the skies with my 12½-inch, it's hard not to feel as if Lance is there with me, taking in the view and suggesting just one more tweak to make the scope work even better. ✦

Gary Seronik (gseronik@SkyandTelescope.com) is an avid telescope maker who figured his first mirror — a 6-inch — nearly 20 years ago. He lives in Victoria, British Columbia.

GARY SERONIK

John Dobson (right) and Lance Olkovick discuss the fine points of Dobsonian telescopes at the 1993 Mount Kobau Star Party.

The editors of Sky & Telescope *answer your questions about amateur astronomy.*

Twirling Windbags

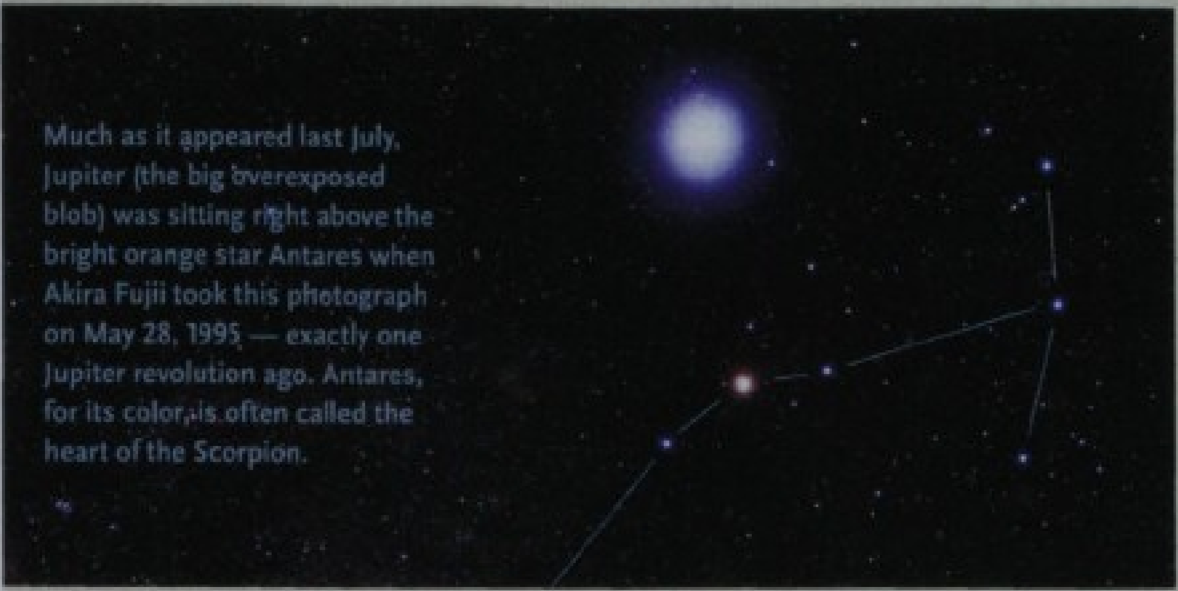
Why do the outer, gas-giant planets generally rotate much faster than the inner, terrestrial planets?

— Bill Dellinges, Apache Junction, AZ

The reasons why some planets rotate as quickly as they do remain puzzling to planetary scientists. Most studies in this area have focused on the inner planets. Earth and Mars, which accumulated gradually from rocky planetesimals, most likely got spun up when they experienced glancing impacts from particularly large objects as they neared the sizes they have today.

But the four largest planets probably came together an entirely different way. According to planet-formation specialist Alan Boss (Carnegie Institution of Washington), these biggies must have accumulated most of their mass from gas in the surrounding solar nebula. That gas formed individual spinning disks (from which many satellites formed), and most likely it carried a lot of angular momentum as it fell onto the outer planets' cores, causing them to spin faster and faster as they coalesced. — *J. Kelly Beatty*

Send questions to qanda@SkyandTelescope.com for consideration. Due to the volume of mail, not all questions can receive personal replies.



Much as it appeared last July, Jupiter (the big overexposed blob) was sitting right above the bright orange star Antares when Akira Fujii took this photograph on May 28, 1995 — exactly one Jupiter revolution ago. Antares, for its color, is often called the heart of the Scorpion.

AKIRA FUJII

What It Was

I'm new to astronomy (1⅓ months) and I live in New Jersey. Last night, July 31st, I saw a bright planet (I assume Jupiter) in the southwestern sky, and just below it what looked like an airplane with a flashing red tail marker — but it never moved. When I got home I looked at both with my 70-millimeter telescope. Jupiter had three moons in a line, but the object below it looked like an LED attention-getter that stores sold in the 1970s, flashing in different colors. What was it?

— Jim Hobson, Vernon, NJ

Newcomers send us more questions about flickering, starlike objects low in the sky than anything else. You start noticing these twinklers when you pay close attention to the night sky.

Your mystery object had to be the bright orange star Antares, which was then sparkling about 5° below Jupiter (see the all-sky star map in the center of our July issue). Atmospheric turbulence makes all stars scintillate, and bright ones can look especially wild and colorful when they're very low. — *R. W. S.*

Seeing Jupiter's Moons

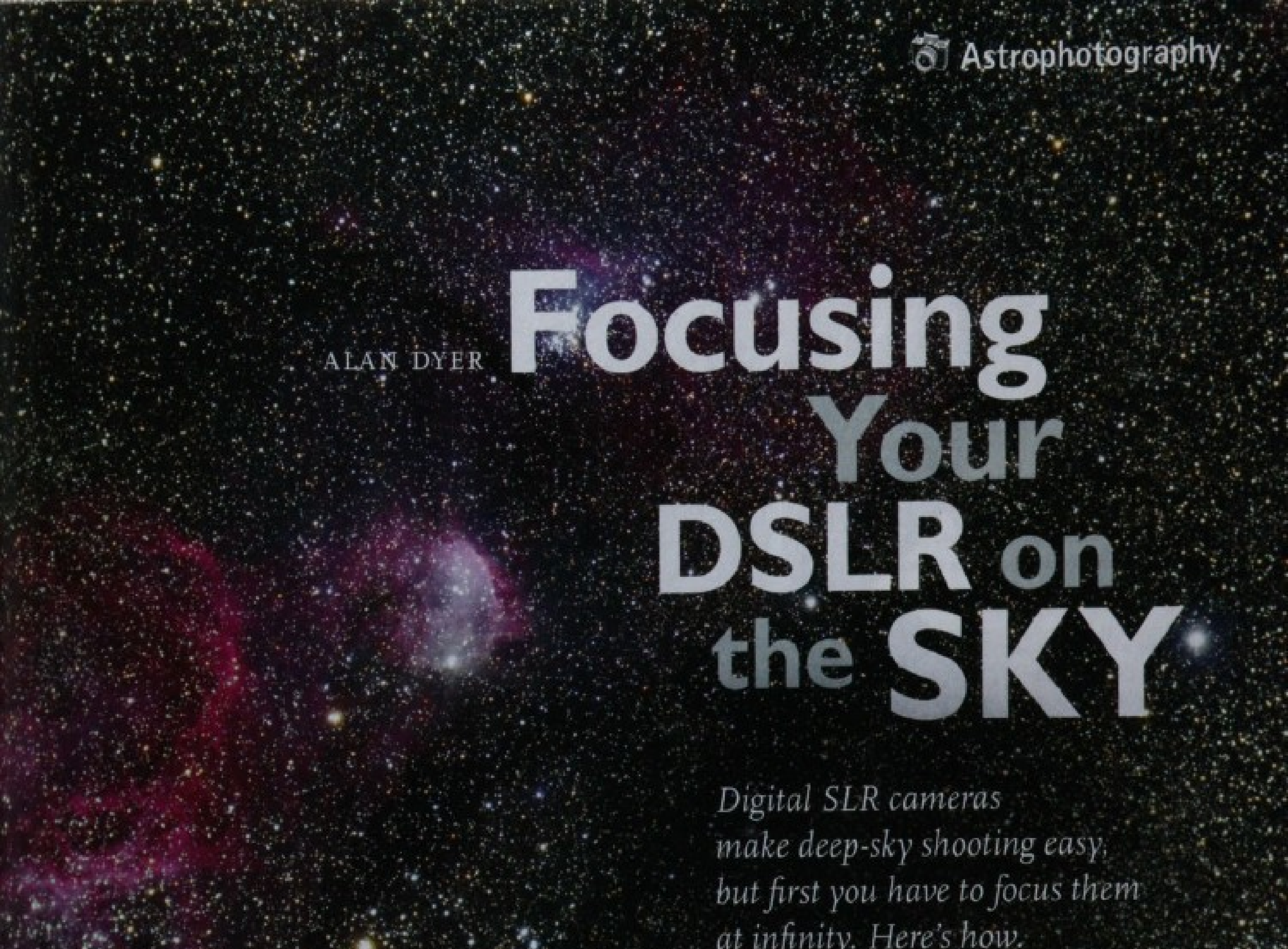
I've heard it might be possible to detect Jupiter's satellites with the unaided eye if Callisto and Ganymede appear together when Ganymede is at greatest elongation from Jupiter. Will this happen anytime soon?

— Tom Moore, Houston, TX

Jupiter is now setting soon after sunset. But three times in 2008, Texans (and North Americans generally) will have a chance to see what you're describing: on March 6th near 5:40 a.m. Central Standard Time, then on October 20th between 8 and 9 p.m. Central Daylight Time, and finally on November 14th near 7:10 p.m. CST.

But don't get your hopes up. Ganymede is the brightest moon, near magnitude 5.2 on these dates, but it never strays more than 6′ from Jupiter. Callisto, magnitude 6.2, enhances Ganymede's brightness to just 4.8 (combined). Compare this to Mizar's naked-eye companion, Alcor, in the Big Dipper's handle. Alcor is magnitude 4.0 and 11.8′ from Mizar — and they're often called a test of acuity.

So I doubt Ganymede can ever be seen with the naked eye, with or without Callisto's help. But they'd be fine targets for an instrument I've dreamed of yet *never* seen in the marketplace: a modern, wide-field binocular with a magnification of just 3× or 4×. — *Roger W. Sinnott*



Focusing Your DSLR on the SKY

ALAN DYER

Digital SLR cameras make deep-sky shooting easy, but first you have to focus them at infinity. Here's how.

ABOVE The perfect flatness of imaging chips makes unrelenting demands of optical quality and exacting focus. Taking care at the telescope can yield images with pinpoint stars across the frame. This view of NGC 3293, the Gem Cluster in Carina, is a stack of four 8-minute exposures with a Canon 20Da shooting through a 4-inch refractor with a field flattener.

PHOTOGRAPHS BY ALAN DYER

IF YOU WANT TO take great astrophotos, you have to be focused. I know this sounds like a meditation ritual from "Zen and the art of astrophotography." But I really mean getting the image sharp. It can be tough to do.

Digital SLR cameras are easy to use because you actually look through the lens to frame and focus. But stick one on a telescope and the immediate reaction is, "The image is dim! How do I focus?" My answer? Carefully!

Focusing Misfortunes

During the day you can simply switch on "Autofocus" and the job is done. But at night there's rarely anything bright enough in the frame for a camera's lens to home in on and determine proper focus. Put the camera body on a telescope and your fancy multipoint servo-autofocus becomes useless baggage.

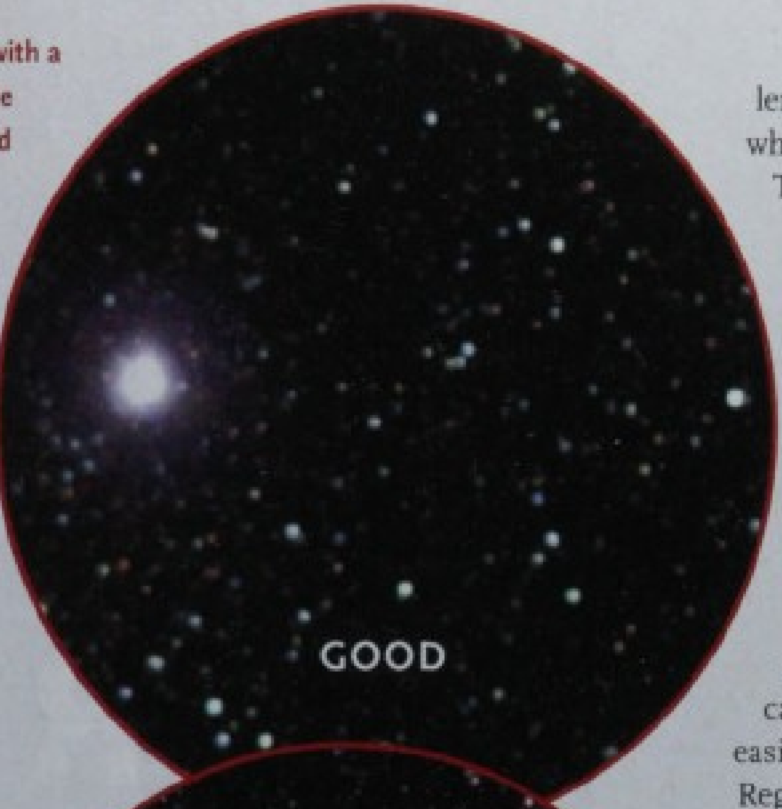
Instead, the task falls to you and your best judgment.

Enlargements of shots taken with a telephoto lens reveal the subtle difference between "good" and "great" focus.

GOOD
The focus is OK and might pass an uncritical eye, but stars appear soft and enlarged.

BETTER
Star images are tighter and apparently in focus yet remain surrounded by magenta halos from chromatic aberration in the lens.

BEST
A slight tweak to the focus eliminates the chromatic aberration while keeping star images tight. Your setup is now in perfect focus.



In the film era you had to trust that judgment and hope for the best. Thank goodness those days are gone! The beauty of digital SLRs, or any digital camera, is their instant feedback. Even so, if there's one flaw I still see now and then in my astrophotos, especially shots through a wide-angle or telephoto lens, it's soft focus.

The problem rears its fuzzy head because it is hard to tell when a star is a sharp pinpoint simply by looking through the viewfinder. The focusing screen is dim and coarse. Unlike the best film cameras, interchangeable focusing screens are not an option for most digital SLRs. With the stock screen, you can get it close, but close doesn't count here.

For example, images taken with a piggybacked camera lens may look sharp but are surrounded by magenta or cyan glows. You thought you'd paid good money for a color-free ED lens, so why is there color? The lens will deliver its promised colorless images only when it is *precisely* in focus. And I mean precisely! The difference between so-so focus and superb focus can be the slightest twist of a lens ring.

COLLIMATE THE OPTICS

Optics that are even slightly misaligned will produce fuzzy or misshapen stars, not just in the corners but also in the center of the frame. Reflectors of any type are most likely to need occasional collimation.

Method #1: Simply Visual

The first means of attacking focus is to magnify the view through the camera. Canon, Nikon, and Olympus offer a right-angle magnifier that clips onto a camera's viewfinder, offering an image magnified 2 or 2½ times. I consider this an essential accessory — even if you opt for some other focusing method, the right-angle viewing makes looking through the camera so much easier.

LET YOUR OPTICS COOL

Focus will shift as temperatures cool and tubes contract, even with camera lenses. Wait until your gear has cooled down before attempting to focus it, and refocus through the night if temperatures continue to fall.

Regardless whether you're shooting the Milky Way or the Moon, you should first aim the camera at a bright star and, with the magnifying finder on maximum power, adjust focus until the star is as small as possible. Be sure to place the star on a blank area of the screen away from any etched lines that will disturb the image. Rolling the focus back and forth helps me see the star enlarge on either side of focus so I can gradually home in on where the star appears as a pinpoint, usually with some spiky flares shooting from the star.

Here's where you can get fouled up: Before doing this, you must first focus the diopter adjustment on both the camera eyepiece and on the magnifier itself to suit your eyesight. Focus with your glasses on or off, whichever you prefer, so that the image looks as sharp as possible (it may not look really sharp until you next focus the lens or telescope). These diopter adjustments don't affect what gets recorded by the camera. But without getting them right first, the image on the camera's focusing screen will never look sharp to your

With today's autofocus camera lenses, the best focus is almost certainly *not* at the infinity mark. It can be a millimeter or two on either side of infinity. With this lens, this is the setting where stars look sharpest, a point found by trial and error.

An aperture cover with three small off-axis holes splits a star's image into a trio of dots when out of focus but merges them into a single dot when in focus. You can make one yourself or purchase one from Kendrick Astro Instruments (www.kendrickastro.com).

eye, making it impossible for you to judge focus.

To aid optical focusing some astrophotographers place a mask over the front of the telescope with two or more off-axis holes. Another classic method is a knife-edge focuser that replaces the camera body. When the telescope is in focus, the knife-edge cuts off the disk of light from a bright star instantly. As an alternative, Stellar Technologies (www.stellar-international.com) offers a nifty bright focusing screen that goes in place of your camera. While I've not tried that unit, I have tried the other two methods. My experience is that neither is practical when shooting with piggybacked camera lenses. That's when I turn to the next line of attack.

Method #2: Camera Trial-and-Error

When shooting through a telescope I usually find it easy to judge best focus by using nothing more than the magnifying finder. But the tiny, faint stars presented by wide-angle lenses make it nearly impossible to focus by eye alone.

So, to be really sure of focus, here's what I suggest: take test shots of the focus star. Exposures of just a few seconds at a high ISO setting are all you'll need.

Then zoom in on the playback image. Stars will always look a little bloated on the LCD screen, but are they as small and colorless as possible? Are faint stars as bright as possible? Shift the focus slightly (noting which way you moved the focus), then take another shot, zoom in and click between the two test frames. You can see immediately if the focus improved or got worse. It will take several iterations to get it right.

RECHECK FOCUS AFTER MAJOR MOVES

If you rotate the camera to frame the subject, you might have to refocus. Mirrors can shift as they move across the sky. Experience will determine how much you can trust your equipment.

This is where a precise mechanical readout of a telescope's focus position can be handy. But with piggybacked camera lenses, there's little recourse but to be patient and exacting. For example, the Hutech-modified Canon 5D I use, while superb for wide-angle astrophotography, is a challenge to focus. The 5D has taught me that taking the time to shoot trial-and-error test frames, while tedious, is worth it. Without the extra effort, I find that piggybacked shots can be filled with slightly bloated stars, or with sharp but magenta-tinted stars. Be sure to mark the focus position on the lens afterwards. This will speed up the focusing process next time out.

UPGRADE TO DUAL-SPEED FOCUSING

Available as upgrades on some telescopes and now standard on most models designed for imaging, a dual-speed focuser is essential for making fine-focus adjustments, either manually or electrically.

Method #3: Computer-Aided Focusing

I have to admit, in the interest of keeping things simple at the telescope I rarely resort to this next level of complexity. But it does work, as long as you don't mind setting up a laptop in the field next to your camera. The computer connects to the camera and fires its shutter; the camera then downloads its images to the computer, not to its internal memory card. The laptop's larger display makes it much easier to judge focus.

You can do all this using the control software that came with your camera. However, a better choice is to get one of the DSLR-control programs designed for astrophotography. Some are complete image-processing packages; others are just for focusing and capture. All have focus routines that keep snapping the shutter and downloading, but not saving, images, while displaying graphic or numeric readouts to help you find focus, both by eye and by the numbers. Routines that sample just the area surrounding a bright star speed up the download time. Many choices exist, so always check that the software you choose works with your brand and model of camera.

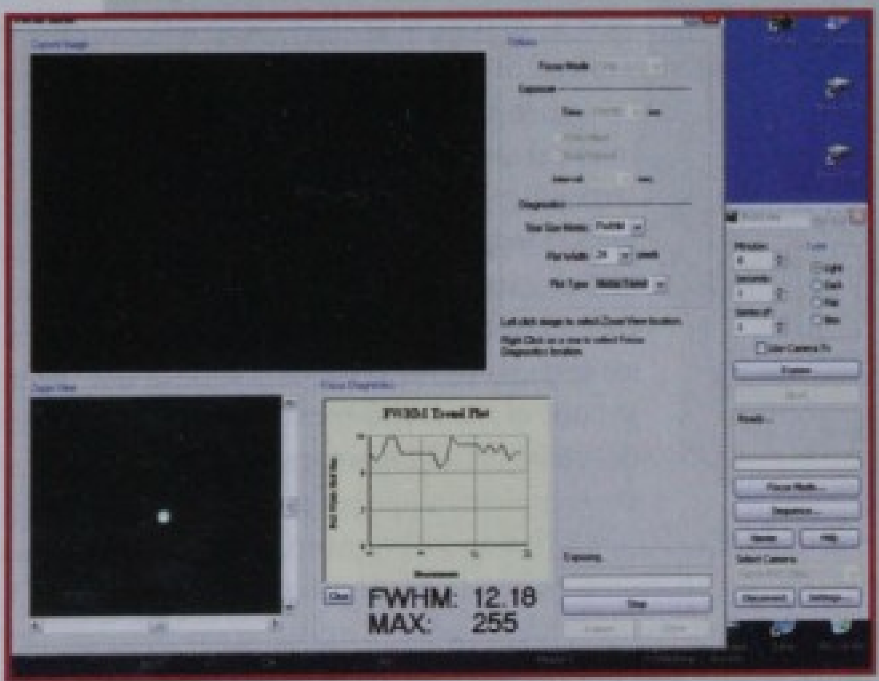
With any of these control programs, connecting a DSLR to the computer requires the USB cable that came with your camera, as well as the installation of your camera's utility software and drivers. Keep in mind that, even with a computer controlling the camera's shutter, you still must focus manually, performing careful tweaks while looking at the star image and graphic displays on the laptop screen.

However, an added benefit of some programs is that they can control robotic focusers simultaneously via a feedback loop — autofocus for your telescope. This might be a great system to install on a dedicated setup in a permanent observatory. For me it's impractical. I often shoot in the field, using at least a half dozen lenses and one of many telescopes. Also, while this might seem like the best method, I find that variations in atmospheric seeing make the readout numbers jump up and down even without changing focus. That annoyance, and the several-second delay from one image to the next, makes it hard to judge when the focus has truly peaked. Patience is still required.

CHECK THE CAMERA

Slide-in camera adapters can become slightly skewed, causing the sensor chip to be angled to the light path. If stars look fuzzy or distorted on just one side of the frame, a tilted camera could be the culprit.

Some focusing programs offer not only a display of the magnified star image but also large easy-to-read numeric readouts. *DslrStar* from Cercis Astro can also display a trend plot that makes it easier to tell if your camera's focus is getting better or worse.



Software Solutions

There are lots of options for controlling your DSLR with a computer, and many have free demos available. Unless stated otherwise, all those listed here are for Windows only.

Astroart **(www.msb-astroart.com)**
Works with Canon, Meade DSI, and many webcams

DSLRFocus **(www.dslrfocus.com)**
Update pending for post-2005 camera models

DslrStar **and** ***DslrLite*** **(www.cercisastro.com)**
Works with Canon and Nikon; offers stand-alone controller

ImagesPlus **(www.mlunsold.com)**
Works with Canon and Nikon for focus and capture

MaxDSLR **(www.cyanogen.com)**
Works with Canon, Nikon, Meade DSI, and many webcams

Nebulosity **(www.stark-labs.com)**
Low-cost, for Canon only; available for Mac OS

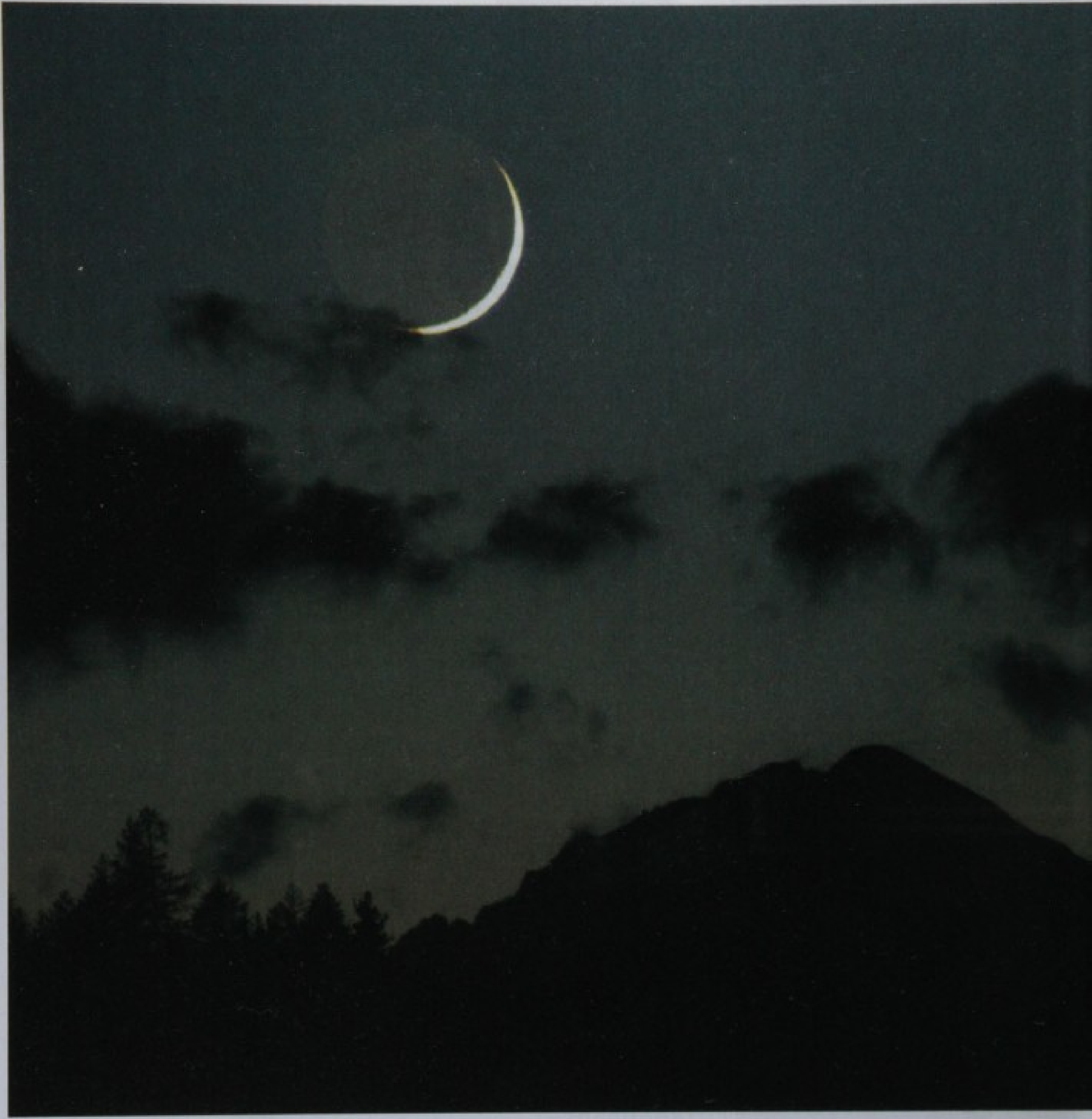
Method #4: Live Focus

If you're one of the lucky owners of a Canon EOS 20Da, you're laughing at all this fuss and bother! This camera's live-focus mode makes it easy to nail focus. Place a bright star in the center of the frame and then set the shutter to FC2 mode. Open the shutter, and a real-time, 10× magnified view of the star appears on the rear LCD screen, making it a snap to focus precisely, as quickly as if you were looking through an eyepiece — no waiting between test shots! It works with any lens or telescope, and you can feed the live image via the camera's Video Out jack to a TV monitor should you need to see the focus image more clearly. Live focus is one of the great advantages of the now-discontinued 20Da, a limited-edition DSLR that Canon made specifically for astrophotography.

However, live focus is now becoming a standard feature on other Canon cameras, such as their new 10-megapixel 40D and high-end 1D and 1Ds models. Nikon has also added live focus to their new D3 and D300 cameras, while Fuji and Olympus have long offered "live view" modes on their top-end DSLRs. This is all good news for astrophotographers. Bravo!

So unless you're lucky enough to own a Canon 20Da or are in the market for a new digital SLR, I recommend perfecting some of the other techniques as the best way to ensure your own photo attempts stay sharply focused. ✦

Contributing editor ***Alan Dyer*** *tries to stay focused when shooting the sky from home in rural Alberta, Canada, or from southern-sky sites in Australia.*




April 30
May 15
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◂ **EARTHSHINE OVER THE TETON RANGE**

Tom Fleming

The Teton mountains in Wyoming were Texas amateur Tom Fleming's inspiration as he captured this scenic vista with the 2-day-old Moon (its night side reflecting earthlight) sinking toward Grand Teton peak.

Details: *Snapshot recorded the evening of June 16, 2007.*

Each month Gallery showcases the finest astronomical images submitted to us by our readers. We encourage you to send your very best shots to gallery@SkyandTelescope.com; if we publish any here, we'll pay you $50. For more information, see our Astro Imager's Guide at SkyandTelescope .com/aboutsky/guidelines. Not all submissions can be published.

▾ **NEBULOUS NEIGHBOR**

Dean Salman

Sharpless 2-9, a wonderful mix of emission and reflection nebulosity, surrounds the 3rd-magnitude double star Sigma Scorpii. At lower left, roughly 1° to its southeast, lies the impressive globular cluster Messier 4.

Details: *Takahashi Epsilon 180 f/2.8 astrograph and SBIG ST-10XME CCD camera. Total exposure 8 hours 51 minutes.*

◂ **VENUS CLOSING IN**

Rick Schrantz

As noted last month on page 96, our sister world was an irresistible afternoon target for observers in mid-2007, as this stunning series of photographs demonstrates.

Details: *10-inch Newtonian reflector and modified Philips ToUcam Pro webcam with Schuler ultraviolet filter.*

▸ **CLOUD FRONT**

Bruce Karbal

Known for decades as the California Nebula, NGC 1499 appears to billow serenely among the stars of Perseus about 12° north of the Pleiades star cluster, M45 (not shown). Deep CCD images such as this one raise questions as to the origin of the nebula's nickname.

Details: *Pentax 125-mm f/6.4 refractor, FLI Proline 16803 CCD camera, and Astrodon hydrogen-alpha filter. Exposure time 90 minutes.*

◂ **COMET LINEAR BRUSHES PAST M3**

Michael Jäger and Gerald Rhemann

Comets often arrive unannounced, as was the case with Comet LINEAR (C/2006 VZ13). Carbon-rich gas gives the coma its aquamarine glow. Though not a bright object, this interloper was easy to find when it passed within ⅓° of the globular cluster Messier 3 in Canes Venatici, just north of the Boötes border.

Details: *Astro Systeme Austria 8-inch f/2.75 astrograph and Sigma 6303E CCD camera. Total exposure 15 minutes on July 22, 2007.* ✦

For sky-shooting tips, visit SkyandTelescope.com/howto/astrophotography

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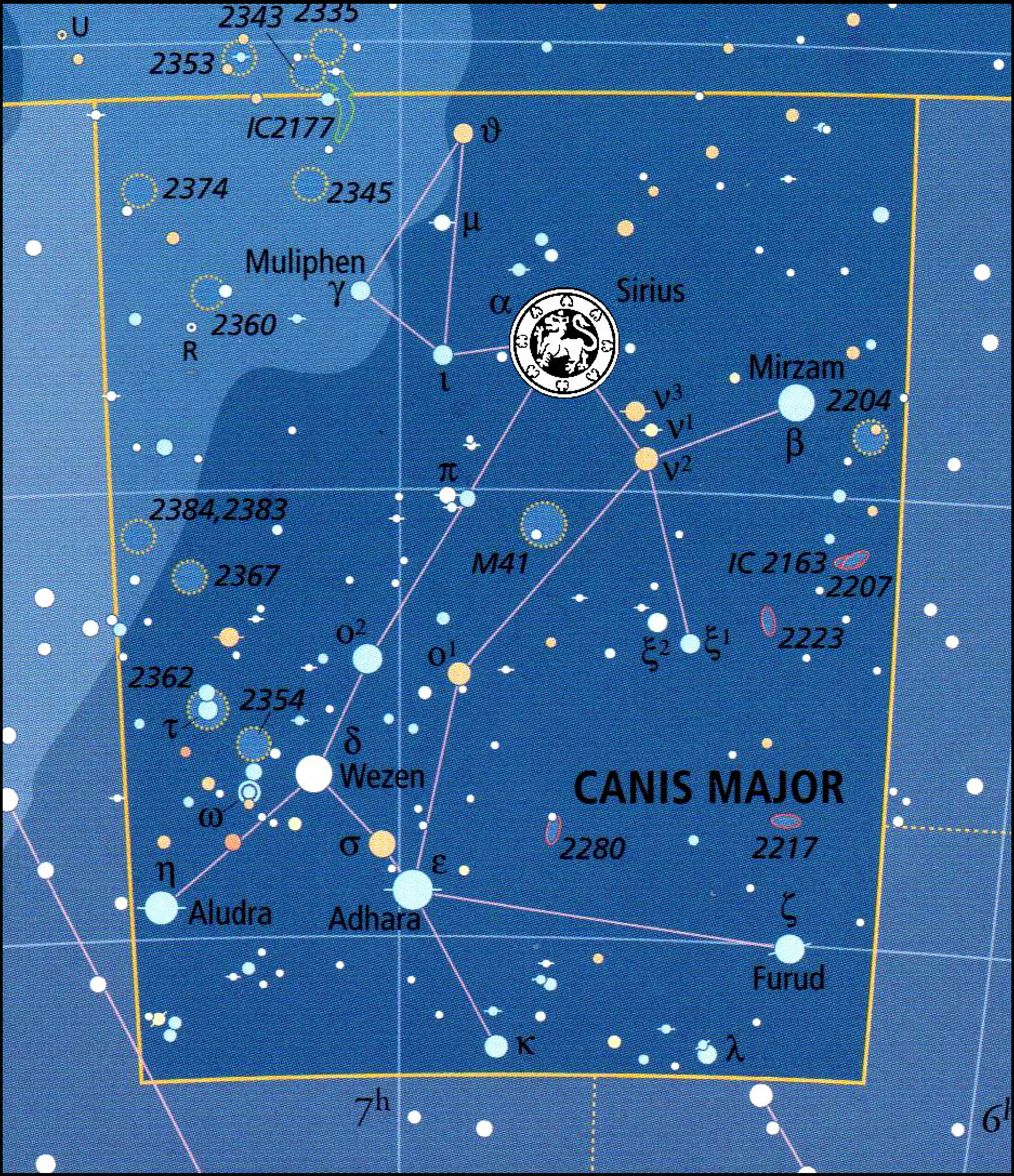

STARHOME