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THE ESSENTIAL GUIDE TO ASTRONOMY

SKY & TELESCOPE

NOVEMBER 2016

ANNIVERSARY ISSUE

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November 2016 VOL. 132, NO. 5

On the cover:
With this issue, *S&T* celebrates 75 years of service to the astronomical community.

COVER: PATRICIA GILLIS-COPPOLA

COVER STORIES

FEATURES

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OBSERVING NOVEMBER

S&T TEST REPORT

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SKY & TELESCOPE

November 2016 Digital Extra

BONUS WEB CONTENT

- **Mars Rover Update**
  Read the full online article on the latest milestone of the Mars 2020 rover.
- **New All-Sky Meteor Network**
  Find out more about how the innovative FRIPON network will engages pros and the public in the hunt for space rocks.
- **Using Sky Charts**
  Learn how to use a star map at your telescope and find your way to the deep sky.

Photo Gallery

Image by Kevin Morefield

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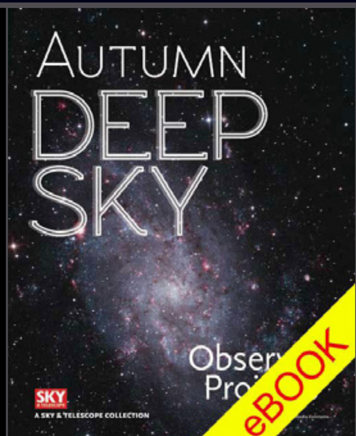

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August, September, and October

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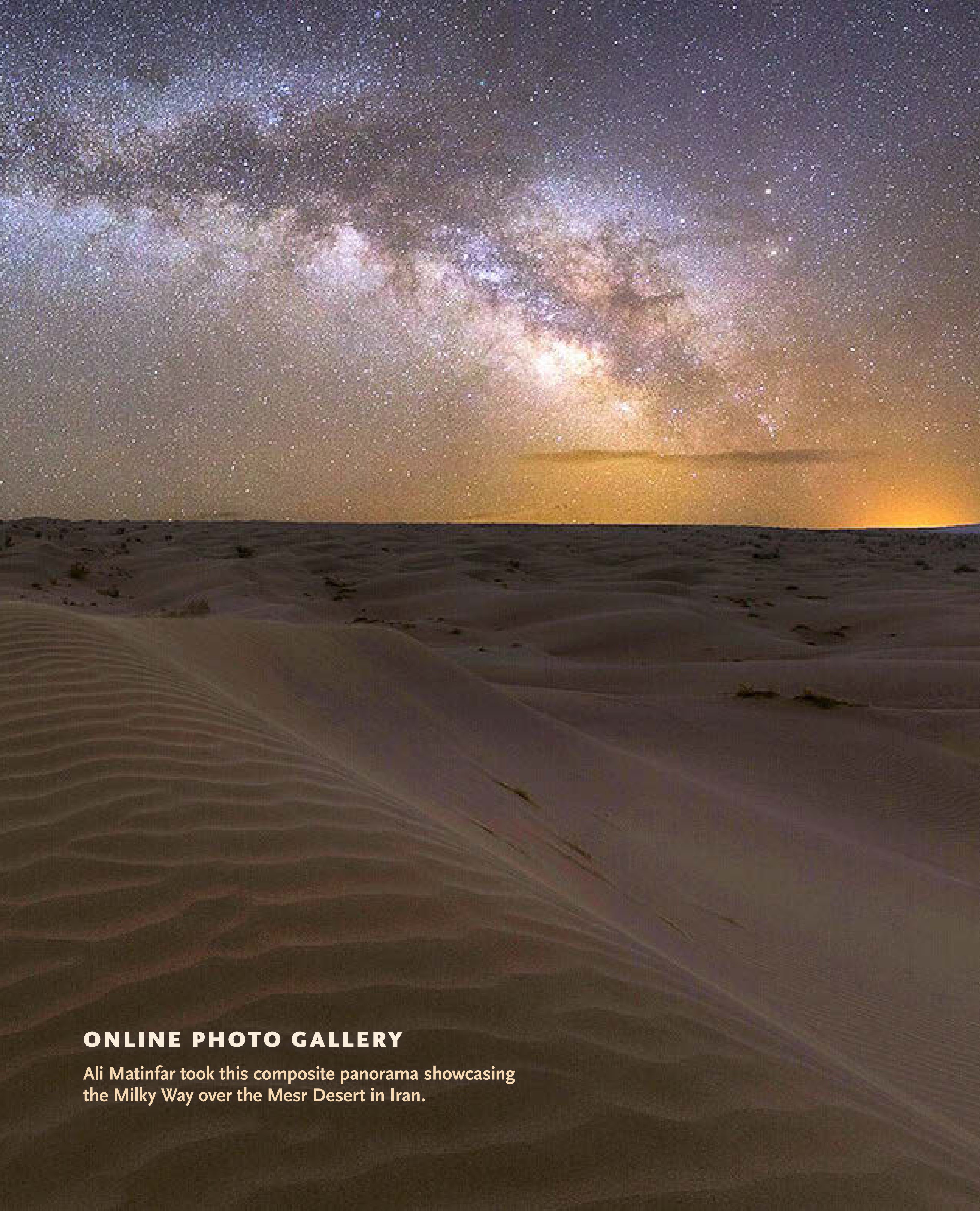

ONLINE PHOTO GALLERY

Ali Matinfar took this composite panorama showcasing the Milky Way over the Mesr Desert in Iran.

Larger Than Life

ONE OF THE FIRST THINGS I noticed about the staff of *Sky & Telescope* upon arriving two years ago was the lack of pretension. Many of my new colleagues had devoted years, in some cases decades, to the magazine. Surely these deeply experienced pros had earned the right to at least some mild chest-thumping. But no. To a man or woman, the editors, designers, and advertising folks here are self-effacing.

What accounts for this? Perhaps it's that this quality has been a hallmark of *Sky & Telescope* since its founding in 1941. Charlie and Helen Federer, when they merged *The Sky* and *The Telescope* three-quarters of a century ago this month, weren't in it for the glory, nor certainly for the money or the lavish offices. They launched *S&T* while barely earning a living wage, and this publication's first headquarters was an alcove beneath stairs at the Harvard College Observatory that has been likened to a cubbyhole.

As the magazine's only staffers in the first years, the Federers had to turn to their *children* for help. "We were often called upon to read the original copy aloud, learning to state all the punctuation marks, so that our parents could mark corrections," their kids Barbara and Tony recalled (*S&T*: Nov. 2011, p. 19). For special mailings, these small-statured faux employees remember "licking envelopes and stamps by the hundreds. . . ."

In 1956, realizing the rapidly growing staff would soon need significantly more space, Charlie bought a piece of land about a mile from the Observatory. He wasn't fussy: the property abutted the Cambridge city dump, where heaps of garbage smoldered day and night. By 1959, all of *S&T* had relocated to three buildings there along Bay State Road, none of them remotely approaching lavish. As Dennis di Cicco puts it in his brief history of *S&T* on page 22, "Opulence, it seems, wasn't a big concern."

What *was* a big concern were the intangibles. A devotion to the magazine and its mission. A focus on excellence. A conviction to always put the reader first. And, of course, a love of astronomy. (See Alan MacRobert's sprightly timeline of astronomical milestones we've covered in those seven and a half decades, on page 28.)

Our pioneer editor's aspirations remain ours today. We all feel enormously privileged to further his hopes for this highly respected fountainhead of popular astronomy magazines.

Now, this is not to say that *S&T* staffers are shrinking violets. Hardly. If you could be a fly on the wall at one of our weekly meetings, you'd quickly see how obstreperously they speak their minds whenever they see fit, which is pretty much all the time. In short, they're competent, self-assured, opinionated professionals — just the kind of people you'd want in charge as we begin, with this issue, what we hope will be the next 75 years of *Sky & Telescope*. ✦

Peter

Editor in Chief

SKY & TELESCOPE
Founded in 1941 by Charles A. Federer, Jr. and Helen Spence Federer
The Essential Guide to Astronomy

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BARBARA MEREDITH & C. ANTHONY FEDERER

S&T founders Charlie and Helen Federer, together with their children Tony (left) and "Bar," pose for a family portrait in March 1943 — 1½ years after the magazine's debut.

Celebrating 75 Years of *S&T*

As senior surviving member of its founding family, I want to congratulate the staff of *Sky & Telescope*, as well as all your predecessors, on keeping the magazine going for 75 years.

When my parents moved me (age 2½) and my sister (age 2 weeks!) from New York City to Cambridge, Massachusetts, in October 1941 (*S&T:* Nov. 2011, p. 18), any thought that I would be writing this letter was about as remote as the Andromeda Galaxy. Harlow Shapley had invited Dad and Mom to Harvard College Observatory to combine its magazine, *The Telescope*, with *The Sky*, which my parents had taken over two years earlier from Hayden Planetarium in New York City.

Dad later wrote, "The November 1941 issue of *S&T* was published in 10,000 copies, and after that I reduced the print order to 7,500." It has always been a wonder to me that they could move both the newly increased family and the magazine without missing an issue. It was truly a small family business in its early years. My sister and I helped out with proofreading both in our home and by kerosene lamps at our old farmhouse in New Hampshire, and we enjoyed driving around the country with our parents to meetings of the American Astronomical Society and Astronomical League as well as two trips to Europe for the International Astronomical Union.

I still read most of every issue. Keep up the great work for another 75.

Charles Anthony (Tony) Federer III
Falmouth, Maine

May I, as the junior member of the family, add my congratulations to those expressed by Tony. I, too, scan every issue with interest, although, as the non-scientist of the two Federer children, I particularly look for and enjoy the pieces which link arts or history with astronomy. My best wishes to you all.

Barbara (Federer) Meredith
Manchester, England

The Nearest *Northern* Star?

The nearest star to our solar system is Alpha Centauri (and specifically its faint third component, Proxima). However, for those of us who live in Earth's mid-northern latitudes, we can't see that far south in our night sky. So what's the nearest star that can be seen from a latitude of, say, 40° north?

Mark A. Bradbury
Greenwood, Indiana

Alan MacRobert replies: *According to the 2016* RASC Observer's Handbook, *it's 9.6-magnitude Barnard's Star, located at right ascension 17^h 58^m, declination +4° 42′. With a distance of 5.98 light-years, it just beats out WISE 1049-5319, a much-dimmer brown dwarf binary. The nearest bright star is Sirius, 8.58 light-years away.*

Tracing the "Teapot"

I read Fred Schaaf's columns every month and enjoy them all. In "The Seal of the Sky" (*S&T:* June 2016, p. 45), he comments that the Summer Triangle asterism wasn't popularized until a little more than 50 years ago and that the famous Teapot asterism of Sagittarius is even younger.

My dad was a navigator in the Army Air Corps during World War II. When he taught me to find my way around the stars, probably starting before I was 10, he pointed out both the Teapot and the Summer Triangle because that's the way he learned them in nav school.

Granted, the general public might have started using these names later, but both asterisms have been around for at least 75 years.

Phil Petersen
League City, Texas

Colors in the Trifid Nebula

I enjoyed Howard Banich's column about the Trifid Nebula (*S&T:* June 2016, p. 57) and took particular interest in his description of the subtle colors he occasionally observes. It reminded me of my own observations of the Trifid in 2010 and 2011 under the crystal clear and inky black skies of the Atacama Desert in Chile. Observing with an 18-inch Dobsonian reflector, I was able to easily see the contrasting pink and blue colors depicted

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Please limit your comments to 250 words.

in every photograph. It was a remarkable view, and one that I shared with (and had confirmed by) my fellow observers.

Aaron Dittrich
Cochrane, Alberta

Why Does Ammonia Float?

In reading Fran Bagenal's beautifully written account of Juno's imminent arrival at Jupiter (*S&T:* July 2016, p. 18), I noticed something that prompts a question. How is it that clouds of such heavy molecules as NH_3 (ammonia) and NH_4SH (ammonium hydrosulfide) can float above an atmosphere composed of extremely light H_2 molecules?

Our planet's air is composed mainly of O_2 and N_2, so it makes sense that its clouds of lower-mass water vapor (H_2O) should float in it, as they do. Yet the opposite seems to be the case at Jupiter. So what's the story?

Jim Baughman
West Hollywood, California

Fran Bagenal responds: *Jupiter's atmospheric gas is primarily hydrogen, along with small amounts of water, ammonia, methane, and other compounds. Deep down these gases are pretty well mixed. However, as you go up in an atmosphere the temperature decreases, and at some point the temperature drops below the condensation temperature of a component. (That's why water clouds form over Earth.)*

At Jupiter, the water condenses out at lower levels where it's warmer. Above this cloud deck of water, as the atmosphere continues to cool down, the ammonia hydrosulphate vapor condenses out. Then higher up (and colder) the gaseous ammonia condenses out. These are all tiny aerosol droplets or ice crystals kept aloft by atmospheric motion.

Were they to collect into very large masses, then, yes, they would precipitate downward — just as, again on Earth, rain falls once the water droplets get too big to stay buoyed by air currents.

Probing the Unknowns

Peter Tyson's reflective "To the Unknowable" (*S&T:* July 2016, p. 4) reminds us that, without eschewing rigor or even a temperate pride in humanity's achievement, intellectual humility nonetheless remains a requisite for full contemplation upon the sublime and ultimate unfathomability of our cosmos.

James Tracy
East Greenwich, Rhode Island

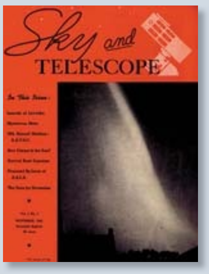
Visiting Mars: No Rush Needed

Here's one more reason why we should go slowly before sending humans to Mars (*S&T:* June 2016, p. 84). Any human presence there will inevitably leave behind some biological footprints, defying the very reason for our fascination with the Red Planet: the prospect — slim as it might be — of finding evidence of ancient life there. So I say, let's go slow!

Eli Maor
Morton Grove, Illinois

75, 50 & 25 Years Ago

Roger W. Sinnott



November 1941

Vol. 1, No. 1 "Once again we start on a new venture. This time, however, it is really a synthesis of many existing projects and agencies. It is expected that *Sky and Telescope* will endure for many years to come, and play an important part in the development of the layman's interest in astronomy.

"We wish to call attention to the pictures and letters on page 13. Scientists are still active abroad, in spite of the hardships which they must endure — they merit all the support we can give them."

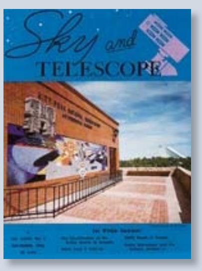
Charles and Helen Federer mustered little fanfare for their first editorial in the new magazine. Europe had been in chaos more than two years, and America's entry into World War II was just a month away.

November 1966

On the Moon "The successful soft landing on the moon by the Soviet Union's Luna-9 spacecraft on February 3, 1966, enabled earthmen for the first time to see millimeter-sized details of the lunar surface. [The soft landing itself was] carried out for the first time in the history of cosmonautics. . . .

"That the top layer of lunar soil must be very porous has been known for some time [because] brightnesses of lunar features increase to sharp maxima near full moon, indicating considerable small-scale shadowing at other times. Calculations and laboratory experiments had shown that this shadow effect was well simulated by a structure of randomly oriented fibers . . . and also by a 'fairy castle' structure.

"It had been conjectured that very fine dust from meteoric impacts on the moon could produce fairy castles, since in the lunar vacuum the particles could fuse together at their points of contact to form fluffy configurations of very low density. . . . In the transmitted pictures, there are no fine-fibered structures, no fairy castles, no heaps of angular fragments, sand or loose dust [that] many authors had supposed to form the moon's microrelief. . . ."

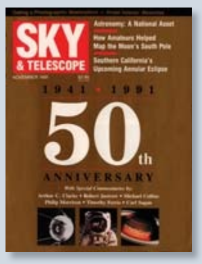


Cold War rivalries and the space race didn't stop Yuri N. Lipsky (Sternberg State Astronomical Institute, Moscow) from excitedly sharing with S&T *readers mankind's first close-up glimpses of another world.*

November 1991

Starry Vista "Astronauts always return to Earth gushing superlatives about their views of our planet from space. But they have said comparatively little about the appearance of the night sky from orbit. So *Sky & Telescope* queried astronaut Jay Apt about the stargazing he did last April during his first trip aboard the Space Shuttle. . . . 'I did not need to be as well dark adapted in space as on the ground to see the Magellanic Clouds'. . . .

"As he picked out familiar constellations, using the Milky Way itself as a guidepost, Apt noticed one thing right away: 'I was able to see more stars with color.' He attributes this to the complete absence of atmospheric blurring, which allowed starlight to concentrate very effectively onto his eyes' color receptors. . . .



"When asked for the most interesting astronomical phenomenon he saw from space, Apt answered: 'To see a meteor burn up below you is pretty neat!'"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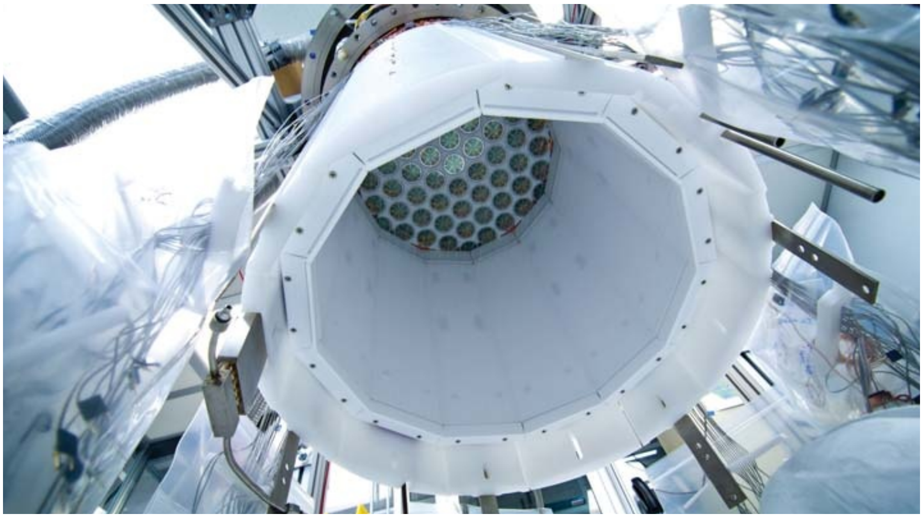
DARK MATTER | No WIMPs from LUX



C. H. FAHAM / CC BY-NC-ND 2.0

This construction shot of LUX shows the cylinder later to be filled with liquid xenon. At the tank's far end, photomultiplier tubes are visible. Similar tubes were placed on the bottom.

Scientists working with the Large Underground Xenon (LUX) experiment have come up empty-handed in their search for *weakly interacting massive particles* (WIMPs). WIMPs are the top candidate for the invisible stuff that makes up about 84% of the universe's matter (*S&T:* Jan. 2013, p. 26).

Astronomers know that dark matter interacts with gravity but not with light or the strong force that holds nuclei together. But WIMP theory posits that dark particles should also interact via the weak force, which governs nature on a subatomic level, including fusion within the Sun. So a WIMP particle should very rarely smash into a heavy nucleus, generating a flash of light.

To detect this flash, scientists built LUX, a 3-foot-tall, dodecagonal cylinder of liquid xenon. It lies more than a mile underground in South Dakota's Homestake Mine. Down there, the 122 photomultiplier tubes at the container's top and bottom await the glitter of light that would signal an elusive dark particle shooting through the cylinder and interacting with one of the xenon atoms.

But after more than a year of collecting data, the LUX team announced July 21st at the Identification of Dark Matter 2016 conference that they've still found nothing. Simply put: either WIMPs don't exist at all, or the WIMPs that do exist really, really don't like interacting with normal matter.

Other experiments (such as CDMS II, CoGeNT, and CRESST) have found glimmers of WIMP detections, but none of these are statistically significant enough to be claimed as a real detection. The LUX results have been helpful in ruling out those hints of low-mass WIMPs.

"It turns out there is no experiment we can think of so far that can eliminate the WIMP hypothesis entirely," says LUX member Dan McKinsey (University of California, Berkeley). "But if we don't detect WIMPs with the experiments planned in the next 15 years or so . . . physicists will likely conclude that dark matter isn't made of WIMPs."

■ **MONICA YOUNG**

KUIPER BELT | Big, New, Far-out Object

A distant discovery announced on July 11th has created heightened interest among Kuiper Belt cognoscenti. Designated 2015 RR_{245}, it's some 64 astronomical units (9½ billion km) from the Sun, more than twice Neptune's distance. Despite appearing just 22nd magnitude, it could be as large as 700 km (450 miles) across.

Observer JJ Kavelaars (National Research Council of Canada) first spotted it on September 9, 2015, using the Canada-France-Hawai'i Telescope atop Mauna Kea as part of a large search effort called the Outer Solar System Origins Survey (OSSOS).

But it wasn't until Michele Bannister (University of Victoria, Canada) and others took follow-up images in February 2016 and again in June that the orbit of 2015 RR_{245} could be calculated with any certainty. Its mean solar distance (81.4 a.u.) and large orbital eccentricity (0.59) carries the object from Neptune's vicinity out to 129 a.u. (19.3 billion km). One trip around the Sun takes about 735 years. Dynamicists already suspect that the new find might be in an orbital resonance with Neptune.

The large estimated size is based on the object's distance and assumed brightness. For example, the 700-km diameter corresponds to having a surface that's 10% reflective, typical of Kuiper Belt objects. But if it's partly ice-covered and 25% reflective overall, then the corresponding diameter drops to about 450 km.

Size does matter, at least when considering whether 2015 RR_{245} qualifies as a dwarf planet. To date the International Astronomical Union has named only five objects as dwarf planets: Ceres, Pluto, Eris, Makemake, and Haumea. Yet the IAU's main criterion for dwarf planethood — that a body have enough mass to be round — suggests that dozens more objects would qualify on the basis that they're likely massive enough to be spheres. If 2015 RR_{245} really is 700 km across, then it's highly likely to qualify as a dwarf planet.

■ **J. KELLY BEATTY**

METEORITES | FRIPON: A New All-Sky Network

A French network of all-sky sentinels intends to speed up determination of meteorites' trajectories and landing sites.

The innovative Fireball Recovery and Interplanetary Observation Network (FRIPON) is a collaboration between the Observatory of Paris, National Center of Scientific Research (CNRS), University of Paris-South, French National Museum of Natural History, and Aix-Marseille University. The network of 100 cameras and 25 radio receivers provides continuous all-sky coverage over all of France.

Researchers estimate that 10 meteorites fall in the country every year, but a meteor sighting followed by a subsequent recovery has been a once-a-decade affair. With FRIPON, researchers will catch a meteorite's fall from various angles and from known coordinates, enabling them to quickly and accurately determine the location of a possible *strewnfield* for an organized search campaign. The goal is to accomplish a ground recovery within 24 hours, before space rocks become heavily contaminated. An accurate trajectory might also help reveal the object's source.

Researchers hope to expand FRIPON into other European countries. Other networks include those in the UK and Spain, and NASA researchers maintain two in the United States. Read more about FRIPON at **https://is.gd/fripon**.

■ **DAVID DICKINSON**

BLACK HOLES | Clouds Rain Down

Astronomers have detected three cold gas clumps falling toward a galaxy's center — at odds with the prevailing idea for how black holes get their food.

Scientists have long assumed that a galaxy's central black hole eats from a steady-stream buffet of hot gas impinging on it from all sides. But there's growing reason to think this notion is wrong. Instead, the hot gas a galaxy sits in should — under the right conditions — cool and form clumps, which then rain down into the galactic center and feed the black hole. The difference matters, because it might dramatically change the effect a black hole has on its galaxy.

Last March, astronomers confirmed that the threshold conditions for this clumping and raining exists in a range of galaxy clusters. Now, Grant Tremblay (Yale) and colleagues report the first detection of cold clouds falling toward the central black hole in the brightest big elliptical of the cluster Abell 2597. As detailed in the June 9th *Nature*, the team didn't detect the clouds directly; rather, they show up in ALMA data as "shadows," places where cold gas soaked up the light from the hole's brilliant jet. Each clump is probably tens of light-years across. Although the observations don't reveal whether the clouds are orbiting the black hole or just plunging toward it, the team can tell that they are falling in at about 300 km/s (670,000 mph) and that they're within 300 light-years of the black hole.

These results are "entirely inconsistent" with the longstanding hot-accretion scenario for black hole growth, Tremblay explains. "If these 'rainstorms' exist in more galaxies, we may need to seriously rethink how we model black hole accretion," he says.

■ **CAMILLE M. CARLISLE**

NRAO / AUI / NSF, DANA BERRY / SKYWORKS

This artist's concept depicts clouds of cold molecular gas condensing around the brightest galaxy in the cluster Abell 2597. The clouds condense out of the hot, ionized gas that suffuses the cluster. New ALMA data reveal three such clouds raining in on the galaxy, plunging toward the central supermassive black hole.

SCOPES | Spy Dish Restored for Education

Students at the Pisgah Astronomical Research Institute (PARI) now have a new radio telescope to use for exploring the cosmos. The North Carolina facility began in 1962 as a NASA satellite tracking station and then was handed over to the Department of Defense, which installed a 12-meter-wide radio antenna to collect classified data during the Cold War. For 15 years, the big dish operated mysteriously under a large dome.

PARI took possession of the site in 1999 and has since transformed the sprawling complex into an education center (*S&T:* Sept. 2013, p. 36). The staff found the 12-m antenna dead — a lightning strike had destroyed its control processor. Needing new motors and drives, the big dish languished until 2012, when funding became available for renovations.

With the help of various contributors and volunteers, including students, PARI staff removed the aging dome, installed new hardware, cleaned the entire instrument, and created software to allow users to operate the telescope remotely. Now fully operational after lying dormant for 25 years, the restored telescope captures photons emanating from hydrogen atoms at a frequency of 1420 megahertz (21 cm in wavelength).

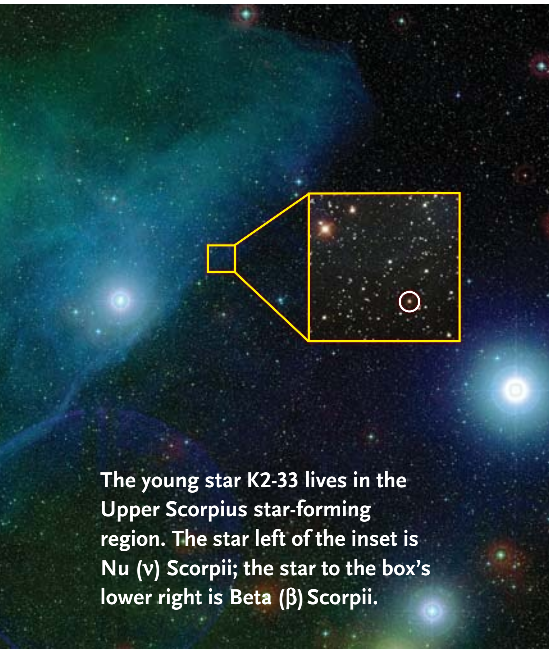
This summer, Duke University students used the telescope as a one-of-a-kind teaching tool. Then, in the fall, PARI plans to make the instrument available to students around the world to remotely examine star formation, stellar nurseries, and the motion of stars with respect to Earth, among other projects.

■ **ANA V. ACEVES**

EXOPLANETS | Newborns Point to Early Chaos

The discovery of several infant worlds by four independent teams suggests early chaos helps shape planetary systems.

In their first years, planets shift orbits and even trade places. Nowhere is this migration more certain than in cases involving hot Jupiters and hot Neptunes: these gas giants would have a hard time forming so close to their stars, because stellar winds would strip their atmospheres away. They probably form much farther out and then migrate inward.



The young star K2-33 lives in the Upper Scorpius star-forming region. The star left of the inset is Nu (ν) Scorpii; the star to the box's lower right is Beta (β) Scorpii.

A. MANN / MCDONALD OBSERVATORY; BACKGROUND: DIGITIZED SKY SURVEY; INSET: SLOAN DIGITAL SKY SURVEY

The only way a planet can change its orbit is to transfer angular velocity to another body via gravitational interactions. But the nature of that other body is debated: suggestions have included planet-planet scattering, interplay with a second star, or interactions with the primordial gas disk that the planet coalesced in.

While the first two mechanisms probably take more than 100 million years, the latter happens quickly, within a couple million years. So researchers set off in search of big, young planets circling close around young stars in order to test the disk theory.

The first of the recent successes is Kepler-223, a 6-billion-year-old Sun-like star that hosts four super-Neptunes, each one seen in transit across the face of the star. Sean Mills (University of Chicago) and colleagues show in the May 26th *Nature* that the planets circle their star in *resonant orbits*, that is, orbits whose periods are multiples of one another. Such a configuration is difficult to explain unless the planets migrated to their current positions by disk interactions.

Soon after in June, two independent teams announced the discovery of planet K2-33b. The super-Neptune orbits its red dwarf star every 5.4 days, at a distance of only 0.04 astronomical unit, or one-tenth that of Mercury's distance from the Sun. What makes the discovery noteworthy is that the star K2-33 is only 10 million years old. There are two ways the super-Neptune could have arrived at its current orbit in so short a time: either it formed where it is now (unlikely, but possible) or it migrated there by interacting gravitationally with the primordial gas disk.

A team led by Trevor David (Caltech) announced K2-33b's discovery June 20th in *Nature*, while Andrew Mann (University of Texas, Austin) and colleagues report their independent observations from the MEarth Project in an upcoming *Astronomical Journal*.

Meanwhile, Jean-François Donati (University of Toulouse, France) and colleagues announced another discovery, also published in the June 30th *Nature*: a hot Jupiter orbiting a stellar infant, the 2-million-year-old V830 Tauri. This second close-in gas giant around an even younger star strengthens the case for migration through the disk.

■ **MONICA YOUNG**

IN BRIEF

Mars 2020 Rover Moves Ahead. In mid-July NASA managers announced that they will proceed with the final design and construction of the Mars 2020 rover. Set to launch in the summer of 2020, the as-yet unnamed rover will explicitly look for signs of life, past and present. It will carry a suite of instruments from institutions in the U.S., France, Spain, and Norway, including one that will produce oxygen from atmospheric carbon dioxide as a testbed for future human explorers. The rover will also carry microphones and cache soil samples for a later potential sample-return mission. Modeled after Curiosity, the vehicle will weigh in at about 1,050 kilograms, the heaviest payload fielded on any planetary surface yet. Read more about the rover at https://is.gd/mars2020phasec.

■ **DAVID DICKINSON**

K2 Confirms 100+ Exoplanets. In 2014, NASA's Kepler spacecraft entered a second life as K2, searching for exoplanets and other phenomena across a broader swath of sky. Ian Crossfield (University of Arizona) and colleagues now report 197 planet candidates from K2, 104 of which they've confirmed to be real planets. The worlds range between 20% and 50% times larger than Earth. Among the discoveries is a system of four, potentially rocky planets orbiting the *M* dwarf star K2-72, 181 light-years away in Aquarius. Astronomers expect K2 will discover between 500 and 1,000 planets in its planned three- to four-year mission. Details of the discoveries appear in an upcoming *Astrophysical Journal Supplement*.

■ **ANA V. ACEVES**

NASA Explores Next Mars Orbiter. On July 18th NASA announced its selection of five U.S. aerospace companies to compete in a four-month concept study to develop its next Mars orbiter. The agency has a fleet of aging spacecraft circling the Red Planet, including Mars Odyssey, which has been there for 15 years. In addition to conducting research, the future orbiter would provide essential communications relays between craft on the Martian surface and Earth.

■ **DAVID DICKINSON**

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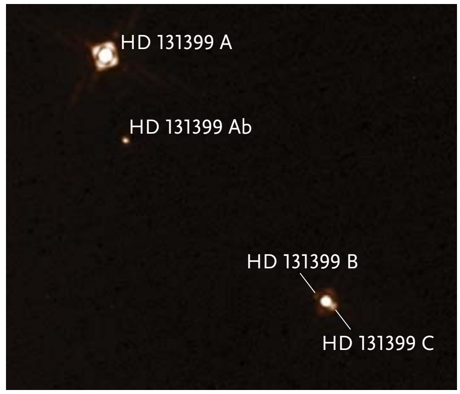
EXOPLANETS | Giant Found in Triple-Star System

Astronomers have discovered a giant planet with an exceptionally wide orbit in the young, triple-star system HD 131399. Kevin Wagner (University of Arizona) and others report the discovery July 7th in the journal *Science*.

The planet, HD 131399 Ab, appears to orbit the brightest star of the bunch, HD 131399 A, which is roughly 10 times brighter than the Sun. The team didn't pin down the planet's path but estimate that the world is about 82 astronomical units from the star and could complete an orbit in 400 to 700 years. Because so little is known about the system's configuration, it's unclear whether HD 131399 Ab's wide orbit is stable.

Astronomers have found about a half dozen worlds in triple-star systems. What's interesting about HD 131399 Ab is that it has the widest orbit of any planet in a multiple-star family. In fact, it lies a fair fraction of the way to the pair of much smaller, yellower stars that whirl around the primary at a distance of about 300 a.u.

The researchers directly imaged the exoplanet, a technique used rarely because it's hard to see a planet hidden in the brilliant glare of its host star: HD 131399 Ab is only 1/100,000 as bright as star A. But because the system is only 16 million years old, the planet is still glowing with the heat of its formation. The team used the glow to estimate the world's mass at about four times that of Jupiter. Spectra reveal methane and water in the exoplanet's atmosphere, as expected for such objects.



ESO / K. WAGNER ET AL.

This composite image shows the newly discovered exoplanet HD 131399 Ab in the triple-star system HD 131399. The image combines two: one of the planet (which in reality is 1/100,000 as bright as star A) and a second of the stars. The SPHERE imager on the ESO Very Large Telescope in Chile took the images.

Astronomers haven't spent much time looking for exoplanets around binary stars because they're so hard to detect. But multiple-star systems are about as common as single stars, so we need to know how often planets can form in these environments to really understand planet formation.

■ **CAMILLE M. CARLISLE**

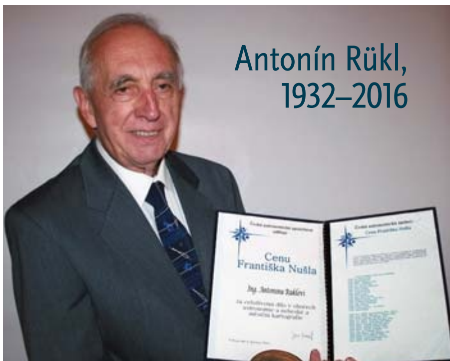
EXOPLANETS
Giant Planets Out of Sync

Sometimes planets "bump" each other into wonky orbits. Sean Mills and Daniel Fabrycky (both University of Chicago) think that happened to the two Saturn-mass objects orbiting the star Kepler-108. Their orbits are tilted 15° with respect to each other. That's unusual, given that planets are supposed to all form together in a thin disk around their star. As a comparison, planet orbits in our solar system tilt within 7° of the ecliptic.

After planets form, they feel gravitational forces from the star and from each other. These forces change as they move in their orbits. Over time their paths might cross, making them scatter into new, different orbits. That's what the team thinks happened to Kepler-108's planets, reported at the 228th American Astronomical Society Meeting in San Diego, California.

If more objects turn out to have non-coplanar orbits around their stars, then it'll be a new challenge to observe them and to figure out how that happened.

■ **ANA V. ACEVES**


VLADIMIR LIBY

Antonín Rükl, 1932–2016

The renowned lunar cartographer Antonín Rükl, whose beautiful atlases have become prized possessions, passed away on July 12th at his home in Prague, Czech Republic. He was 83.

Rükl's loss will be deeply felt by anyone who loves looking at the Moon. Among the many books he authored, his legendary *Atlas of the Moon*, originally published in 1991 and most recently revised in 2007, remains one of the most sought-after works of its kind.

Rükl was born in Čáslav, Czechoslovakia, on September 22, 1932. His keen interest in astronomy began as a student hobby when he was 17 years old. He graduated from Czech Technical University in 1956, after which he joined the school as a staff member and began working at the Prague Planetarium in February 1960. Rükl became head of the planetarium shortly after its establishment, holding that position until late 1999 when he semi-retired. Even then, Rükl continued to work on planetarium programs until his last days.

Besides a planetarium directors' conference in 1999 in Florida, Rükl's only visit to the U.S. was as the keynote speaker at the Atlanta Astronomy Club's Peach State Star Gaze in April 2000. Learning that the selenographer had no telescope of his own, a group of AAC members pitched in to surprise Rükl with his own Meade ETX at the event. It was also there that Rükl received a lifetime membership in the Association of Lunar & Planetary Observers (ALPO). Minor planet 15395 is named for this beloved lunar specialist.

Rükl impressed everyone with his humble and unpretentious demeanor. His wife, Sonja, passed away several years ago. They are survived by two children and four grandchildren. ✦

■ **KEN POSHEDLY**, *ALPO Editor in Chief*

Thank Our Lucky Planets

Human history has always been linked to the influence of distant orbits.

EVERY ASTRONOMER HAS had the annoying experience of being introduced as "an astrologer." We then have to explain that astronomy is the study of the universe beyond Earth, while astrology is the belief that this universe controls our lives. There's no good reason to hold that the position of the planets at your birth decided your personality or life path. But it *is* true that planetary motions have strongly influenced human history and nature.

For several million years, climate changes in Africa repeatedly shaped our evolution. In large part, these climate swings were forced by a complex series of rhythmic oscillations in Earth's orbit and spin — oscillations that stem largely from the perturbing gravitational influence of Jupiter, Saturn, and the Moon.

ISTOCKPHOTO / PETE DRAPER

Several evolutionary breakthroughs came about during such periods of extreme, modified climate. Upright posture, which freed up our inventive hands; a rapid increase in brain size; and the use of fire, allowing a meat diet that spurred further increase in brain size — scientists have linked all these to episodes of rapid climate alteration. These great leaps forward transformed us from just another species to one with the abilities that enabled the science and technology through which we've uncovered our own natural history.

Later we left Africa and peopled the world, our path set by climate-driven changes in sea level such as the one that opened up the Bering Strait land bridge to North America. Seven thousand years ago a phase of stable sea level coincided with the first large coastal settlements and the rise of complex societies. The origin of many sophisticated technologies and the symbolic language to pass them down also seem to have arisen in response to climate-caused survival threats.

Now, in a twist, some of our technology threatens the climate we depend on to survive. Astrology will not save us, but astronomy might. By widening our scope of knowledge and improving our modeling capabilities, planetary exploration is crucial for understanding climate and responding effectively to our current challenges.

Our exploration of the solar system owes its own path to fortuitous planetary positions. Every 175 years the outer planets arrange themselves perfectly for a "grand tour" mission that can ricochet from one gas giant to the next. One such rare alignment came in the 1970s, when we'd just barely developed the necessary technology to launch the pair of Voyager spacecraft. Another important lineup occurred soon after astronomers discovered Pluto's moon Charon in 1978 (no doubt causing astrologers to redo their charts).

It's lucky we found Charon when we did. Just two years later, the plane of its orbit lined up precisely with Earth to create a 5-year-long season of Pluto-Charon eclipses. This won't happen again for more than a century. More importantly, these events and subsequent studies, along with the puzzling nature of Neptune's moon Triton, seen in Voyager's final pass in 1989, helped motivate those who agitated for a dedicated Pluto mission, culminating in last year's historic flyby.

Maybe a species that has colonized its home world would have emerged on Earth even if the solar system didn't work the way it does. Once here, maybe we were bound to explore our neighboring worlds. But route and timing were dictated from above. The planets have indeed always ruled us. ✦

David Grinspoon *is an astrobiologist and senior scientist at the Planetary Science Institute. His book* Earth in Human Hands *is due out next month. Follow him on Twitter at @DrFunkySpoon.*

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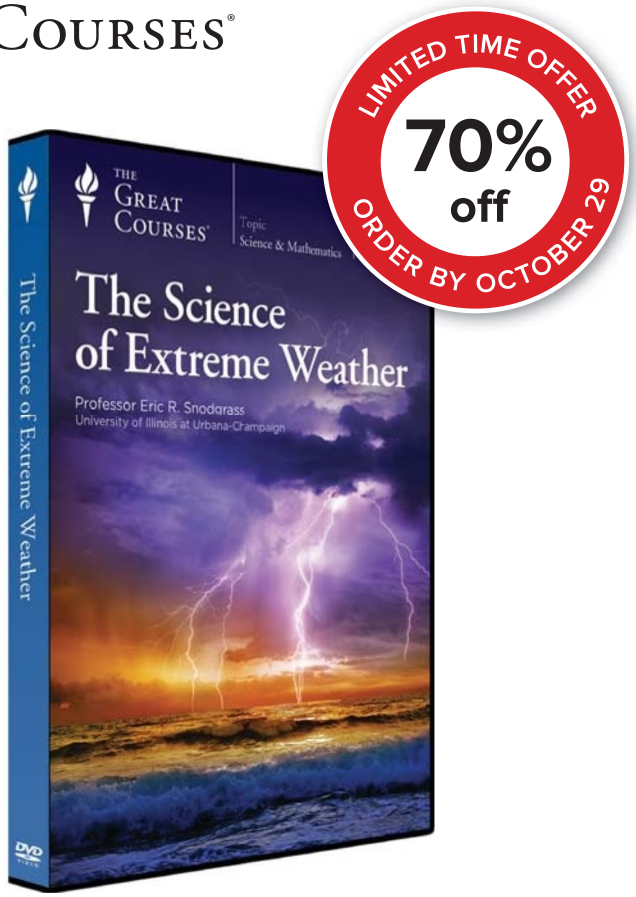

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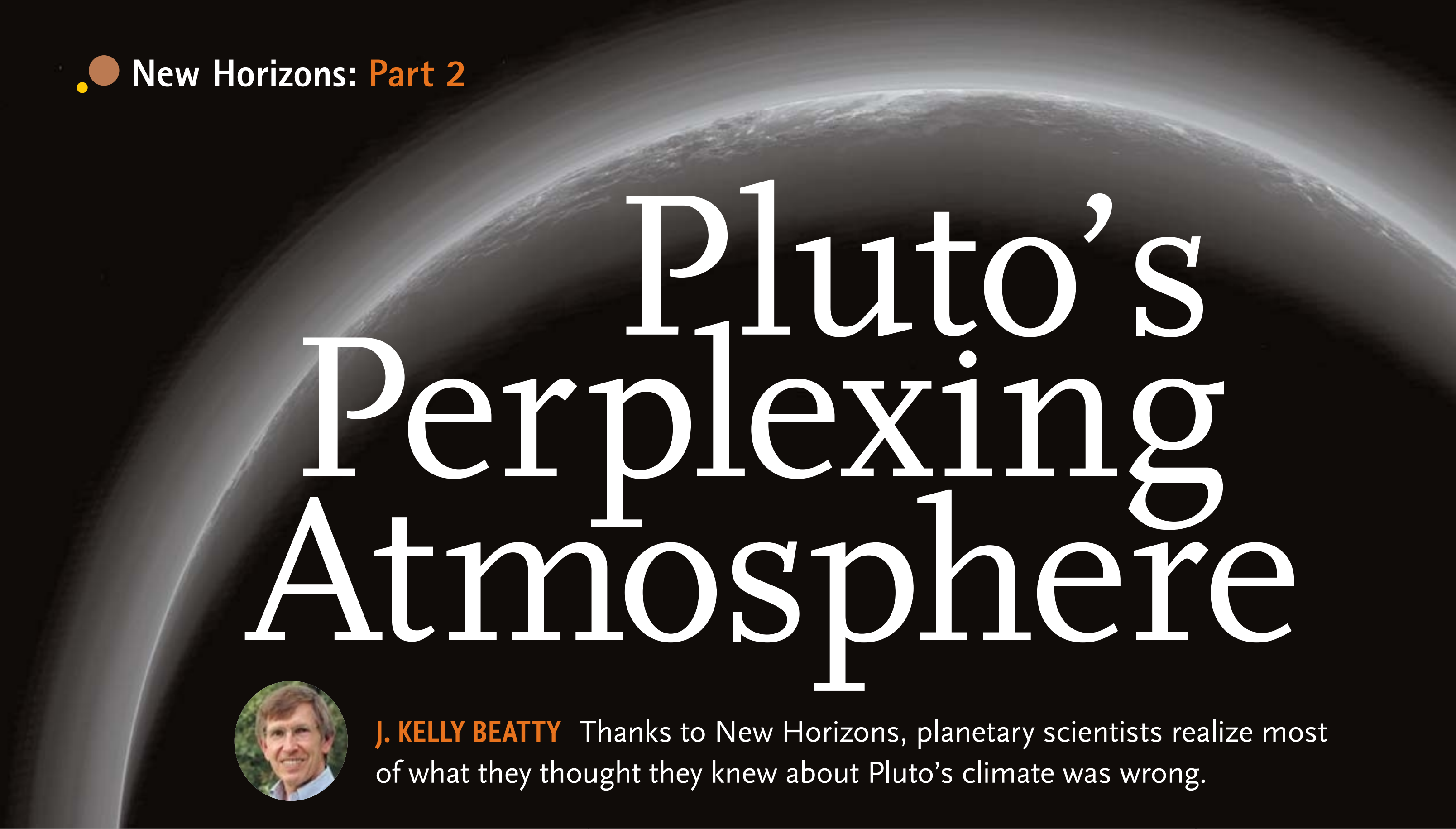


Pluto's Perplexing Atmosphere

J. KELLY BEATTY Thanks to New Horizons, planetary scientists realize most of what they thought they knew about Pluto's climate was wrong.

SECOND IN A SERIES

October's issue devoted eight pages to New Horizons results about Pluto's surface. This article explores Pluto's atmosphere and its solar-wind interactions. December's issue will examine Charon and its four smaller siblings.

Ever since the discovery of Pluto's tenuous atmosphere in June 1988, outer-planet specialists have pondered how it has managed to stick around. Its only possible source is surface ice, *sublimating* (converting directly to gas) as sunlight warms it. Yet this small, distant world is so cold, averaging about 45 kelvin (–380° Fahrenheit), that the frozen nitrogen and methane on its surface can sublimate only very slowly. Moreover, given that Pluto swung closest to the Sun in 1989 along its strongly eccentric orbit, many researchers thought that conditions wouldn't be warm enough to heat the ice for long, and what little atmosphere surrounds this little world would all soon freeze and literally drop from the sky onto the surface. If we didn't get there soon, mission proponents had argued to gain NASA's approval, there'd be no gas left to study.

Then a recent series of stellar occultations by Pluto, recorded by ground-based astronomers, showed an unexpected trend: even as Pluto edged farther from the Sun, its atmospheric pressure started *rising*, not falling. That wouldn't happen if the gases were freezing out.

The explanation seems to be rooted in Pluto's extreme axial tilt: its north pole is tipped 120° downward with respect to "up" in solar system coordinates. For much of its 248-year-long orbit around the Sun, Pluto has one pole constantly in sunlight and the other in shadow. Back in 2013, Leslie Young (Southwest Research Institute) figured out that there's enough frozen nitrogen and methane in the northern hemisphere (the one now in sunlight) to supply the atmosphere with a sizable reservoir and keep it from completely collapsing. But that didn't explain why the pressure might be on the rise.

Many such questions about the state of Pluto's atmosphere awaited New Horizons, and the mission's scientists had a carefully designed plan for finding the answers. First, the ultraviolet spectrometer, named Alice, deduced the frigid air's composition. Second, the spacecraft briefly ducked out of view behind Pluto as seen from both the Sun and Earth, and those occultations allowed scientists to probe the atmosphere's temperature and pressure from top to bottom. Finally, instruments called PEPSSI (a clever acronym for Pluto Energetic Particle Spectrometer Science Investigation) and SWAP (Solar Wind Around Pluto) detected a huge but vanishingly thin bubble of gas stripped from Pluto's upper atmosphere by the solar wind and ionized by ultraviolet sunlight.

HAZY CIRCLE Despite the thinness of Pluto's atmosphere, New Horizons scientists were startled to find dozens of thin haze layers in this view taken while looking back in the Sun's direction minutes after the spacecraft's flyby on July 14, 2015.

NASA / JHU-APL / SWRI

Meanwhile, prior to the spacecraft's arrival, the scientific consensus held that Pluto had too little gravity to hold onto its nitrogen gas and thus must be irreversibly losing it to space at a rapid rate, roughly 10^{27} molecules per second. That's a few thousand tons per day, enough for researchers to question where it's all coming from and whether it's been leaving Pluto so rapidly throughout solar system history. Some had even speculated that Pluto's atmosphere extended all the way to Charon, some 18,500 km away.

Reality Check

So imagine the team's surprise — shock, really — to learn that Pluto's upper atmosphere is far colder than expected (roughly 70K instead of the anticipated 100K), and consequently that it hugs the surface much more compactly than anyone realized. Decades of ground-based observations, especially stellar occultations, had suggested that the *exobase* (essentially the level at which atoms can fly away freely into space) was roughly 7,500 km up — seven or eight times Pluto's radius. But instead, Young reports, it's more like 2½ times. "From an Earth-based perspective," admits principal investigator Alan Stern (Southwest Research Institute), "we got it all wrong."

Because it's so close to Pluto, the thin air is held in place far more strongly by gravity than it would be if it were puffed up higher. Consequently, the solar wind can't strip it away easily. In fact, PEPSSI didn't detect any interaction with the solar wind until the spacecraft got to within about 7,000 km of Pluto. Instead, the escape rate of nitrogen must be only 10^{23} molecules per second — a mere 1⁄10,000 (0.01%) of the pre-arrival prediction. What little gas does leak away is mostly methane. "There's essentially no nitrogen escaping from the upper atmosphere of Pluto," admits Michael Summers (George Mason University).

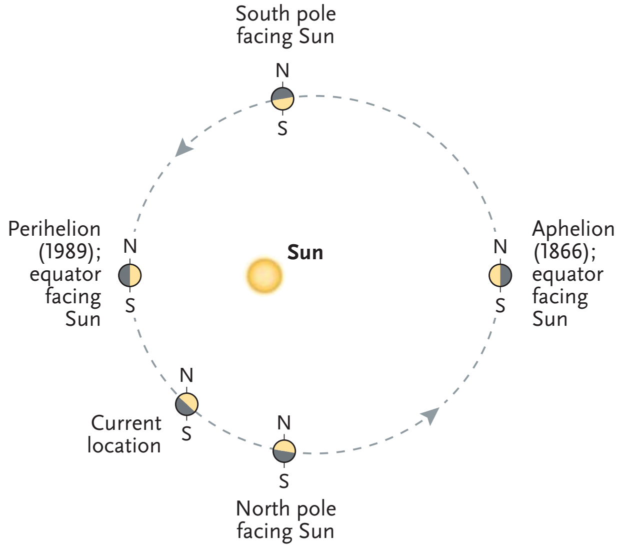
This key finding means that Pluto's atmosphere is there to stay. "We expected [an] escape rate rapid enough to lose the equivalent of a half-mile-thick layer of surface ice over 4½ billion years," Young explains, "but now it's more like a half foot."

As the New Horizons investigators detail in one of five articles published in March 18th's *Science,* the reasons for the unexpectedly cold upper atmosphere aren't clear. Perhaps some other compound is radiating away heat to space. The simple organic molecule hydrogen cyanide (HCN) synthesizes easily in the upper atmosphere and would be a plausible candidate. But observations with the ALMA radio-telescope array in Chile, acquired by Emmanuel Lellouch (Paris Observatory) and others weeks before the flyby, suggest that there's not nearly enough HCN present to do the job.

Soon after the flyby, investigators announced that they'd seen a number of discrete haze layers suspended high above the surface. The idea of hazes wasn't new — they'd been implicated for decades as a way to explain quirks in ground-based occultation data. Besides, once sunlight breaks down methane, the molecular fragments readily recombine to form tiny aerosol particles of heavier compounds like acetylene (C_2H_2), ethylene (C_2H_4), and ethane (C_2H_6). The spacecraft detected all of these.

The puzzle was finding *so many* layers — a score of them — each a few kilometers thick and situated at roughly regular intervals that extend to 200 km above the surface. The ones high up can't be stable, because temperatures there are warm enough (by Plutonian standards) to vaporize those candidate organic aerosols.

An important clue comes from the haze layers' quasi-regular spacing. As Randy Gladstone (Southwest Research Institute) and colleagues explain in one of the *Science* papers, gentle surface-level winds that transport heat from warmer to cooler regions can trigger the formation of *gravity waves* while flowing over Pluto's rather substantial mountain ranges. The waves propagate upward, alternately compressing and rarefying haze particles with just the right spacing. "It's almost like the atmosphere of Pluto is 'ringing' in a radial direction," Summers explains. Some other process might be involved, but gravity waves offer the best explanation.



NEAR AND FAR **Pluto's highly eccentric orbit means that this little world is nearly twice as distant from the Sun at aphelion as it is at perihelion — apparently with major climatic consequences.**

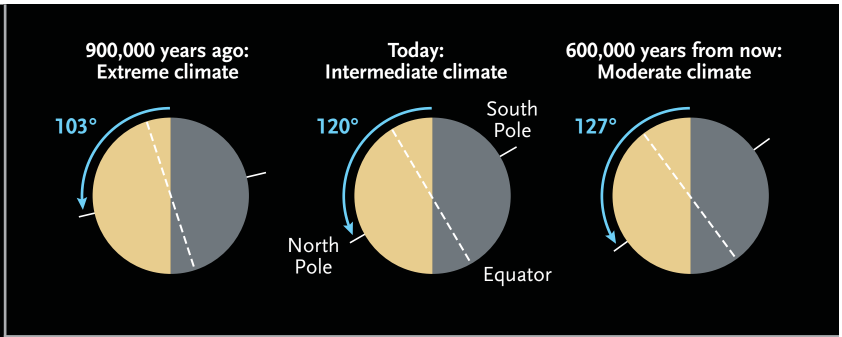
S&T: LEAH TISCIONE, SOURCE: NASA / JHU-APL / SWRI

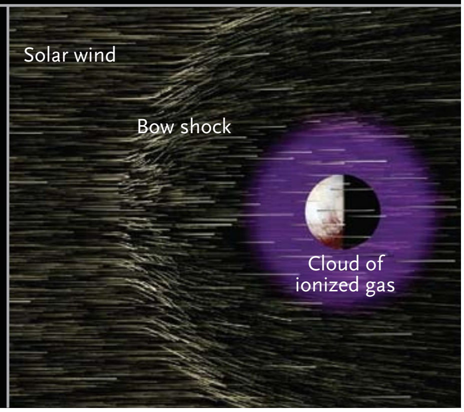
Hints of a Far Denser Atmosphere

The recording of New Horizons' radio signal as it ducked behind Pluto and then reappeared revealed surface pressures of 11 and 10 microbars, respectively — only 0.001%

GRAVITY VS. GRAVITATIONAL WAVE

Gravitational waves are ripples in spacetime, created by accelerating masses. *Gravity waves* form when buoyancy pushes a fluid up and gravity pulls it back down (such as flow over a mountain) in an attempt to preserve equilibrium.





EXTREME TILTS *Top:* Pluto's *obliquity,* the tilt of its spin axis with respect to its orbital plane, is both very large and quite variable over million-year time scales. When its tilt is smallest, the poles can point almost directly toward and away from the Sun. This alignment creates extreme climate conditions. Conversely, when Pluto's axial tilt is greatest, the total sunlight increases at lower latitudes, equalizing the climate.

BLUE VISTA *Left:* Although Pluto's atmosphere is vanishingly thin, soot-size aerosol particles scatter light in a way that imparts a blue color to the sky.

CAUGHT IN THE FLOW *Right:* The solar wind rushes past Pluto at roughly 400 km per second. A tenuous cloud of ions and electrons, derived from gas that's escaping from the upper atmosphere, is enough to deflect the flow.

TOP: S&T: LEAH TISCIONE, SOURCE: NASA / JHU-APL / SWRI; BOTTOM LEFT: NASA / JHU-APL / SWRI; BOTTOM RIGHT: S. BARTLETT / NASA SCIENTIFIC VISUALIZATION STUDIO

of sea-level pressure on Earth. This meshes well with ground-based occultation measurements made June 29, 2015 — just two weeks before the spacecraft's flyby.

But not only does Pluto's atmosphere never disappear, there's also evidence that, under certain circumstances, it can get thousands of times *denser* than it is now.

The key is Pluto's extreme obliquity, which varies between a minimum of 103° and a maximum of 127° over a 2.8-million-year cycle. Those swings in Pluto's already wacky tilt have dramatic implications for how much sunlight the surface receives and how much gas gets liberated.

When Alissa Earle and Richard Binzel (MIT) took a close look at these long-term obliquity swings, and folded in the gradually changing location of Pluto's orbital perihelion over a cycle of 3.7 million years, the result was surprising. Pluto undergoes such extreme seasonal swings that at times its "tropics" — areas where the Sun can appear directly overhead — cover 97% of the globe.

The most recent of these "super-seasons" occurred 900,000 years ago, when Pluto's north pole (the one currently basking in continuous sunlight) was pointing sunward at each perihelion. At that time the maximum global temperature rose about 7K higher than it is now.

This might not seem like much of a bump, but Stern explains that even a small uptick in Pluto's surface temperature can yield an exponential increase in the sublimation rate. He thinks that during the most recent seasonal extreme, the airmass enveloping Pluto reached

STACKED DECK Taken shortly after New Horizons came closest to Pluto on July 14, 2015, this image reveals about 20 distinct haze layers in the tenuous atmosphere surrounding Pluto. The scene is 1,200 km (750 miles) wide.

NASA / JHU-APL / SWRI

a peak surface pressure of anywhere from 18 millibars (three times that on Mars) to 280 millibars (more than 25% of sea-level pressure on Earth), depending on the surface's reflectivity and other assumptions.

In fact, Stern speculates, it's conceivable that the pressure and temperature could rise enough to allow nitrogen to flow across the surface as a liquid. Lakes on Pluto? Many of the images returned by New Horizons show evidence of runoff involving some kind of liquid — and at least one close-up reveals a small enclosed depression that looks remarkably like a frozen pond.

Another tantalizing bit of evidence involves the string of very dark patches, anchored by a large one nicknamed Cthulhu Regio, that gird much of Pluto's equator. This largely ice-free belt corresponds nicely to the region within 13° of the equator that receives a lot of sunlight and is *never* subjected to continuous darkness.

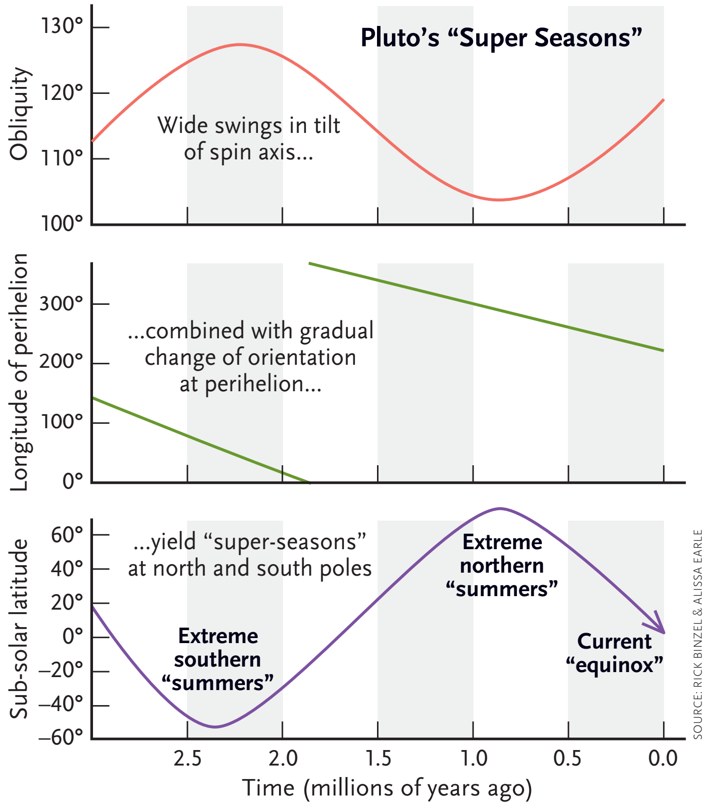
On the other hand, through it all, it appears that Tombaugh Regio remains the "cold icy heart" of Pluto. New modeling by Earle, Binzel, and others shows than even in the midst of the warmest possible super-seasons, this broad region (which includes white-as-snow Sputnik Planitia) remains unshakably cold, despite its location near Pluto's equator. The long-term model suggests that Tombaugh Regio never gets warmer than 37K, while nearly black Cthulhu Regio never gets colder than 42.5K.

Why do these close neighbors on Pluto appear so very different? One very telling result is that the spectrometers on New Horizons didn't detect any veneer of ice atop Cthulhu Regio. So perhaps it simply never gets cold enough for any ice to accumulate, no matter what the season. Conversely, Tombaugh Regio never gets warm enough to lose its blanket of nitrogen and methane ice. Binzel believes these starkly different cases are examples of "runaway albedo."

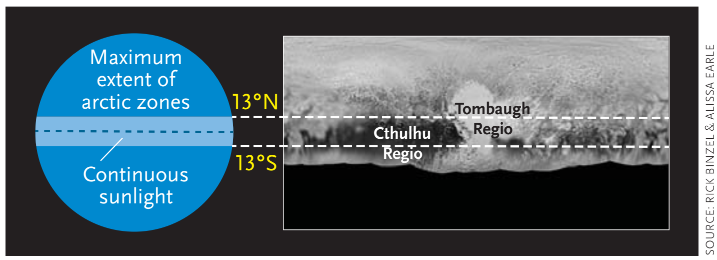
Interestingly, planetary scientists have known about Pluto's seasonal extremes for decades. Dynamicists Anthony Dobrovolskis and Alan Harris first recognized the 2.8-million-year cycle in 1983. Then two nearly forgotten papers by Belgian researcher Etienne Van Hemelrijck, also from the 1980s, explored how much sunlight Pluto's surface should receive as the obliquity changed.

So should we have anticipated some of this wacky weather long before the spacecraft arrived? "We see many things that, in retrospect, weren't obvious before we got there," Stern offers. But, clearly, results from New Horizons have made the notion of climatic extremes on Pluto far more compelling. "We see things on the surface indicating that past conditions were very different," he continues. "There's no slam-dunk case for any one of them being due to an atmospheric extreme, but it's hard to imagine that *none* of them were." ✦

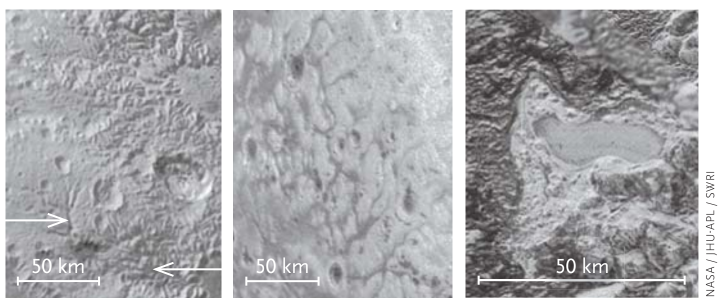
Senior Editor ***Kelly Beatty*** *has written about planetary science in the pages of* Sky & Telescope *for more than 40 years.*



CLIMATIC EXTREMES A widely varying axial tilt, combined with a cyclical shift in the season that coincides with perihelion, creates dramatic swings in where the Sun shines most intensely on Pluto's surface.



BLACK BELT Computer modeling reveals that, over long time scales, a narrow band along Pluto's equator is always in sunlight and thus never subjected to long arctic nights. Much of the surface within this band is extremely dark and relatively free of ice.



DENSE-AIR EVIDENCE New Horizons spotted numerous surface features — *(from left)* dendritic channel networks, interconnected terrain, and a frozen "lake" — strongly suggesting that Pluto's atmosphere has been much denser in the past.

A Brief History of Sky & Telescope

Dennis di Cicco

We mark our 75th anniversary with a look back at some of the people, places, and events that helped launch the magazine you're reading.

IN NOVEMBER 1941, as a young couple stood paging through the first issue of *Sky & Telescope* in a small alcove at Harvard Observatory, it's unlikely their thoughts were anywhere near the 21st century. The couple — Charles "Charlie" and Helen Federer, the new magazine's entire editorial staff — had more immediate concerns. There was the business of putting out the second issue, of course. But others involved settling into a new environment after leaving New York City a month earlier with a three-year-old son and two-week-old daughter; new part-time jobs at the observatory in addition to their magazine responsibilities; and, on the world stage, an expanding war in Europe, which only a month later would draw in the United States when Pearl Harbor was atacked.

But here we are 75 years later, and despite wars, financial upheavals, and blizzards, readers have received a new issue of *Sky & Telescope* every month without exception. That's 901 issues counting the one you're reading now. Stacked one atop another, the pile would rise more than 12 feet.

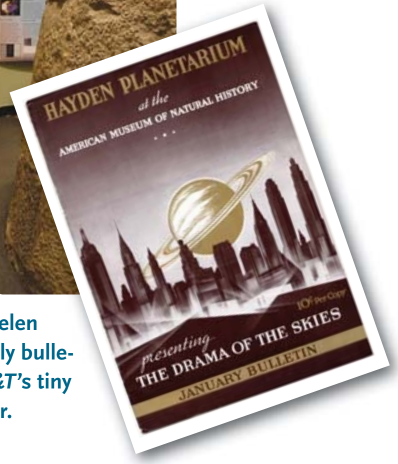
The 77,000-plus pages are a profusely illustrated who, what, when, and where of amateur and professional astronomy for the past three-quarters of a century. And while readers today confidently look forward to each monthly issue, the magazine's future was anything but certain at the outset.

Finding the Headwaters

Ever since the first issue rolled off the press in 1941, *Sky & Telescope* has been published in Cambridge, Massachusetts. The magazine's first office was little more than a glorified closet off the rotunda surrounding the

COUPLE OF EDITORS Charlie Federer *(left)* joined *The Sky* in 1937 while he was a lecturer at the Hayden Planetarium and his wife, Helen, seen here at a 1945 Canadian eclipse, worked in the planetarium's Book Corner.

ALL IMAGES FROM S&T PHOTO ARCHIVE



STELLAR COMBINATION ***Sky & Telescope*** **grew from two risky business ventures that Charlie** ***(left)*** **and Helen agreed to take on. The first was assuming ownership of** ***The Sky*****, which evolved from the planetarium's monthly bulletin** ***(far right)*****. The second was a merger with** ***The Telescope*** **published at Harvard Observatory. The door to** ***S&T*****'s tiny first alcove-office** ***(right)*** **was off the rotunda surrounding the pier of the observatory's historic 15-inch refractor.**

towering pier of Harvard's historic 15-inch refractor. And while many readers know that the publication began as the merger of *The Sky* and *The Telescope,* its true beginnings lie further back in time and at locations far from the shadow cast by that observatory's great copper dome.

The first strands of *Sky & Telescope*'s DNA appeared in New York City, where in April 1929 the Amateur Astronomers Association, headquartered at the American Museum of Natural History, launched *The Amateur Astronomer,* a four-page bulletin for its members. Published monthly except for July and August, it featured star charts, the month's celestial highlights, short articles, and summaries of lectures presented by the organization. In early 1934 *The Amateur Astronomer* changed to a quarterly schedule and a larger format.

The following year the Hayden Planetarium opened at the museum, and in November its staff introduced a slick little monthly publication that quickly grew from 16 to 20 and later 28 pages. It cost a dime, or $1.20 for a year's mailed subscription. Officially it was the *Hayden Planetarium Bulletin*, but its popular subtitle, The Drama of the Skies, became the magazine's heading by the 10th issue. Its content was heavily slanted toward amateur astronomers, including a monthly evening-sky map, and it had a scattering of ads, mostly for astronomy books, cameras, and the occasional telescope. Flipping through an issue of the *Hayden Planetarium Bulletin* today, a seasoned *Sky & Telescope* reader would likely feel a homey connection with its content.

With two astronomy publications headquartered at the American Museum of Natural History, what came next isn't surprising. In November 1936, what would have been the *Hayden Planetarium Bulletin*'s 13th issue merged with *The Amateur Astronomer* and began anew as *The Sky,* billing itself as the "Magazine of Cosmic News." Officially it was still the bulletin of the Hayden Planetarium, but it now included much of the local astronomy news previously in *The Amateur Astronomer.* Membership in the Amateur Astronomers Association ($2.00 annually) came with a subscription to *The Sky.*

The magazine's reputation and circulation grew in the following years, as various planetarium staff served as contributors and editors. In November 1937 Charlie Federer, then a staff assistant and lecturer at the planetarium, joined the magazine as an assistant editor. Charlie was also secretary of the Amateur Astronomers Association, and he clearly recognized how vital *The Sky* could be for the hobby of amateur astronomy in general. This belief would drive critical decisions that he and Helen, who ran the planetarium's Book Corner, would make before the decade ended. It would also change amateur astronomy far outside New York City.

Reminiscing for an oral history in the 1980s, Charlie recalled that the museum's vice-director approached him in 1939 saying, "Charlie, the museum wants to be free of *The Sky*, which is taking in $10,000 a year and

MAN OF MANY SEASONS
Roger Sinnott joined the ***S&T*** **staff in 1971 and is still active with the magazine today. As a 14-year-old in 1959 he posed with his younger siblings and "almost-finished" 6-inch reflector.**

DEEP SKY HISTORY ***The Telescope*** **got its start at Perkins Observatory *(left)* on the campus of Ohio Wesleyan University just before the completion of the observatory's 69-inch reflector in the early 1930s. Walter Scott Houston *(right)* was a 20th-century amateur astronomy icon and one of *S&T*'s many longtime contributors. He penned the Deep-Sky Wonders column for 47 years prior to his death in 1993.**

costing $25,000. We wonder if you and Helen would like to take it over. You can have an office in the planetarium basement." It's unknown how the museum figured its annual cost at $25,000, but somehow Charlie and Helen felt they could keep the magazine alive without the museum's financial support other than free office space.

The couple formed Sky Publishing Corporation in late 1939 and officially took over ownership and management of *The Sky* with the January 1940 issue. Charlie became the editor and Helen the managing editor. "We shall try to make the magazine meet the needs of amateur astronomy," they told readers, "so that amateur astronomers will come to regard it as essential to their pursuit, and professionals to consider it a worthwhile medium in which to bring their work before the public."

While these events were unfolding in New York, 500 miles to the west in Delaware, Ohio, *The Telescope* was getting its start at Perkins Observatory on the campus of Ohio Wesleyan University. In the 1920s the university's trustees committed to the construction of a 60-inch reflector and associated observatory. An oversized glass blank for the primary mirror was cast in 1927, and it was deemed of sufficient quality to make a mirror 69 inches in diameter, which would gather 32% more light than a 60-inch. It would also rank the Perkins reflector as the third-largest operating telescope in the world.

As the mirror neared completion, observatory director Harlan T. Stetson started a small-format publication called *The Telescope* to keep the public up to date with the happenings at the observatory and to help popularize astronomy. The first 12-page issue appeared in March 1931. It continued quarterly until summer 1933, when the format was slightly enlarged. A 6-month gap followed the October printing before an 8-page issue came out in April 1934. This one, however, included an upbeat note saying that *The Telescope*, like Stetson, was moving east to Cambridge, where future issues would be produced bimonthly "under sponsorship of the Bond Astronomical Club affiliated with the Harvard Observatory." The next issues appeared on schedule, with Harvard Observatory's executive secretary Loring B. Andrews acting as their skillful editor. An annual subscription cost $1.00.

The Telescope was strong on articles about scientific findings written for a popular audience, but it had only superficial coverage of current celestial events, typically limited to a monthly all-sky chart and a mention of which constellations held the naked-eye planets.

During the spring of 1937 Andrews left Harvard to do research in England, and Harlow Shapley, the observatory's director, assigned editorship of *The Telescope* to astronomer Donald Menzel. Although highly qualified for the job, Menzel was never enthusiastic about his added responsibilities, writing later in an unpublished autobiography, "Frankly, it was a pain in the neck." Nevertheless, he improved the look and content of the magazine, occasionally including articles for observers.

The Merger

On April 1, 1939, the New York World's Fair opened with the theme "Building the World of Tomorrow." Science and technology were on grand display, and the fair drew almost 45 million visitors before its gates closed in October 1940. During the fair's first season, Charlie Federer was deeply involved with establishing a national federation of amateur astronomy clubs; it would eventually become today's Astronomical League (Shapley's name, according to Charlie). Included in the plan was a big meeting of amateurs, and Shapley, who was in favor of an amateur federation and had met Charlie earlier when a group of New York amateurs visited Harvard, accepted an invitation to give a public lecture on astronomy at the World's Fair. On August 19th, a "drenching" rain soaked the fairgrounds. After those present retreated under a tent, Charlie and Helen spent time talking with

Shapley and Gerald Wendt, the fair's scientific director. Knowing Menzel's discontent as editor of *The Telescope,* Shapley floated an idea that to Charlie and Helen must have seemed like déjà vu. "If the Federers came up to Harvard," Shapley said to Wendt, with the Federers in earshot, "we could join our two magazines."

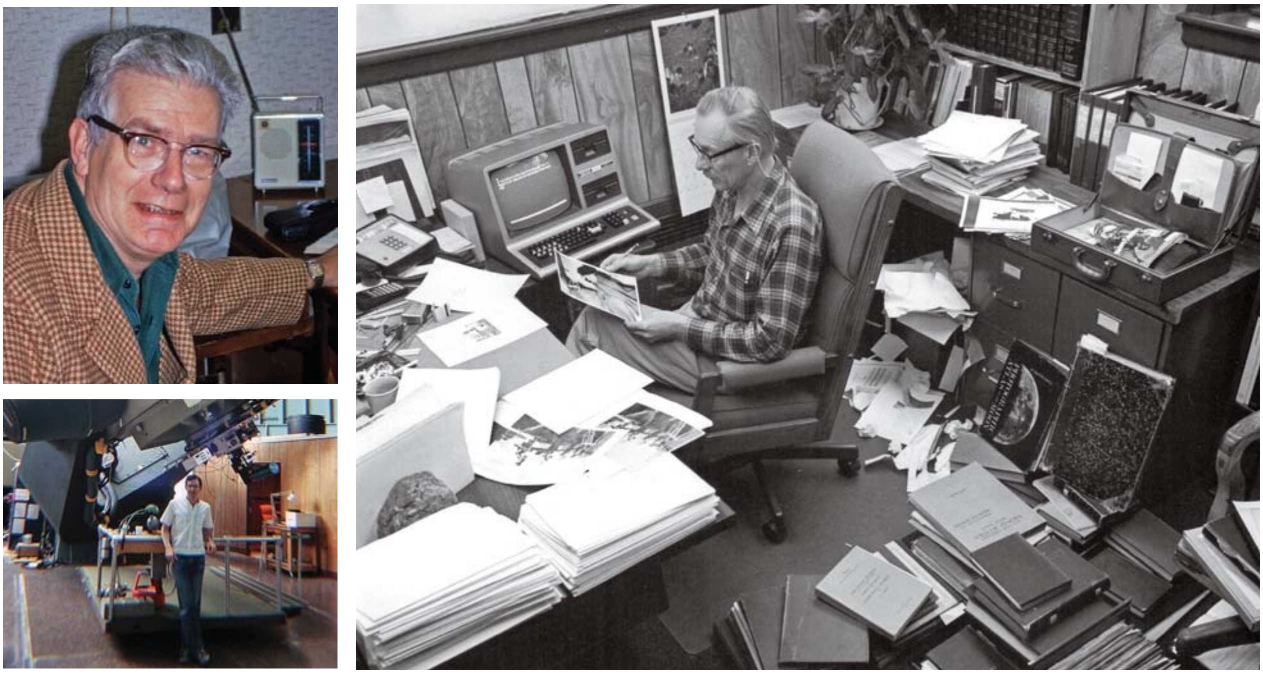
The discussion continued sporadically by mail but became more serious when, in mid-1941, Menzel tendered his resignation as *The Telescope*'s editor. Money was a stumbling block, since even when combined, revenues from the two magazines could not cover the cost of printing and mailing the issues *and* pay the Federers a living income; they estimated they would need around $3,200 a year to get by. Shapley, however, said he could find Charlie and Helen part-time jobs at the observatory, which would supplement their meager editorial salaries. It was a tenuous financial plan, but Charlie and Helen had been there before. On August 11th Charlie's letter to Shapley began, "After a two-hour discussion, Helen and I have decided the material factors are about balanced between going and staying, so the intangible personal feelings, desires, and what the future holds are most important." There's little doubt that those thoughts for the future included a magazine that would better "meet the needs of amateur astronomy" and be regarded as "essential" to amateurs. The details were hammered out in a flurry of letters, and by early October the Federers were on their way to Massachusetts.

Location, Location, Location

In addition to free if cramped office space at the observatory, Charlie and Helen now had ready access to world-class astronomers, some of whom helped with the new-found magazine being published in their midst. Equally important was the Harvard mailing address, which lent prestige to the publication.

The 1940s were lean years, but *Sky & Telescope*'s circulation slowly grew. One key to this was the symbiotic relationship that Charlie engineered with his other pet project, the Astronomical League. He used the magazine to promote the League heavily and to report on its doings. And he used the growing League to build the magazine's circulation, by getting League clubs to sell subscriptions to their members at a special "club rate." It worked. Even today, *Sky & Telescope* continues to offer a club rate to qualifying astronomy clubs.

FORMER DIGS ***S&T*'s headquarters *(left)* were on Bay State Road in Cambridge for nearly 50 years. The light-colored house at right served as editorial offices, while the largish building behind it and partially hidden by trees includes the "annex" built in 1957 *(right top)*. That building is now home to the American Association of Variable Star Observers, which was housed in the center foreground building when this photo was taken in the 1980s. For many years *S&T* was run more like a family than a business, and staff members often pitched in with such chores as shoveling snow, including longtime managing editor and company president William Shawcross, who paid homage to Grant Wood's "American Gothic" in this photograph.**



OFFICE MATES ***Clockwise from upper left:*** **Joseph Ashbrook, Leif Robinson, and Richard Fienberg were *S&T*'s second, third, and fourth editors, respectively, and provided more than a half century of editorial leadership.**

Despite the eventual addition of several more rooms at the observatory, space was growing tight, and in late 1952 the magazine's subscription-fulfillment department moved to a rented storefront a two-minute walk from the observatory. Then in 1956 the editorial staff packed up and moved across the street to Harvard's Kittridge Hall, which was home to Harvard University Press and the Smithsonian Astrophysical Observatory's newly established Moonwatch program, formed in anticipation of the first artificial satellites. But the magazine's mailing address remained at the world-renowned observatory.

In contrast to the 1940s, the 1950s saw robust growth for amateur astronomy, fueled by cheap war-surplus equipment and the approaching Space Age. Sensing a more secure future, Charlie knew the magazine would need even more space. In 1956 he purchased a small plot of land about a mile west of the observatory on Bay State Road next to the Cambridge dump, where piles of trash burned in open-air fires. There the following year Sky Publishing built a 50-by-55-foot "annex" for the magazine's fulfillment department. Nevertheless, Charlie's hand-drawn sketches and notes from the time make it clear he envisioned the building as the eventual *Sky & Telescope* headquarters, complete with a 10-by-12-foot office for himself as company president. Opulence, it seems, wasn't a big concern.

The whole company consolidated onto the site in 1959, but with a slight change in plans since by then Charlie had purchased a small house next to the annex and one directly across the street. One became the company's front office, fulfillment, and customer-service departments, while the other served as editorial offices. The annex became shipping and receiving. These buildings formed the venerable "49-50-51 Bay State Road" address that served the company for the next half century. Most of the magazine's veteran readers will vividly remember writing to that address to start and renew subscriptions.

The dump closed in 1971, reducing the smell, and in the coming years it was transformed into a pleasant city park after being covered with a mountain of clean fill excavated when the local subway line was extended westward from Harvard Square. Today the magazine's editorial offices are on the other side of that park. Some of the former buildings on Bay State Road are now home to the American Association of Variable Star Observers.

The Staff

Over the years, hundreds of people have worked for *Sky & Telescope*. But Charlie had a knack for hiring people who stuck with the publication. His first full-time editorial hire was astronomer and Yale University teacher Joseph Ashbrook, a diligent scholar and meticulous word person who came on board in 1953. Joe rose to become the magazine's editor in 1964 and remained in that position until he died at age 60 of a heart attack while vacationing in 1980. Joe was followed by his long-time colleague Leif Robinson, who'd tallied 38 years on the staff when he retired in 2000.

And it wasn't just the editorial staff that chalked up years of service to the magazine. Business manager John Simmons was in high school when he began working part-time "sweeping floors" at the magazine. Like Joe, his employment at Sky ended with an untimely death, in this case from a brain tumor at age 55. Sarah "Sally" Bulger worked in fulfillment and customer service for 46 years. Many astronomy club secretaries and treasurers knew Sally as the familiar voice on the other end of the line when they called about club subscriptions. Currently, five people actively involved with the magazine — Roger Sinnott, myself, Kelly Beatty, Lester Stockman, and Alan MacRobert — have amassed a combined work history here totaling more than 203 years.

Epilogue

In the beginning, Charlie and Helen were the magazine's sole owners. As the years passed, the company's ownership never extended outside a small handful of longtime employees, all of whom shared Charlie's deep devotion to the magazine. The owners continually plowed the bulk of the company's profits into improving the magazine, often by hiring more staff and bringing more of the fulfillment and production capabilities in-house. By the late 1990s, this "mom and pop" business had grown to nearly 50 full- and part-time employees.

With the turn of the century and the rise of the internet, independent magazine publishers, especially those putting out a single title, were fighting an increasingly uphill battle. In early 2006 Sky Publishing Corp. was sold to New Track Media, a newly formed private-equity company intent on gathering a block of hobby-oriented magazines under one roof. Sharing production, marketing, and management resources across multiple publications, while maintaining an editorial staff devoted only to *Sky & Telescope,* seemed like the best way to maintain the magazine's tradition of excellence in a radically changing world. In 2014, New Track Media was acquired by the Cincinnati-based publishing giant F+W Media.

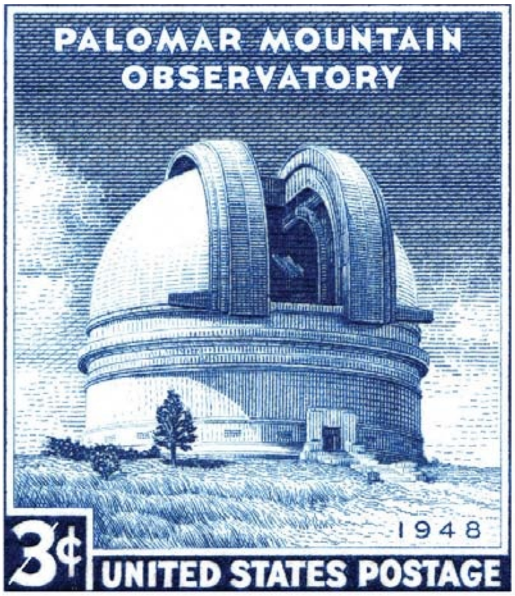
Charlie Federer was once asked how *Sky & Telescope* grew and thrived across decades when so many other magazines came and went. His instant answer: "We always put the reader first." Despite the changes in ownership, *Sky & Telescope* continues to adhere to the original vision of Charlie and Helen — to make the magazine "meet the needs of amateur astronomy." It's a vision we expect to follow well into the future. ✦

NEW DIGS ***Above:*** **A blindfolded staff took a mystery trolley ride to their new offices when** ***S&T*** **was purchased by New Track Media in 2006.**

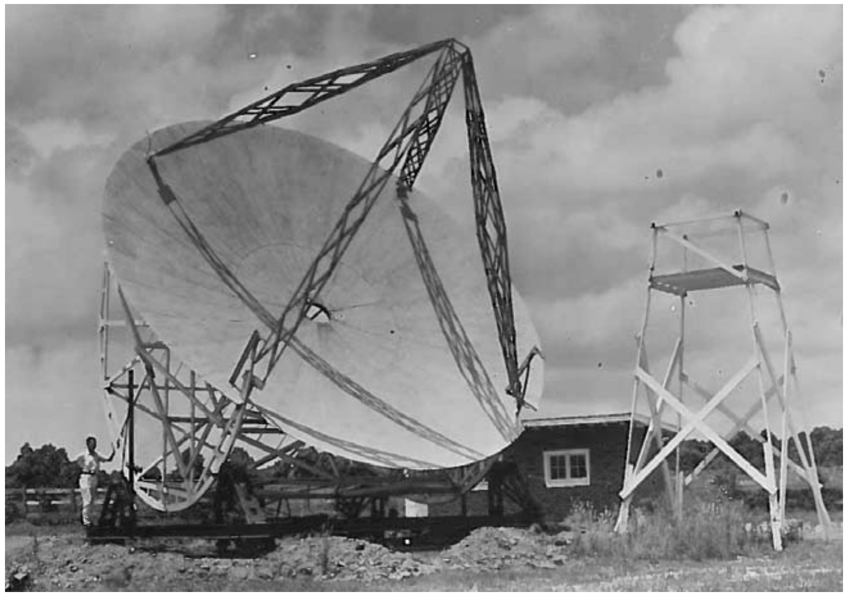
In 1974, **Dennis di Cicco** *and Kelly Beatty were the last members of* Sky & Telescope*'s staff hired by Charlie Federer. Dennis considers this article an excerpt from the book on the magazine's history that he'll never get around to writing.*

SKY PEOPLE ***Left:*** **Robert Naeye was the magazine's fifth editor.** ***Right:*** **The** ***S&T*** **"family" gathered for a group portrait in front of their new offices in 2006.**

A Lifetime of Science



U.S. POSTAL SERVICE



S&T ARCHIVES

Alan MacRobert

Astronomy grew more in the last 75 years than in all prior history. *Sky & Tel* was there at every step.

Many times a day *I walk past every* Sky & Telescope *ever published. They fill a bookcase of bound volumes outside my office, nearly from floor to ceiling. Occasionally I pull out one of the big blue books and open it. Always it's hard to close. Because I've just dropped into the broadest, most detailed single record of astronomy's development, culture, and events across three-quarters of a century.*

For our 75th birthday, here are some of the milestones chronicled in that bookcase. How often have you eagerly opened an issue just arrived in the mail to find revelatory new discoveries and concepts — things you immediately knew would forever change the science or the hobby? Now they rest quietly on old paper, like deep geologic layers supporting the busy and colorful, but thin, layer of the present that's accreting new material on top. We begin.

The 1940s: The 200-Inch

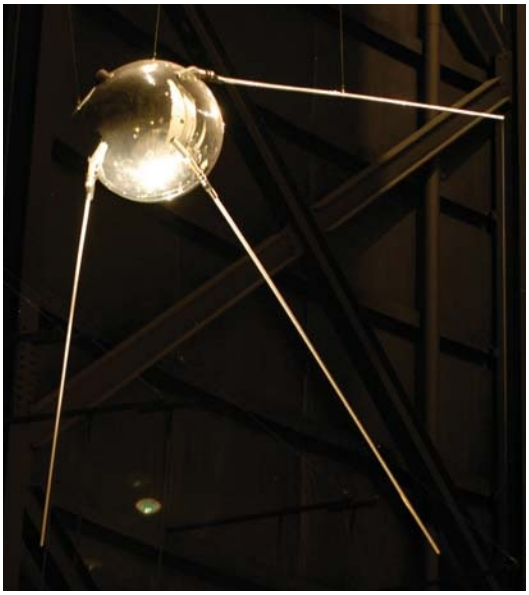
It is not given to us to know the fruits of what we do. So we must do them on faith, because good works occasionally pay off far beyond sight. If, in the 1930s and '40s, Charlie and Helen Federer hadn't taken one risky leap in life after another for the advancement of amateur astronomy and the popularization of science, the hobby and perhaps scientific literacy in America would not have grown as well as they did. Perhaps your own life would be less. The story of *Sky & Telescope*'s fluky, obsession-driven origin begins on page 22.

Flip open the first issue, November 1941, and on page 20 you see the hobby's embryonic backbone. Published there are Charlie's proposed founding documents for what would become the Astronomical League. Right from the start, he used the magazine to organize and grow the astronomy-club movement. And he used the resulting Astronomical League to grow the magazine. Having put the documents out for comment and input, he could then claim authority to implement them. Today the League includes 298 astronomy clubs and societies,

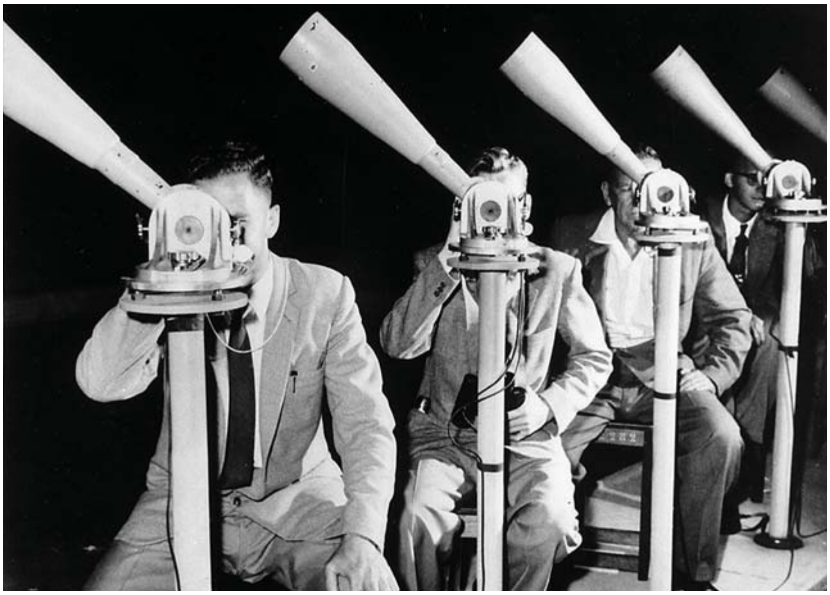
Above: **When astronomers dedicated the Hale 200-inch telescope in 1948, the public was probably as excited as it was by the launch of the Hubble Space Telescope in 1990. A postage stamp honored the occasion.**

In 1937 Grote Reber, an amateur astronomer and ham radio tinkerer, built the world's second radio telescope and the first that you'd recognize as such today. He hand-shaped its 31-foot paraboloidal dish and was the world's only radio astronomer for nearly a decade. Reber carried out an all-sky survey at 160 megahertz one big pixel at a time (after getting poor results at higher frequencies) and published many results in the early 1940s.

and Skywatching



NATIONAL AIR AND SPACE MUSEUM



OPERATION MOONWATCH / SMITHSONIAN INSTITUTION ARCHIVES

while our entire worldwide listing (at **SkyandTelescope.com/astronomy-clubs-organizations**) has data on 2,155 clubs around the globe, many of them inspired by the League's examples.

Dipping elsewhere into the 1940s issues, we read the leading scientific thought on whether Mars is inhabited (conclusion: "we just do not know"). And we come across a report about an exciting new development: "Radar and Radio in Astronomy." To many readers, the concept of radio astronomy was new. Astronomy had always been about the narrow little bit of the spectrum spanning visible light, with slight extensions into the infrared and ultraviolet. But now, radio "noise of cosmic origin promises to become a fact-finder on Milky Way structure." In the decades to follow, readers had front-row seats on the slow opening of the entire electromagnetic spectrum to astronomy — bit by bit, here and there, from radio to the highest-energy gamma rays — something the current generation of astronomers takes for granted.

However, if you asked our readers at the end of the 1940s to pick the decade's biggest astronomical development, most would surely have named the brand-new, 200-inch (5-meter) Hale telescope on Palomar Mountain. It had twice the aperture of the world's previous largest telescope (Mount Wilson's 100-inch, dating from 1919), and it would hold the title until 1975. We had covered its construction every step of the way.

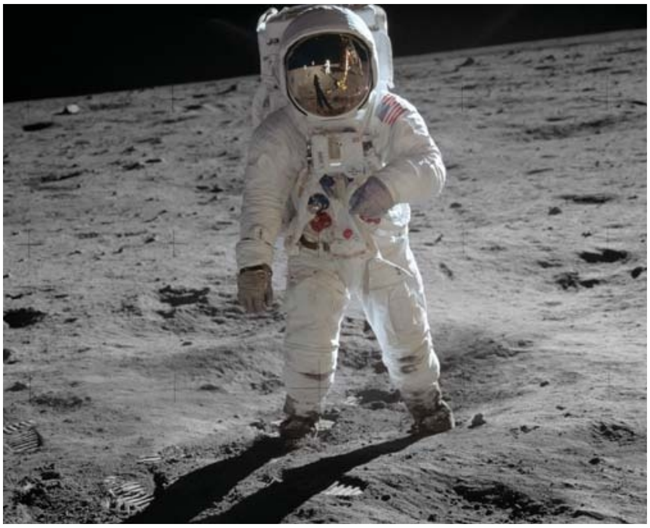
The 1950s: Dawn of the Space Age

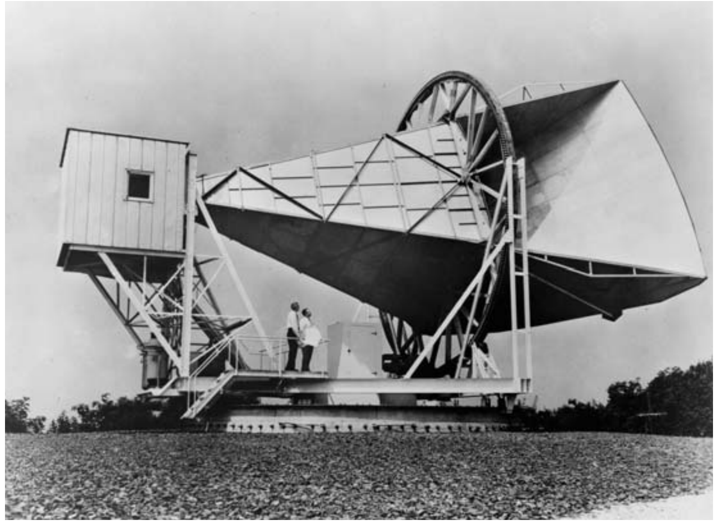
With World War II over and America testing and improving upon captured German V2 rockets (the source of science fiction's iconic image of the finned rocket ship), a Space Age actually seemed within reach — at least to readers of literature like Willy Ley's *The Conquest of Space* (1951) and *S&T*. We reported extensively on rocketry and spaceflight planning in the 1950s.

The rest of the world suddenly awoke to the Space Age on October 4, 1957, when the Soviet Union launched the first artificial satellite, Sputnik 1. *S&T* readers were ready and waiting. Fred Whipple, just down the hall from our first office at Harvard Observatory, had already organized Operation Moonwatch worldwide. The program called for rows of observers with special wide-field telescopes to create "picket fences" of overlapping fields of view, to detect and record the paths of any orbiting

A replica of the 23-inch-wide Sputnik 1 hangs in the National Air and Space Museum. The only surviving part of the real Sputnik 1 is a small arming key, which was pulled out shortly before launch to start the satellite's radio transmitter.

A "picket fence" of satellite spotters in Pretoria, South Africa, uses Operation Moonwatch telescopes to chart the paths of any miniature new moons that might cross the sky.





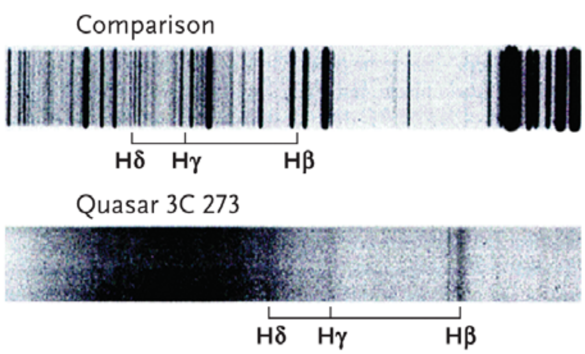
NASA (2)

objects passing overhead. Thousands of amateur astronomers and other volunteers participated in this effort, and *S&T* covered their work in depth.

In early 1958, three months after Sputnik 1, the U.S. launched its own first satellite, Explorer 1. We reported on James Van Allen's discovery, using his detector aboard the spacecraft, of the Van Allen radiation belts surrounding Earth. They soon proved not to be the deadly blockade to space travel that some feared. Later that year the U.S. Congress established NASA.

Space and science education shot to the top of national priorities, driven by Cold War fears of the Soviet Union leaving the U.S. behind. Space was hot, astronomy was cool, planetariums opened in many cities, kids everywhere put solar-system posters over their beds, and *Sky & Telescope*'s future seemed assured.

Our readers already knew that Jan Oort was predicting a vast reservoir of distant comets orbiting the Sun in what would be called the Oort Cloud. A 1957 article set off a craze among amateur telescope makers for John Gregory's Maksutov telescope design.



J. GREENSTEIN & M. SCHMIDT / APJ 1964

The Maksutov Club quickly grew to 200 members. This is why you can buy compact Maksutovs today. Anton Kuttner submitted stunning lunar photographs that he took with an unobstructed, tilted-component 12-inch reflector, introducing *S&T*'s readers to the possibilities of tilted-component optical designs.

Large commercial telescopes were still too expensive for most people to afford. The amateur telescope making movement, led by *Scientific American* and *S&T,* democratized astronomy, drove down prices, and trained up the people who founded and staffed many of the telescope companies that we buy from today.

The 1960s: To the Moon!

The 1960s will forever be known as when America landed the first humans on another world. On July 20, 1969, as Apollo 11 astronauts Neil Armstrong and Buzz Aldrin prepared to step out of their lander, the science-fiction writer Robert A. Heinlein declared to CBS News anchorman Walter Cronkite, "This is the greatest event in all the history of the human race, up to this time. Today is New Year's Day of the Year One. If we don't change the calendar, historians will do so. This is our change . . . from infancy to adulthood of the human race."

Nope. For one thing, humans haven't again ventured beyond low Earth orbit since 1972. But it was a time when all sorts of great possibilities seemed near at hand. In 1960, Frank Drake turned centuries of speculation about civilizations among the stars into a scientific endeavor with his Drake Equation and Project Ozma, the world's

Top: Buzz Aldrin poses for photographer Neil Armstrong, seen reflected in Aldrin's visor. _Bottom:_ No one could make sense of quasar spectra until Maarten Schmidt realized, in 1963, that their emission lines (dark lines in this negative) were ordinary hydrogen lines extremely redshifted. Indicated above is where the lines would appear in a stationary comparison spectrum.

Arno Penzias and Robert Wilson stand under the Bell Laboratories Holmdel horn antenna (fully rotatable), with which they accidentally discovered the all-sky afterglow of the Big Bang.


NASA / JPL


S&T ARCHIVES

first serious SETI experiment. *S&T* readers read Drake explaining his ideas before practically anyone else. Our readers had front-row seats on the birth of X-ray astronomy, the detection of neutrinos from the Sun's core, and the discovery that mysterious quasi-stellar radio sources, QSRS or "quasars," had redshifts that placed them at fantastic distances, meaning they had to be fantastically powerful. *S&T* readers were among the first to learn about the discovery of pulsars and had advance notice of the Leonid meteor storm of 1966.

In an even greater turning point, they learned that Arno Penzias and Robert Wilson had discovered a cosmic hiss of microwave radiation emanating from the entire celestial sphere. This was the predicted, brilliant white-light afterglow of the Big Bang itself, redshifted by a factor of 1,100 to microwave wavelengths by the subsequent expansion of space. The discovery tipped the scientific consensus into accepting that the universe truly had a Big Bang origin at a particular moment in time.

The 1970s: Black Holes

Human exploration of space dwindled in part because machines, expendable and far more economical, proved so good at it. In the 1970s and 1980s, readers followed Mariner flybys of Mars, Mariner 10 unveiling Mercury, the Soviet Union's Venera landings on Venus, and the long, epic missions of Voyagers 1 and 2 to Jupiter, Saturn, Uranus, and Neptune and their systems of moons.

The astronomical high note of the 1970s has to be the first successful Mars landers, NASA's Vikings 1 and 2, in the summer of 1976. After a lifetime of intense public yearning to know what Mars was really like, we saw the answer: barren deserts of rock and dust with no discernible trace of life, much less Martians. Once and for all the world grasped that we're alone in the solar system, and that there's no decent real estate beyond Earth. But *S&T* readers knew much earlier that this would be the case.

Every era has its particular astronomical fascination, and in the 1970s it was black holes. Physicists had only recently come around to the idea that such things could be physically real, rather than irrelevant mathematical quirks of Einstein's equations. In 1971 astronomers noted rapid X-ray variability in Cygnus X-1, a sign that extremely hot matter was cramming down onto an extremely small object. The tiny object was so massive, judging by its orbital effect on its giant companion star, that only a black hole would fit the bill. X-ray astronomers turned up more such systems that seemed to include "stellar mass" black holes. Others realized that matter accreting onto "supermassive" black holes offered the best solution to the mystery of quasars and active galactic nuclei.

A quirky visionary named John Dobson broke the rules of telescope making to popularize giant scopes on cheap, boxy altazimuth mounts: the Dobsonian reflector. He and his friends originally built them to show off the heavens to people in the sidewalks and parks of San Francisco. Dobsonians became hugely popular, and their large apertures opened up amateur deep-sky observing to a new degree. The 1970s also saw the popularization of the compact Schmidt-Cassegrain telescope, which quickly became as emblematic of the hobby as the refractor and reflector. To accompany the big new scopes, *Burnham's Celestial Handbook* to the deep sky appeared in installments and became a universal must-have.

In the winter of 1976, Comet West lit the morning sky. Readers

No plants, no animals, no canal builders. In 1976 the Viking landers finally revealed Mars to be a bleak and barren desert. This was no surprise to planetologists and *S&T* readers but a letdown to the many others who still held a bit of hope. Here, Viking 2 looks out on Utopia Planitia.

John Dobson aims a Dobsonian telescope — the 24-inch "Delphinium" of the San Francisco Sidewalk Astronomers — during a public astronomy event. Low-cost Dobsonians large and small soon became a central part of amateur astronomy.

NATIONAL ARCHIVES OF AUSTRALIA, A6135:11896739

ESA / NASA HUBBLE

opened *S&T* to discover the finding of Pluto's big moon and the rings of Uranus. Cosmic gamma-ray bursts, first detected by satellites watching for nuclear weapons tests, became an intractable, but clearly important, puzzle. A binary pulsar losing orbital energy indirectly proved the existence of gravitational waves, another triumph for general relativity. The nature of the dark matter showing its influence all over the cosmos became a top problem. And in 1975, a network of clubs began the public-outreach tradition of Astronomy Day.

The 1980s: Halley

Public interest in astronomy took a permanent leap forward in 1980 with Carl Sagan's hit series *Cosmos* on public television. Less visibly, physicist Alan Guth that year had his "spectacular revelation" of how the Big Bang likely worked — whereby known physics could account for the eruption of everything from essentially nothing and explain several other "impossible" features of today's cosmos all at once. Writing about the emerging concept in my first big article after being hired at *S&T,* I came within a hair of inventing the term *multiverse* for the vastly larger ensemble of separate universes, now disconnected from ours, that the theory seemed to imply.

The first Space Shuttle, *Columbia,* launched in 1981. *Challenger* blew up in 1986. Halley's Comet, anticipated by everyone who'd had even a passing interest in astronomy since 1910, proved in 1985 and 1986 to be the distant, poorly placed dud that we had more or less predicted. At least our skilled chart-users could find it with their scopes to show to a disappointed public.

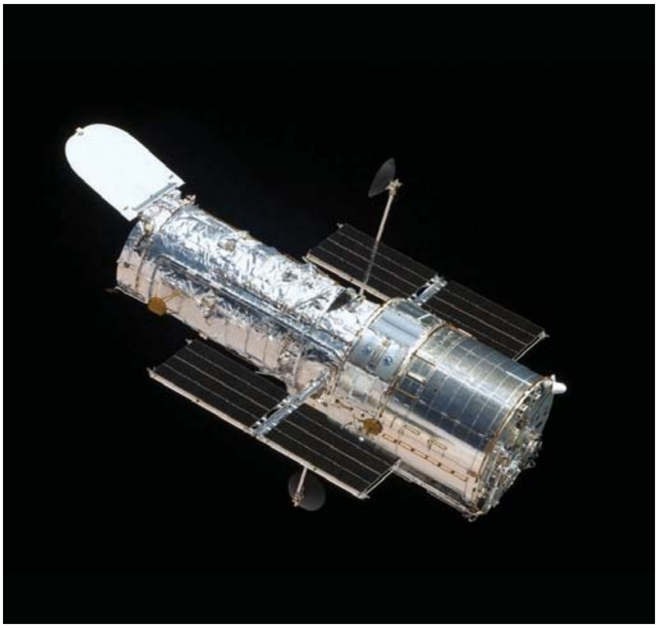
In February 1987, Supernova 1987A in the Large Magellanic Cloud erupted to magnitude 2.9; it was the closest and brightest supernova seen since before the invention of the telescope. A 13-second burst of neutrinos, detected at several places around the globe right about when the explosion should have initiated, confirmed that Type II supernovae result from the sudden collapse of a massive star's core.

The Very Large Array in New Mexico began full operation in 1980, opening today's era of high-resolution, multi-dish radio astronomy. The Dobsonian revolution continued to spread among amateurs. The price of large amateur scopes kept declining in real terms, undercutting amateur telescope making but rendering the hobby ever more accessible.

Alarmists predicted the imminent end of amateur astronomy if light pollution continued to worsen at the rate it was doing. But for the first time, night-sky enthusiasts began gaining the knowledge and organization to do more than wring their hands about it. In Tucson, Arizona, astronomers at Kitt Peak National Observatory met with startling success in getting the city to reduce its waste light beaming sideways and upward. This

Above: **When Comet Halley was at its best in early 1986, naked-eye searchers found it only a little easier to detect than the Lagoon Nebula, M8 (the small pink patch far to the comet's right).**

This Hubble image, taken 24 years after the explosion of Supernova 1987A, shows a faint, oblong debris remnant at center, a ring of much earlier ejecta shining under the impact of the supernova's still-expanding blast wave, and two larger, fainter rings of earlier ejecta. The three rings are part of an hourglass-shaped shell of gas blown off by the progenitor star as it neared the end of its life.



NASA / STSCI

PHILIPP SALZGEBER / CC BY-SA 2.0

effort led to the founding of the International Dark-Sky Association in 1988. It's hard to remember back when the fight was hopeless, when most people ridiculed the notion of "light pollution," and when no one had heard of full-cutoff shielding for outdoor fixtures.

The 1990s: Hubble

The long-anticipated, long-delayed Hubble Space Telescope finally launched in 1990; *S&T* had covered the "Large Space Telescope" project since 1972. Our elation turned to horror when, once opened to the stars, its main mirror immediately proved to have been shaped to the wrong figure. The error was so gross that an amateur telescope maker could have spotted it with a homemade Foucault tester set up on a stepladder aimed at the mirror during the time it was in storage. Not for three years were astronauts able to install corrective lenses near the focal plane to allow the Hubble to see as well as designed. Today, after many other upgrades by visiting Space Shuttle crews and 23 years of spectacular productivity, the primary-mirror catastrophe is all but forgotten.

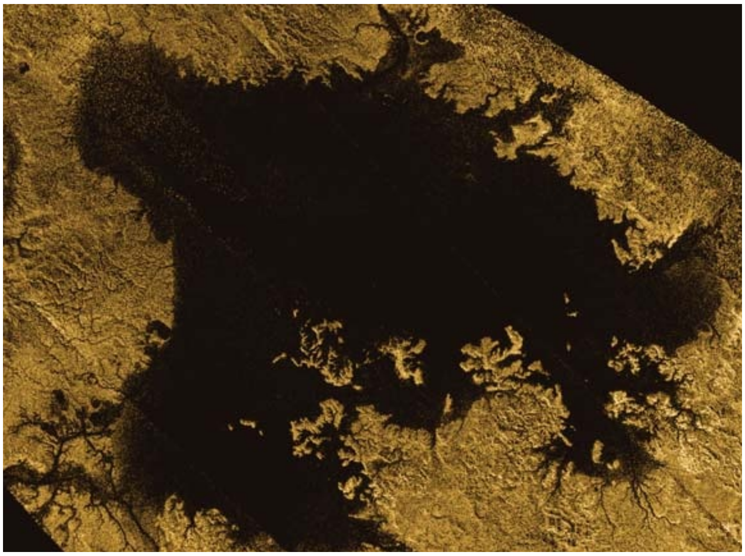
The 1993 repair mission was done just in time for Hubble to follow the fragments of Comet Shoemaker-Levy 9 as they dramatically dove into Jupiter in July 1994, one by one for several days. The impacts left such big, dark marks on Jupiter's cloudtops that you could see them with a 2.6-inch telescope, despite Jupiter's low altitude after dusk. The event dramatized the possibility of devastating impacts in today's solar system. It also revealed the power of the new World Wide Web. For the first time, many of our readers followed the news and pictures on screens rather than on paper.

We had all grown up being taught that the stars are so far away that we could never find any planets they might have. The abundance or scarcity of planets in the universe was one of the greatest unknowns of astronomy. Then in November 1995 came news that a European team had found a giant planet closely orbiting 51 Pegasi, a humdrum Sun-like star just west of the Great Square of Pegasus. They used spectroscopy to track the star's slight radial-velocity wobble induced by the orbiting planet. Teams raced to compete with this new method, and "extrasolar planets" became a new field of astronomy almost overnight. Today at least 3,493 are confirmed, and many more prospects seem likely to be real. The resulting statistics have answered the age-old question: *Most stars have planets*.

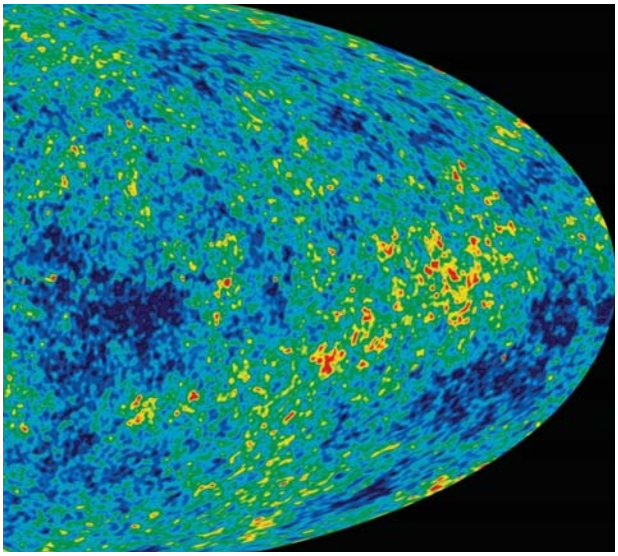
The title of "world's largest telescope" passed to the twin 10-meter Kecks atop Mauna Kea in Hawai'i, the first large telescopes with segmented mirrors. And two great comets finally made up for the disappointment of Halley. The eerie, green-headed, gas-rich Comet Hyakutake (C/1996 B2) whizzed close by Earth in the spring of 1996, with its long, straight gas tail spanning much of

The Hubble Space Telescope at work. Its 2.4-meter mirror was not very large by 1990s professional standards, but with no atmosphere in the way, it provided images with unprecedented resolution that wowed the world. Long before launch, we badgered its handlers to plan for and fully exploit the public's demand for the best possible astronomical imagery.

Comet Hale-Bopp hangs in the western twilight on March 29, 1997. To its lower right glows M31, the Andromeda Galaxy, roughly a match for Comet Halley as it appeared in 1985–86.



NASA / JPL-CALTECH / ASI / CORNELL



NASA / WMAP

the sky for a few nights. The next spring Comet Hale-Bopp shone in the west after dusk, the classic portrait of a bright comet with a curved, dust-rich tail.

The 2000s: Precision Cosmology

The exploration of the solar system continued with Mars orbiters and rovers, missions to asteroids and Comet Tempel 1, Messenger unveiling more of Mercury, and Cassini taking up orbit around Saturn. Cassini's hitchhiking Huygens lander descended through the thick hazes of Titan to find a landscape of riverbeds and methane mudflats. Among Cassini's many other revelations (which continue today), some of the most outstanding are Titan's weather cycle and great polar lakes of methane (liquified natural gas), water-powered geysers spraying out of Enceladus, and the ongoing dynamical intricacies among Saturn's rings.

Astronomers started discovering large Kuiper Belt objects, including an especially big one, Eris, that prompted the 2006 demotion of Pluto to dwarf-planethood. Regarding a supermassive black hole in the center of our own Milky Way, we declared "case closed"; no other explanation remained possible for what was going on there. In 2003, *Columbia* disintegrated with the loss of all on board. The Kepler space observatory launched in 2009, beginning the second wave of exoplanet discovery and analysis — based not on radial-velocity wobbles, but on transits of luckily aligned planets across their stars.

On the grandest scale of all, the 2000s were when "precision cosmology" came of age. NASA's Wilkinson Microwave Anisotropy Probe (WMAP) mapped the afterglow of the Big Bang well enough that cosmologists could finally pin down key cosmic parameters with high accuracy. For instance, the Big Bang happened 13.8 billion years ago. Everything about the universe — including the origin of galaxies, galaxy clusters, and the largest cosmic structures of galaxy strings and walls — proved to be an essentially perfect match for the inflation process behind the Big Bang. As most recently refined, the cosmos consists of 4.9% normal matter (stuff made of atoms and atomic particles), 26% dark matter made of something else unknown, and 69% "dark energy," the whimsical name given to a completely inexplicable property of space itself that's causing the expansion of the universe to speed up. Coincidentally, the expansion speedup had already just been discovered, totally unexpectedly, in 1998.

Add it all up and it comes to just the right total density of matter plus energy — to about 0.5% accuracy at this point — to render space flat and infinite, as predicted by the inflation theory. This, in turn, has made the issue of a multiverse, something thoroughly outlandish to many scientists, more pressing.

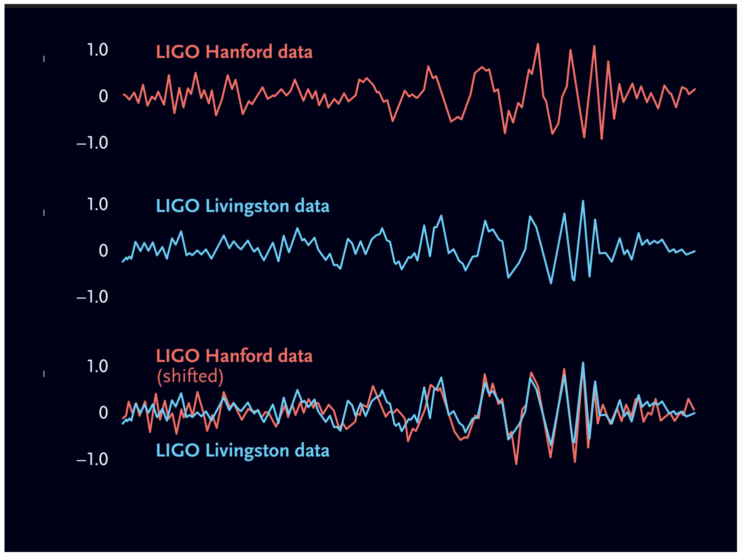
The 2010s: What Next?

So far, the new decade of *S&T* has seen Messenger take up orbit around Mercury, Dawn orbit the big asteroid Vesta and then move on to Ceres, the Curiosity rover crawl up the slopes of Mount Sharp on Mars, and, just

Above: **Titan's Ligeia Mare is about 500 kilometers (300 miles) wide. In this composite radar image from Cassini, the rough uplands of bedrock-hard water ice are tinted yellow. The methane sea and flooded river canyons reflect no radar back to the spacecraft, except for a little from the seabottom in shallow edges.**

Part of WMAP's final (9-year) all-sky map showing temperature differences in the cosmic microwave background radiation. From red to blue, its temperature at different points on the sky differs by only a few parts per hundred thousand.

NASA / JHU APL / SWRI



S&T: LEAH TISCIONE, SOURCE: CALTECH / MIT / LIGO LAB

this July, Juno reach Jupiter orbit. Voyager 1, at more than twice the distance of Pluto, finally left the solar system's heliosphere of solar wind and entered true interstellar space.

The European Space Agency's Planck mission, successor to WMAP, refined precision cosmology and, unexpectedly, played a key role in astronomy's biggest goof in a very long while. In March 2014 a team based at Harvard announced that their experiment at the South Pole, known as BICEP-2, had found the Holy Grail of cosmic microwave background studies. Slight patterns of polarization in the microwaves, they announced, seemed to be relics of the instant of Big Bang inflation itself — patterning the sky with fantastically magnified images of individual gravitons seen some 10^{-35} second after our Big Bang budded off from. . . what? Perhaps an eternally inflating, superdense matrix that exists *outside,* spawning multiverses. This would have been inflation's smoking-gun proof. It was our July 2014 cover story.

Alas, the team had relied on a map displayed at a conference by the competing Planck team, which seemed to show that the part of the sky the BICEP team was watching had no foreground dust to mimic the polarization signal. They'd misinterpreted the Planck map; dust was indeed present and could account for the entire observed signal. So it was back to square one. Deeper and better searches for the polarized inflation signal are under way.

New Horizons flew past Pluto and its bevy of moons on July 14, 2015, returning images of an inexplicably active world, with young, craterless plains of soft nitrogen ice, nitrogen glaciers, and signs of a thick atmosphere in the recent past (see page 18). Little Pluto, the non-planet, was getting the last laugh.

And in the 100th anniversary year of general relativity, LIGO caught gravitational waves from the merger of two black holes far across the universe. The new field of gravitational-wave astronomy promises a bright future.

What unexpected cosmic revelations will the rest of the decade, and the century, bring? We don't know, but we will, and we'll be telling you all about them. ✦

Alan MacRobert has worked at Sky & Telescope *for 34 of its 75 years and has been reading it for 50.*

Curiosity took pictures to assemble this self-portrait as it rested on a ridge on the slopes of Mount Sharp. The question of *microscopic* life on Mars, at least, is not dead yet.

NASA / JPL-CALTECH / MALIN SPACE SCIENCE SYSTEMS / JAMES SORENSON

Pinpoints no more, Pluto and Charon revealed their unexpectedly youthful glories to New Horizons during its flyby in July 2015. The craft is now on its way to fly past the smaller Kuiper Belt object 2014 MU_{69} on January 1, 2019.

Top: **On September 14, 2015, the twin LIGO detectors in Hanford, Washington, and Livingston, Louisiana, detected the death-chirp of two black holes spiraling together, with waveforms that exactly matched predictions. The detections came 7 milliseconds apart — the difference in light-travel time.**

Small Scope Asterisms

LEARN ABOUT THE STORIES BEHIND THESE WHIMSICAL STAR PATTERNS & WHERE TO FIND THEM.

TROY STRATTON

For thousands of years human beings have looked up to the night sky and created shapes, figures, and patterns with the stars. Stars of similar brightness (magnitude) appeared to be the same distance from Earth, making it easy for humans to play "connect-the-dots" with them. Different cultures had different concepts and ideas about the cosmos, which gave rise to a wealth of stories and explanations, sometimes for the same starry patterns. This apparently universal but informal sorting of the stars continued until 1930, when the world's astronomers gathered to divide the sky into 88 constellations, the boundaries of which were designed to give the viewing of the night sky a sense of order and to make it easier for astronomers to communicate with one another.

Even so, there's no "official" way to draw patterns for any of the 88 constellations. For instance, while all astronomers agree on the boundaries of Scorpius, the finder charts in *Sky & Telescope* may connect the dots to the Scorpion's claws differently than will a chart in another book or celestial atlas. And just because we've officially named the 88 sectors, it doesn't mean we don't see other figures in the night sky as well. The patterns and stories of yesteryear linger, the images and shapes supposedly subsumed into formal constellations still draw the eye. These long-lived patterns, sometimes existing within a single constellation, sometimes built from parts of several constellations, are called *asterisms*.

> Some have no distinctive shape or size, resembling nothing but an open cluster.

Asterisms are easy to recognize but aren't formally recognized as constellations. For example, many believe — as I once did — that the Big Dipper is a constellation. But the stars of the Dipper number only a small portion of the several that formed the ancient constellation Ursa Major, the Great Bear. Many constellations started as asterisms. Consider the constellation Cassiopeia, the Queen. Its main stars form the familiar W (or M, depending on the season and your vantage point) asterism. Those same stars originally sketched the shape of the seated queen, and over time, they helped define the modern constellation.

Not everyone agrees on the definition of an asterism, however. According to the IAU, asterisms are "patterns or shapes of stars that are not related to the known constellations, but nonetheless are widely recognized by laypeople or in the amateur astronomy community." This is a rather broad definition, and while the IAU recognizes their existence, it doesn't track or catalog asterisms. The Astronomical League (AL) Asterism Observing Program uses a narrower definition, considering an asterism to be "a group of stars that appear to be associated with each other, but are not." So, while some regular contributors to *Sky & Telescope* may consider the E.T. or owl pattern seen in NGC 457 in Cassiopeia an asterism, the AL does not, because all the figure's member stars are part of the same cluster. (A star cluster consists of a group of gravitationally bound stars of similar age and composition.) The AL still includes NGC 457 on its asterism

ISTOCKPHOTO / ISPYFRIEND

observing list, however, because it's a fun, popular target. Similarly, NGC 2169 in Orion, the brightest stars of which form the number "37," wouldn't be considered an asterism by the AL, because the component stars are gravitationally bound to one another.

Some asterisms have no distinctive shape or image, resembling nothing but an open star cluster. For instance, **Levy 384** in Puppis looks like an open star cluster, but since the stars aren't gravitationally bound or physically related to one another, it's really a non-distinct asterism. Or take the less popular asterism **M73**, which is often omitted from Messier lists. Its four stars were thought to have a gravitational connection as well as nebulosity, but they turned out to be a simple asterism.

Many asterisms have very distinct shapes, though, such as the "Teapot" of Sagittarius. Some can be as simple as a row of several stars, as in the case of **Kemble's Cascade** in Camelopardalis (*S&T:* Jan. 2016, p. 43), yet still offer a very striking view.

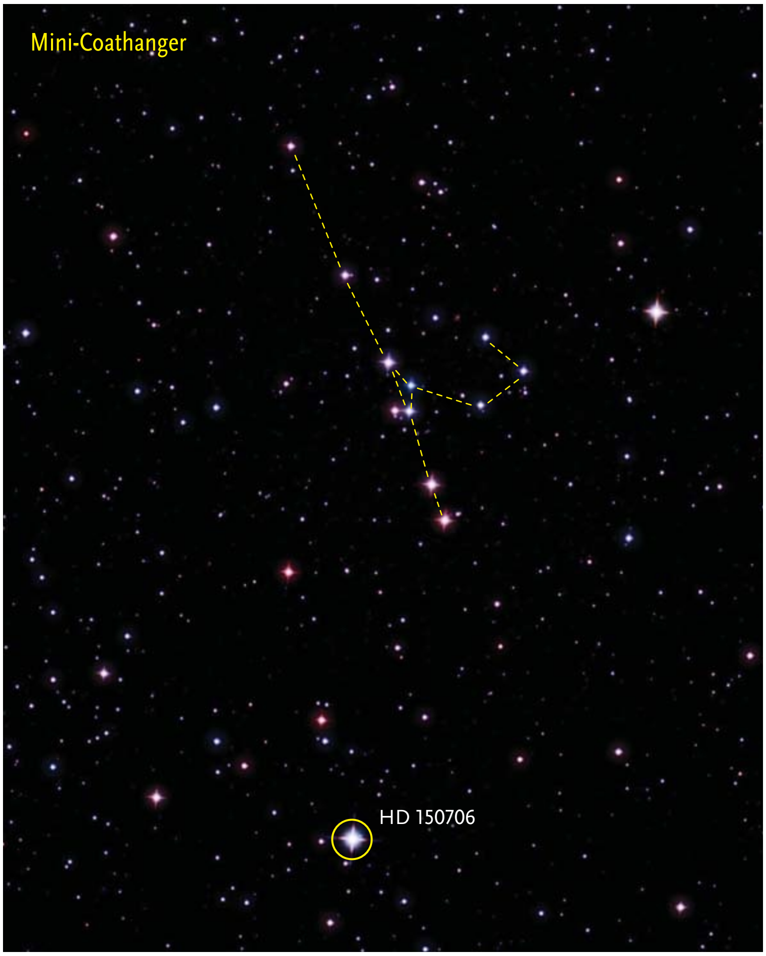
The conflicting definitions and openness to variation allows anybody to discover and name an asterism of their choosing, even if the given name won't be official or documented by a body like the IAU. It also means that someone else could "discover" the same group of stars and assign it a name of their own. For instance, amateur astronomer Herman Heyn wrote about a group of stars in the shape of a cross that he called "Herman's Cross" (the cross appears in any number of photographs of Halley's Comet, including those on pages 560-61 of the June 1986 issue of *Sky & Telescope*). When describing the asterism, Heyn noted that these same stars were mentioned over 1,500 years ago by the astronomer Ptolemy, who called the shape *tetrapleuron*, meaning "quadrilateral" in Greek. Would Ptolemy's recognition make null and void the Heyn's asterism name? No, it wouldn't. The IAU doesn't govern priority, and for the Astronomical League, only one rule applies, and that's the rule of association. I could even start calling the popular asterism Kemble's Cascade "Troy's Waterfall" and nobody could do anything about it. That's not to say that the amateur astronomy community would be very receptive to it, but I could certainly do it.

Aided-Eye Asterisms

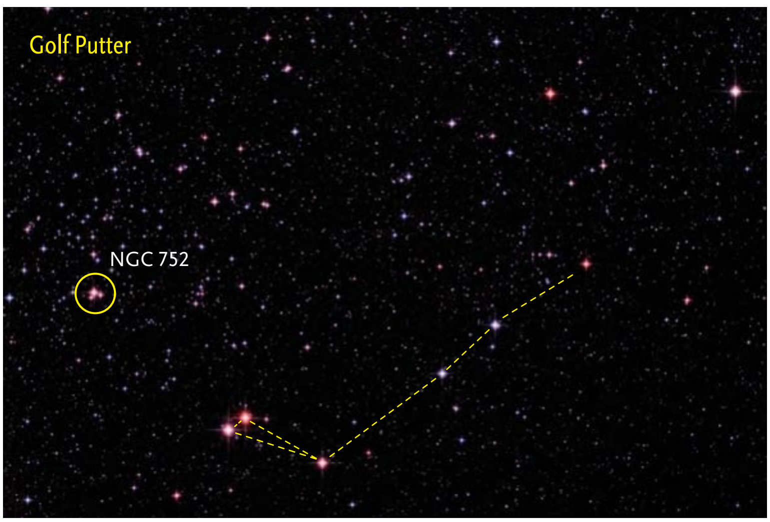
The Big Dipper and the W of Cassiopeia are two well-known naked-eye asterisms. All you have to do is look up on a clear night and you'll be able to pick out their forms. Indeed, the stars forming these two asterisms are relatively bright, so even urban dwellers in light-polluted areas can often spot them. But there's another scale of asterisms available for observing as well. Pull out the binoculars or a small telescope, and a whole new world of star patterns will appear before your eyes. As creator/coordinator of the Astronomical League's Asterism Observing Program, I've compiled a short list of binocular and telescopic asterisms that have proved to be popular, in addition to a few the lesser known figures that offer a pleasant view.

COSMIC CLOAKROOM The orange giant 4 Vulpeculae marks the top of the Coathanger's curve.

HERBERT WALTER



BABY BROTHER The discovery of the Mini-Coathanger in Ursa Minor is credited to Tom Whiting, President of Erie County Mobile Observers Group. At approximately 20 arcminutes across, the Mini is much smaller than the original Coathanger asterism.



DAVID RATLEDGE (2)

GET IN THE HOLE! The handle of the Golf Putter asterism is not quite 2° long. NGC 752, ½° northeast of the end of the club head, serves as the ball in this game of golf among the stars.

One of the most distinctive and well-known binocular asterisms is the **Coathanger**, also known as Brocchi's Cluster, in Vulpecula. Officially cataloged as Collinder 399, this intriguing group of stars was once thought to be a part of an open cluster. However, recent studies prove that the stars are not associated with one another, so now the cluster is "only" an asterism. With stars ranging from magnitude 5.2 to 7.1, the Coathanger is just out of range of the naked eye but easily observable with small binoculars. Look for the brightest, *K*-type orange giant 4 Vulpeculae at the top of the hanger's hook.

Many stargazers are familiar with the Coathanger, but what about the **Mini-Coathanger** in Ursa Minor? Its form is similar to its big brother's but smaller and dimmer, with stars ranging in brightness from 9th to 11th magnitude. Five stars, with three grouped towards the center, make the bar, while another three stars serve as the hook. To find the Mini, start at Epsilon (ε) Ursae Minoris and move about 2½° south to an irregular quadrilateral about 1° across, composed of four 6th- and 7th-magnitude stars. Now look ½° north of HD 150706, the northwesternmost of the four stars. The Mini-Coathanger is similar to the larger version in Vulpecula.

There appears to be an endless number of asterisms named for tools or gardening implements: trowels, spades, drills, and palm sanders. Maybe we amateur astronomers are a handy bunch, or maybe we just like to be in motion, because we've also mapped the stars to our leisure activities. One of the better known asterisms of this sort is the **Golf Putter** in Andromeda. A chain of six stars, ranging in magnitude from 5 to 7, create the handle, with a double star forming the club head. The close proximity of star cluster NGC 752 not only serves as a reference point for locating the putter, but completes the asterism by serving as the golf ball. To find the Golf Putter, tee off at Gamma (γ) Trianguli, fly along a straight line northwest to Beta (β), then continue 4° beyond that star. This is a pretty easy target, but due to its large size, almost 2° in length, your best looks will come through binoculars with a wide field of view.

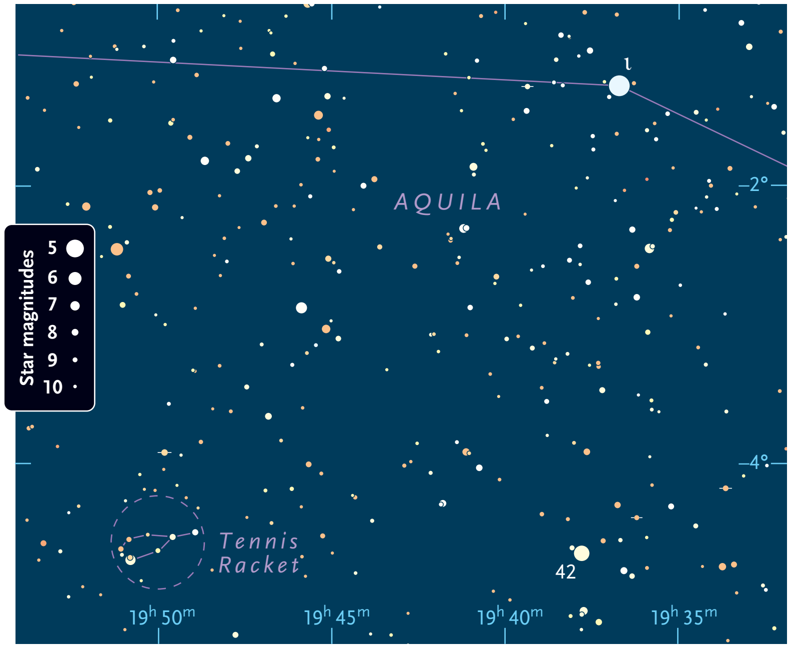
But perhaps you're more of a racket sports person. I really enjoy the asterism dubbed the **Tennis Racket** by John Chiravalle, author of *Pattern Asterisms: A New Way to Chart the Stars* (2006). Found within the constellation Aquila, six stars create the racket oval and two more complete the handle. The asterism's 8th- to 9th-magnitude stars are technically within reach of 10×50 binoculars, but this is a diminutive figure, so consider using a medium-aperture telescope to study it. What I like the best about this asterism is the single 6.8-magnitude star, HD 187570, that serves as the tennis ball. You can find the racket 3° east of star 42 Aquilae.

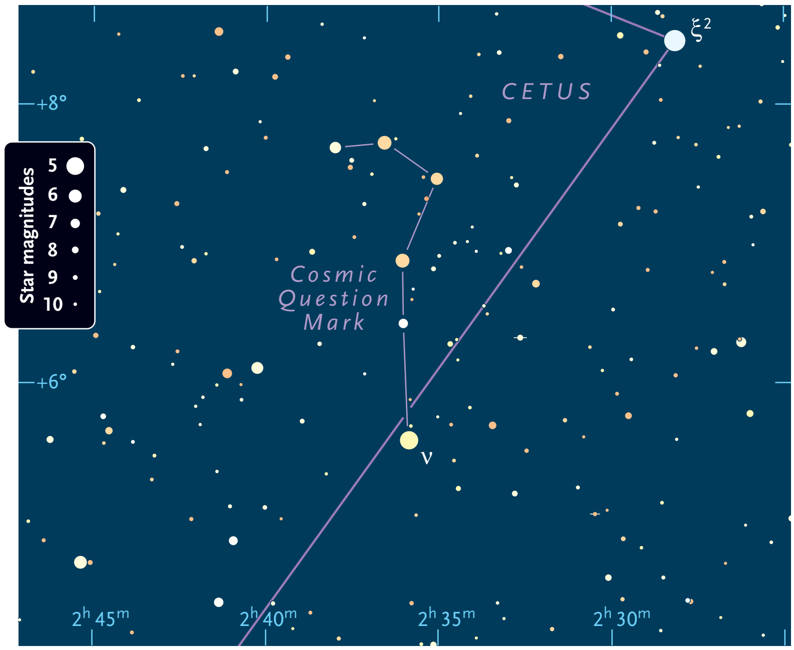
As I was looking for more asterisms to add to the Astronomical League Observing Program, I noticed a reference to an asterism in the Royal Astronomical

Society of Canada's *Observer's Handbook* under "David Levy's Deep-Sky Gems." The entry led me to an internet search for Levy objects (*S&T*: Dec. 2005, p. 80). Levy's lists included **Levy 157**, an asterism in which 8 to 12 stars take the shape of a cane in Cygnus. Find this interesting pattern by drawing an imaginary line from 15 Cygni to 22 Cygni. Look for HD 187880 about halfway between the two stars; Levy 157 is about 20′ west of this 6th-magnitude star. The head of the cane points southwest toward 7.6-magnitude HD 187374. At magnitude 9.0, the cane is somewhat faint, but it should be visible in a small scope even with suburban light pollution. I had no trouble seeing it with my 6-inch reflector; however, it should be even easier to see with darker skies.

Part of the fun of asterisms is discovering your own. While investigating an asterism in the constellation Orion, I chanced upon five stars of similar magnitude that took the rough shape of a backwards capital Sigma (Σ). When I spotted a fainter star adjacent to the form, I suddenly envisioned a **Metronome** lying on its side. It's possible to view this asterism with binoculars, just 1° northwest from the shoulder star Gamma (γ) Orionis (Bellatrix). It's faint, though, shining at magnitude 8. A small telescope at low power brings out all six stars.

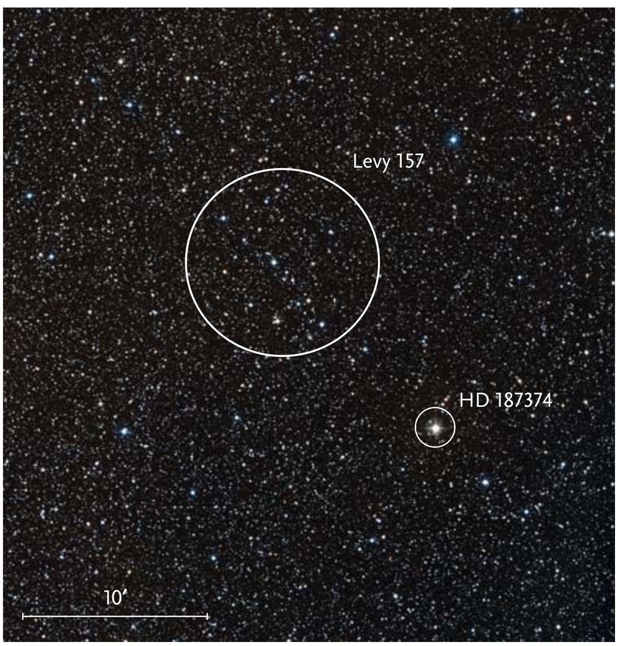
Once, thumbing through my star atlas, I noticed a group of stars in the shape of a question mark southeast of Xi^2 (ξ^2) Ceti. Thinking that I had found an asterism,

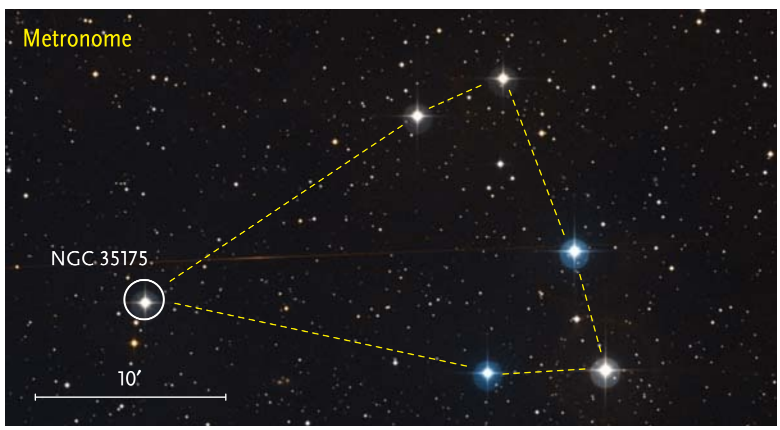




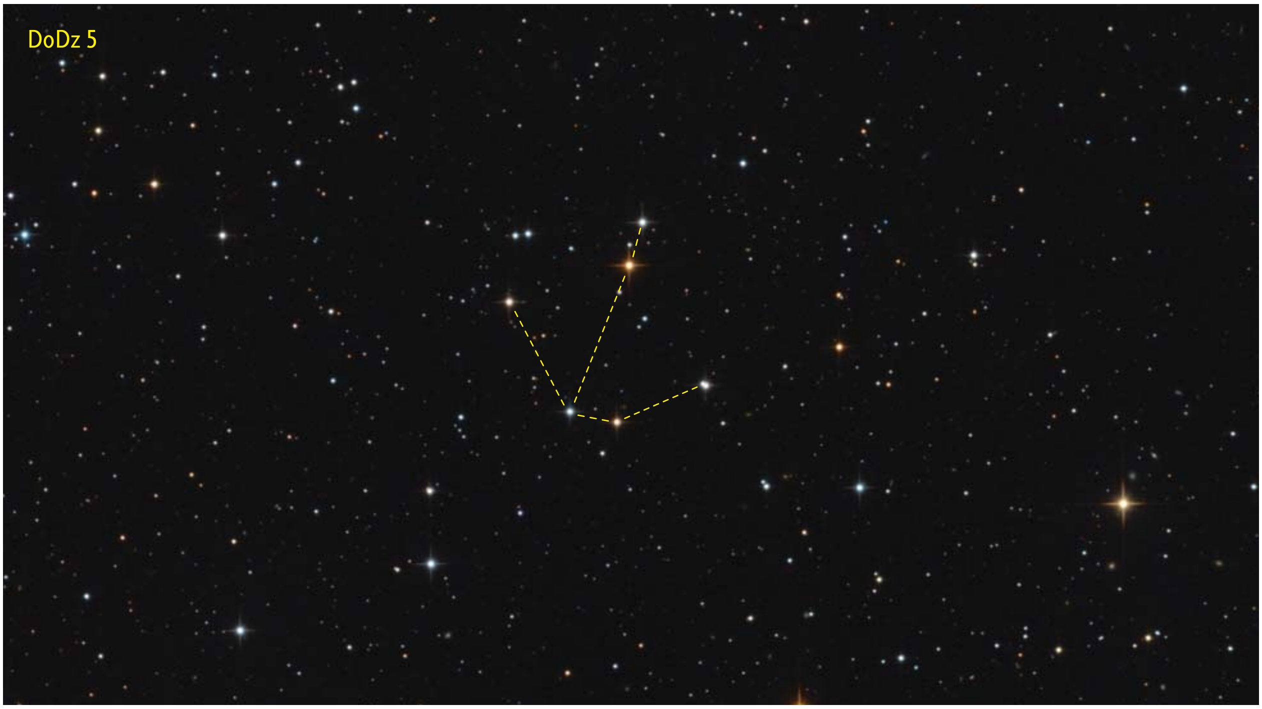
A CANE IN CYGNUS *Below:* Levy 157 lies about halfway between 15 Cygni and 22 Cygni.

KEEPING THE BEAT *Lower right:* The author fashioned a metronome out of the several 7th- and 8th-magnitude stars shining 1° northwest of Gamma Orionis.



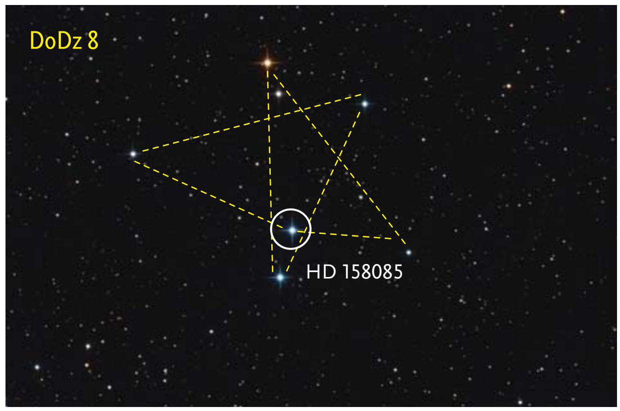


POSS-II / STSCI / CALTECH / PALOMAR OBSERVATORY (2)



HERBERT WALTER (2)

ASTERISM, AHOY Connect the 9th- and 10th-magnitude dots to form a ship's anchor out of DoDz 5 in the dim reaches of Hercules.



GOOD JOB Its pattern is a bit irregular, but with just a bit of imagination, the stars of DoDz 8 can be configured into a drawing of a five-pointed star.

I did an internet search only to learn that my question of having found a new asterism had been quickly answered: it's called the **Cosmic Question Mark**. With a magnitude between 5 and 7, it's easy to view in binoculars. Nu (ν) Ceti serves as the base of the question mark. Look 50′ north of Nu to the bottom of the curve; four more stars round out the punctuation mark.

Having served in the United States Navy years ago, when I saw the asterism **DoDz 5** in Hercules, I immediately thought of a ship's anchor. Four 8th-magnitude stars form its arms and crown, with two more providing the shank. Sail toward this asterism by starting at Eta (η) Herculis and floating 3° 45′ west to 25 Herculis. The brightest point in the anchor, the 9th-magnitude star pinning the middle of the shank, lies 47′ north-northeast of 25 Her. At a size of 16′ across, it's relatively simple to spot with a small telescope in suburban night skies.

On the opposite side of Hercules, look for the five-pointed star pattern of **DoDz 8**. Start at Delta Herculis and starhop 1½° east to 70 Herculis, then move just about the same distance farther east. There you'll find seven 8th- and 9th-magnitude stars arranged in a rough star shape. The DoDz clusters, discovered by astronomers Madona Dolidze and Galina N. Jimsheleishvili, may or not be open clusters (*S&T:* Oct. 2015, p. 55). If future research proves these stars to be physically related, we may have to revisit our list of asterisms!

If I've piqued your interest in asterisms big and small, review the current Astronomical League asterisms at **https://is.gd/ALAsterism** or go out and seek your own. That's the fun of asterisms! We don't need high-tech, expensive gadgets, nor do we need to give up our careers to become full-time astronomers for a chance at discovery. The only tools necessary? A pair of eyes (or possibly low-power optics), clear skies, and imagination. Asterisms allow stargazers the opportunity to use our imaginations and discover something unique in the night sky for ourselves. Most of all, asterisms encourage us to see the natural beauty of the surrounding heavens. ✦

***Troy Stratton** is Program Chair of the Astronomical League's Asterisms Observing Program.*

In This Section

Emission from oxygen atoms, here captured through an O III filter and mapped to blue, dominates the core of IC 1396; see page 57.

PHOTOGRAPH: BOB FRANKE

NOVEMBER 2016

2–3 NIGHT: Algol shines at minimum brightness for roughly two hours centered at 11:42 p.m. November 2nd PDT (2:42 a.m. November 3rd EDT); see page 51.

5 EVENING: The waxing crescent Moon hangs about 7° right or upper right of Mars (for North America).

8 EVENING: Algol shines at minimum brightness for roughly two hours centered at 7:19 p.m. EST.

14–15 NIGHT: The Moon, just past full, shines near Aldebaran and the Hyades.

17 MORNING: The weak Leonid meteor shower peaks before dawn, but skyglow from the waning gibbous Moon will hide all but the brightest meteors.

21 MORNING: Look for 1st-magnitude Regulus, the forefoot of Leo, less than 2° above the last-quarter Moon.

24 MORNING: Look for Gamma (γ) Virginis about 2° lower left of the Moon.

25 DAWN: The crescent Moon, Jupiter, and Spica form a triangle about 9° tall in the southeast.

25–26 NIGHT: Algol shines at minimum brightness for roughly two hours centered at 12:13 a.m. November 26th EST (9:13 p.m. November 25th PST).

28 NIGHT: Algol shines at minimum brightness for roughly two hours centered at 9:02 p.m. EST.

Planet Visibility

SHOWN FOR LATITUDE 40° NORTH AT MID-MONTH

	◀ SUNSET	MIDNIGHT	SUNRISE ▶
Mercury	Hidden in the Sun's glare all month		
Venus	SW		
Mars	S SW		
Jupiter			E SE
Saturn	SW		

Moon Phases

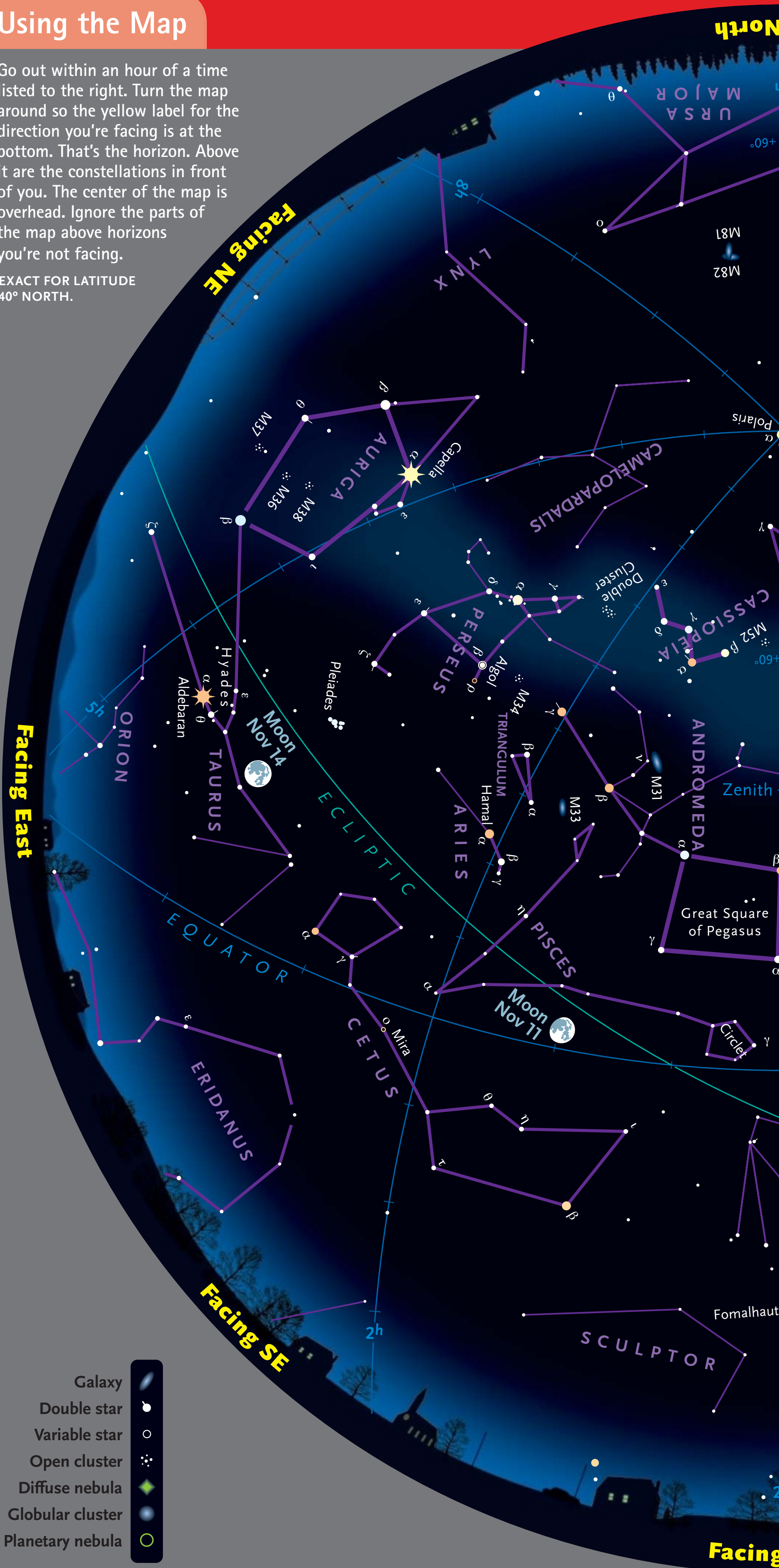
- First Qtr November 7 2:51 p.m. EDT
- Full November 14 8:52 a.m. EDT
- Last Qtr November 21 3:33 a.m. EDT
- New November 29 7:18 a.m. EDT

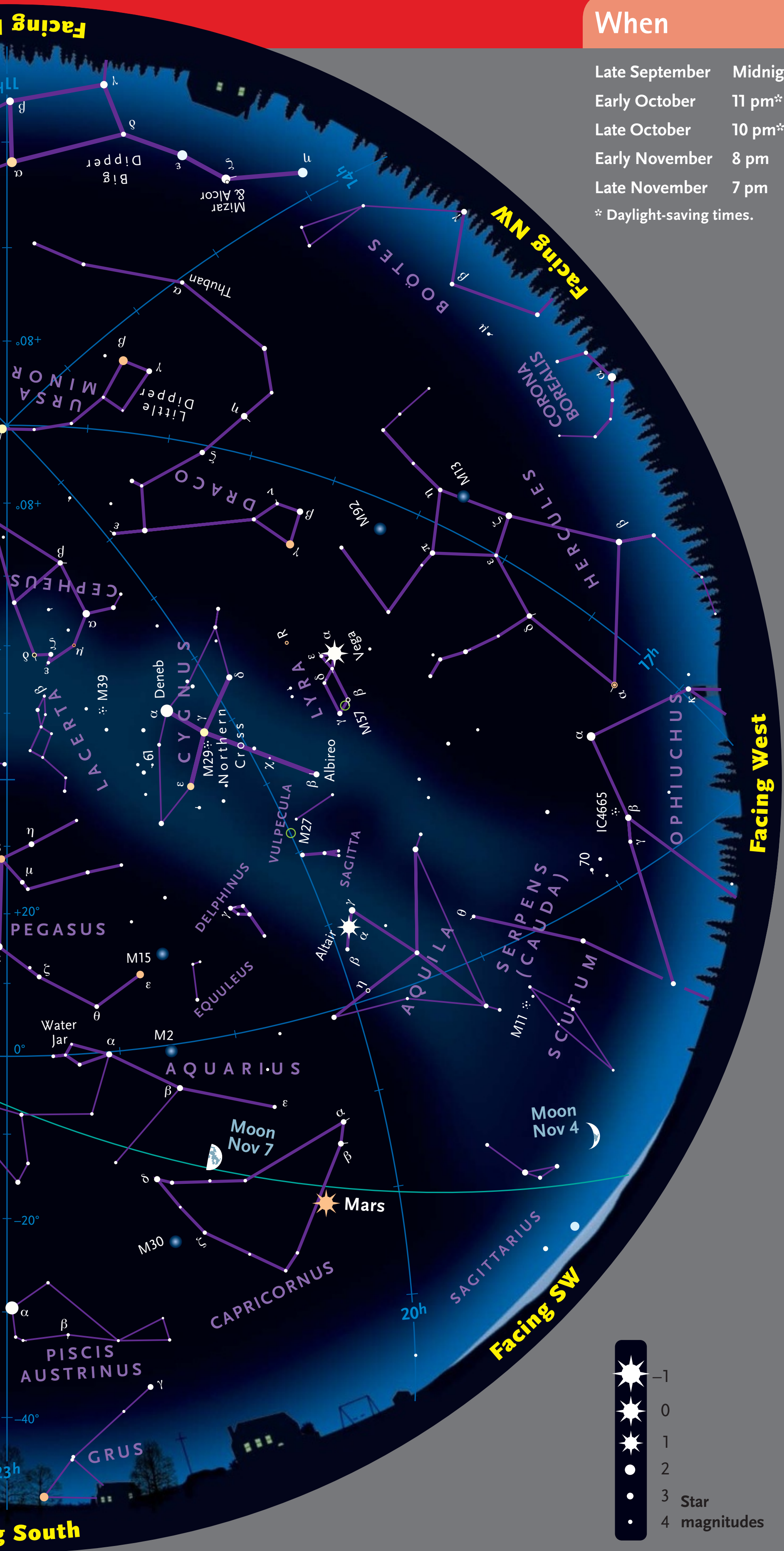
SUN	MON	TUE	WED	THU	FRI	SAT
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30			

Using the Map

Go out within an hour of a time listed to the right. Turn the map around so the yellow label for the direction you're facing is at the bottom. That's the horizon. Above it are the constellations in front of you. The center of the map is overhead. Ignore the parts of the map above horizons you're not facing.

EXACT FOR LATITUDE 40° NORTH.





When

Late September	Midnight
Early October	11 pm*
Late October	10 pm*
Early November	8 pm
Late November	7 pm

* Daylight-saving times.

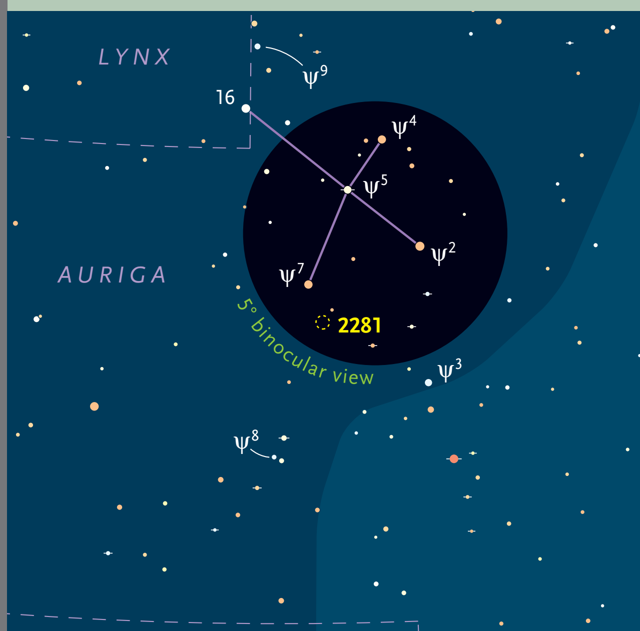
The Charioteer's Cross

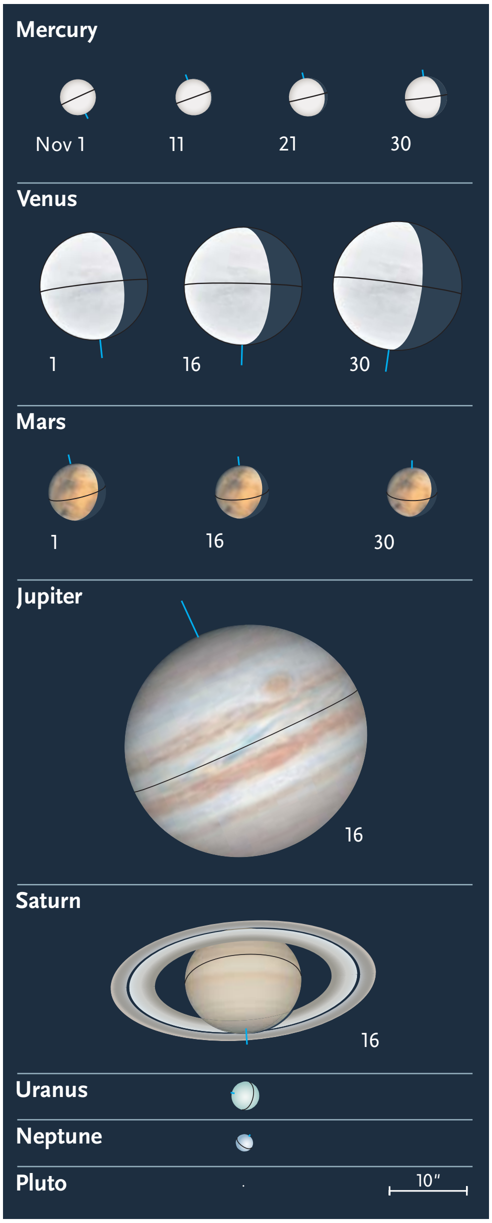
The constellation Auriga, the Charioteer, is a favorite for binocular observers. The center of the constellation is heaped with bright stars, clusters, and asterisms — glittering rewards for a victorious chariot-racer, it seems. But other treasures lurk in the Charioteer's northern reaches.

The open star cluster **NGC 2281** is one such gem. It's a bright target in an uncrowded part of the sky, and it turns up regularly on "best of" target lists for both binoculars and telescopes. At 1,800 light-years away, it's both farther out from the center of the galaxy than we are, and above the disk of the Milky Way.

NGC 2281 also lies just 1° south of a delightful cross-shaped asterism. Both cluster and asterism are easy to find. Draw a line from bright Alpha (α) Aurigae (Capella) east past Beta (β) Aurigae, the next star around in the Auriga pentagon, and onward for an equal distance. The cross is 4° tall and 3° wide, with its base to the northeast and its arms extending northwest-southeast.

The five stars marking the cross are a varied bunch. The central star, Psi^5 (ψ^5) Aurigae, is a *G*-class main sequence star similar to our Sun and lying only 55 light-years from Earth. The arms and head of the cross, Psi^4, Psi^7, and Psi^2 Aurigae, are *K*-type giants between 320 and 420 light-years away. The base of the cross is 16 Lyncis, formerly Psi^{10} Aurigae, an *A*-class main sequence star just across the border in the constellation Lynx, the Wild Cat. Together the five stars make a charming sight in binoculars. They're also well worth revisiting with a telescope: Psi^2, Psi^5, and Psi^7 Aurigae are double stars with separations of ½′ or more. ✦



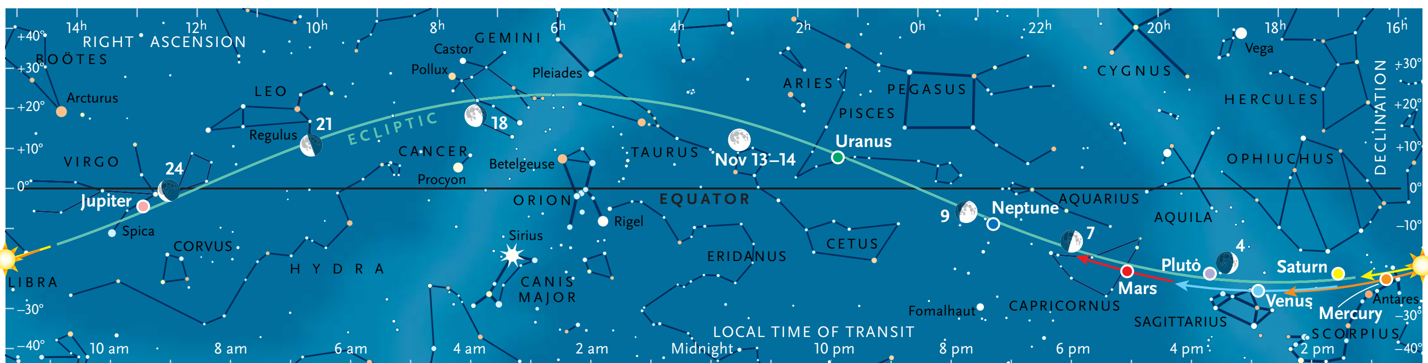


Sun and Planets, November 2016

	November	Right Ascension	Declination	Elongation	Magnitude	Diameter	Illumination	Distance
Sun	1	$14^h 25.5^m$	–14° 25′	—	–26.8	32′ 14″	—	0.993
	30	$16^h 24.8^m$	–21° 38′	—	–26.8	32′ 26″	—	0.986
Mercury	1	$14^h 36.3^m$	–15° 15′	3° Ev	–1.3	4.7″	100%	1.440
	11	$15^h 39.0^m$	–20° 35′	9° Ev	–0.7	4.7″	97%	1.422
	21	$16^h 43.1^m$	–24° 13′	14° Ev	–0.5	5.0″	93%	1.348
	30	$17^h 41.0^m$	–25° 45′	18° Ev	–0.5	5.5″	85%	1.231
Venus	1	$16^h 59.8^m$	–24° 27′	38° Ev	–4.0	14.0″	78%	1.191
	11	$17^h 52.6^m$	–25° 31′	40° Ev	–4.0	14.8″	75%	1.126
	21	$18^h 45.4^m$	–25° 22′	41° Ev	–4.1	15.7″	72%	1.060
	30	$19^h 31.9^m$	–24° 12′	43° Ev	–4.2	16.7″	69%	0.998
Mars	1	$19^h 44.0^m$	–23° 15′	75° Ev	+0.4	7.5″	86%	1.251
	16	$20^h 30.1^m$	–20° 43′	71° Ev	+0.5	7.0″	87%	1.343
	30	$21^h 12.3^m$	–17° 40′	67° Ev	+0.6	6.5″	88%	1.431
Jupiter	1	$12^h 42.1^m$	–3° 18′	28° Mo	–1.7	31.2″	100%	6.312
	30	$13^h 02.4^m$	–5° 22′	52° Mo	–1.8	32.8″	99%	6.013
Saturn	1	$16^h 51.9^m$	–21° 09′	35° Ev	+0.5	15.3″	100%	10.836
	30	$17^h 05.7^m$	–21° 32′	10° Ev	+0.5	15.1″	100%	11.017
Uranus	16	$1^h 18.8^m$	+7° 38′	147° Ev	+5.7	3.7″	100%	19.106
Neptune	16	$22^h 43.8^m$	–9° 00′	105° Ev	+7.9	2.3″	100%	29.678
Pluto	16	$19^h 06.0^m$	–21° 28′	52° Ev	+14.3	0.1″	100%	33.820

The table above gives each object's right ascension and declination (equinox 2000.0) 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. is 149,597,871 kilometers, or 92,955,807 international miles.) For other dates, see SkyandTelescope.com/almanac.

Planet disks at left have south up, to match the view in many telescopes. Blue ticks indicate the pole currently tilted toward Earth.



The Sun and planets are positioned for mid-November; the colored arrows show the motion of each during the month. The Moon is plotted for evening dates in the Americas when it's waxing (right side illuminated) or full, and for morning dates when it's waning (left side). "Local time of transit" tells when (in Local Mean Time) objects cross the meridian — that is, when they appear due south and at their highest — at mid-month. Transits occur an hour later on the 1st, and an hour earlier at month's end.

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

Fred Schaaf

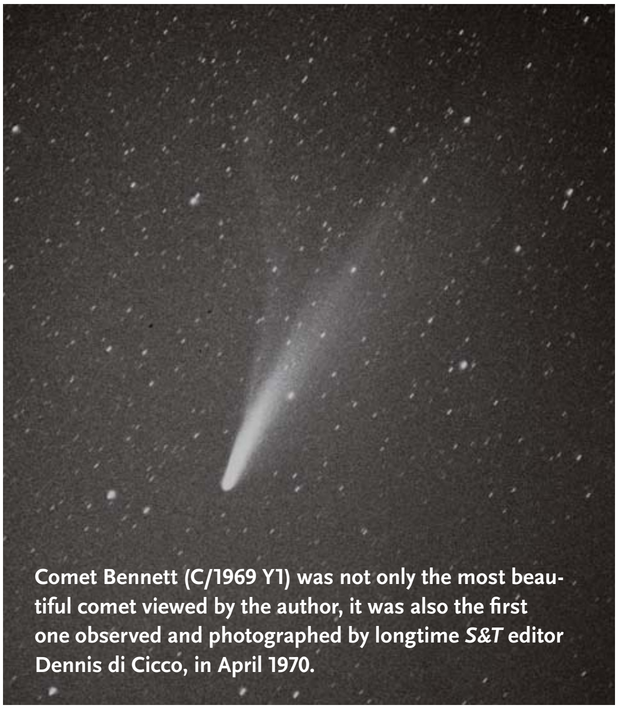
Diamond Anniversary

Mark the occasion with an exploration of royal riches.

We're all celebrating 75 years of *Sky & Telescope* this month. I started teaching myself the constellations when I was six years old, but as a child living in a rural area decades before the invention of the internet, I didn't get a chance to see the magazine until the month after men first landed on the Moon. I was 14, and my mother and I were visiting one of my sisters who then lived in East Lansing, Michigan — and took me to the Abrams Planetarium. There I saw and bought my first issue of *Sky & Telescope*.

It was love at first sight. I immediately started a subscription. In those days, the magazine featured legendary figures of observational astronomy like deep-sky pioneer Walter Scott Houston and ultimate comet consultant John Bortle. Were it not for the *S&T* alert about the imminent arrival of "Bright Comet Bennett" in early 1970, I may well have missed what I still regard as the most beautiful comet I've ever seen.

Now, as I approach a half-century of reading *Sky & Telescope*, and more closely approach a quarter-century of writing the "stars" and "planets" columns in the magazine, I feel *S&T* has never been better. Let's celebrate with a quick look at November's rulers of the high north, Cassiopeia and Cepheus, and at one part of astronomy's future.



Comet Bennett (C/1969 Y1) was not only the most beautiful comet viewed by the author, it was also the first one observed and photographed by longtime *S&T* editor Dennis di Cicco, in April 1970.

Riches of the King and Queen. In last month's column I argued that Cepheus was underrated and described wonders in the Cepheus Milky Way's "spur to Kurhah" and "Delta Cephei triangle." But there's more in Cepheus: the oldest and most northerly open star cluster NGC 188; the Cepheus–Cygnus border "odd couple," galaxy NGC 6946 and open cluster NGC 6939; and yet another lovely double star Beta (β) Cephei (Alfirk).

Last month, our illustration came from *S&T*'s new celestial globe. The globe shows open cluster M52 in Cassiopeia (between the main bodies of Cassiopeia and Cepheus) and four fine open clusters (M103, NGC 663, NGC 559, and NGC 457), all within just a few degrees of the bright zigzag of the Queen's main pattern. But if you go deeper — with the *Pocket Star Atlas, Jumbo Edition* (also, like the new globe, a new creation by *S&T* veteran Roger W. Sinnott) — you'll find no less than 13 open star clusters within a few degrees of Cassiopeia's W figure.

I have seen the future and it is Cepheus. Well, actually, I have seen the future positions of the north celestial pole (on a map in Guy Ottewell's *Astronomical Companion*) and those positions are in Cepheus. Most of us have at some time noticed a cleared lot or start of a construction site with a "Future Home of . . ." sign, followed by the name of a shopping plaza, hospital, or some other building. I can almost imagine such a sign when I move my telescope through the starfields of Cepheus: "Future Home of North." Within just a few hundred years the pole will pass from Ursa Minor to Cepheus.

We often hear that 2,500 years ago the pole was fairly near Beta and Gamma (γ) Ursae Minoris (Kochab and Pherkad, "the Guardians of the Pole"). This proximity led Thales of Miletus to reputedly turn the wings of Draco into the Little Bear, inventing Ursa Minor. We also hear that the early Egyptians had Alpha (α) Draconis (Thuban) as their pole star, quite close to the pole around 2800 BC. But we less often hear about our future pole stars in Cepheus. The pole will be closest to Gamma Cephei (Errai) in about AD 4200, pass lovely double Xi (ξ) Cephei (Kurhah) around the year 6700, come within a few degrees of Alpha Cephei (Alderamin) around 7500, and edge by Mu (μ) Cephei (Herschel's Garnet Star) around 8000. ✦

Evening on the Ecliptic

Venus, Saturn, and Mars shine at dusk, Jupiter gleams at dawn.

November's big story features the rapidly improving prominence of Venus in the southwest at dusk. Saturn remains easily visible to the right of Venus as the month begins, but disappears in the Sun's afterglow late in the month. Mercury emerges to take Saturn's place. Mars continues to dim, but still shines fairly high in the south-southwest at dusk, setting in late evening. Meanwhile, the lone planet at dawn is Jupiter, which appears higher in the east-southeast each week.

DUSK AND EVENING

Venus sets about 2 hours after the Sun on November 1st and a healthy 3 hours after the Sun on November 30th. The brilliant planet's sunset altitude as seen from around latitude 40° north increases from about 16° to 22° over the course of the month. To get steady telescopic views of Venus's gibbous disk, which widens from 14″ to 17″ in diameter as its phase thins from 78% to 70% illuminated in November, go out before sunset. As darkness deepens, the planet's brilliance becomes dramatic: its magnitude improves from –4.0 to –4.2 this month.

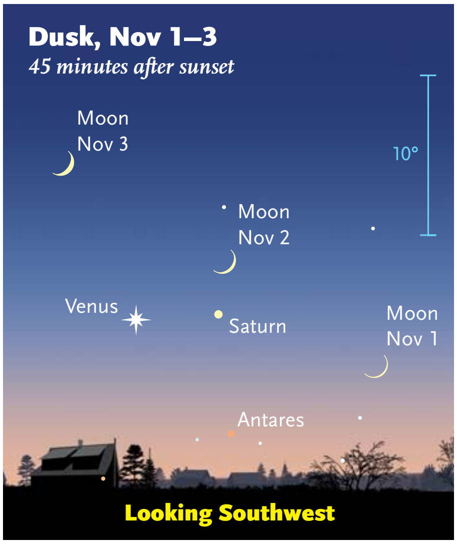
Venus spends the month gliding eastward from Ophiuchus across the top of the Teapot of Sagittarius. On the 17th it poses just ½° from the Teapot's lid star, 3rd-magnitude Lambda (λ) Sagittarii.

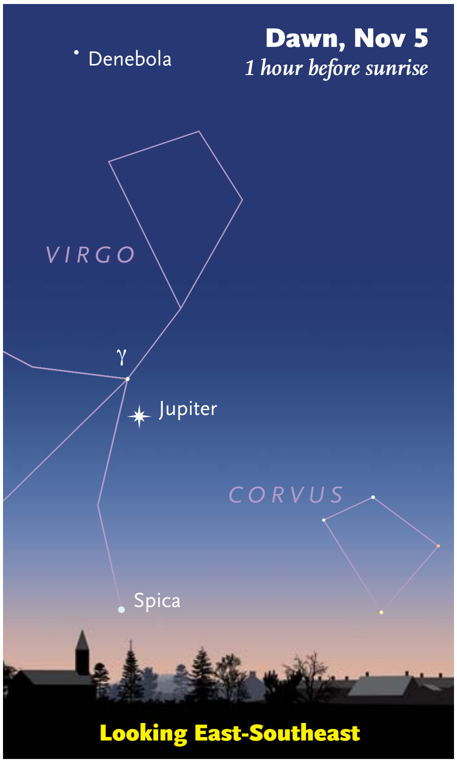
Saturn starts the month only about 5° right of Venus, its magnitude +0.5 light becoming easily visible about 30 minutes after sunset. Even at the opening of November, however, Saturn stands only a bit more than 10° above the southwest horizon 45 minutes after sunset. That's too low to hope for a sharp telescopic view.

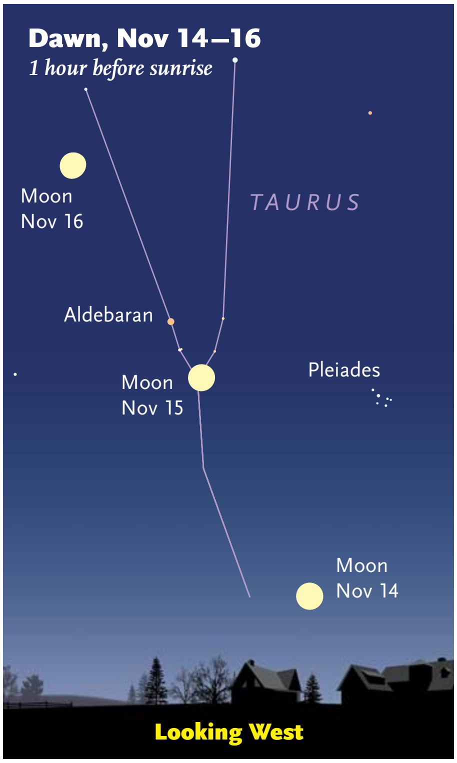
As seen from mid-northern latitudes, the interval between sunset and Saturnset shrinks from 2 hours to ½ hour during November. The ringed planet is wheeling toward conjunction behind the Sun; it will be very hard to see by November 23rd, when it passes 3½° north (upper right) of much brighter **Mercury**. But observers in the southern United States might be able to get a fair look at the pairing with binoculars 15 or 20 minutes after sunset. You'll find them about 27° to Venus's lower right.

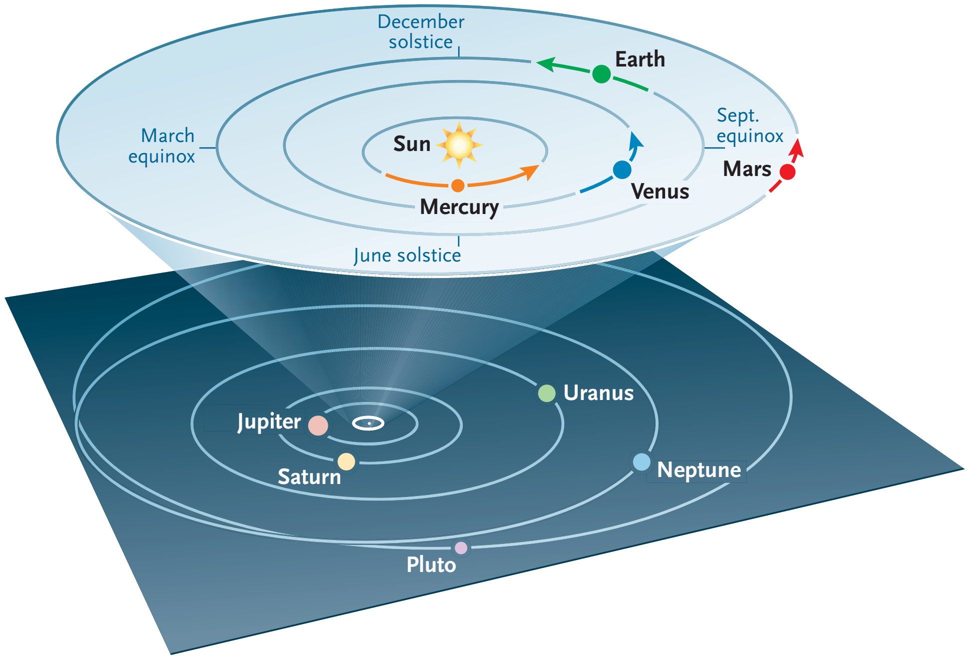
Mercury is magnitude –0.5 when it meets up with Saturn and remains that bright for the following three weeks as it edges higher.

Mars dims from magnitude +0.4 to +0.6 in November, speeding eastward through the faint regions of eastern Sagittarius and Capricornus. For viewers around latitude 40° north, the Red Planet sets at virtually the same time every night from mid-October through the end of winter. In November, look for it just past the meridian in the south as darkness









ORBITS OF THE PLANETS
The curved arrows show each planet's movement during November. The outer planets don't change position enough in a month to notice at this scale.

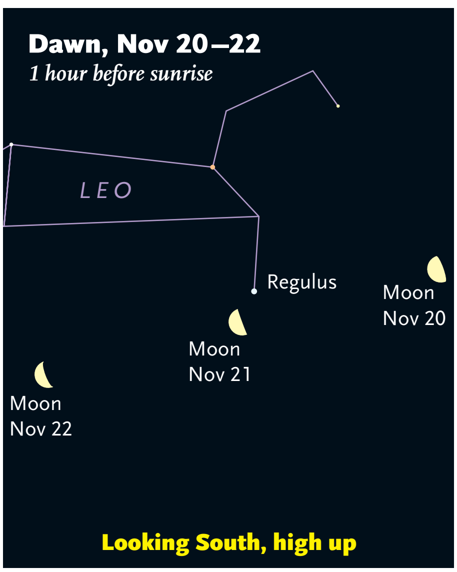
falls. Unfortunately, having Mars visible near its highest doesn't guarantee seeing its surface features. Its apparent diameter dwindles to less than 7″ wide this month, making surface details a challenge.

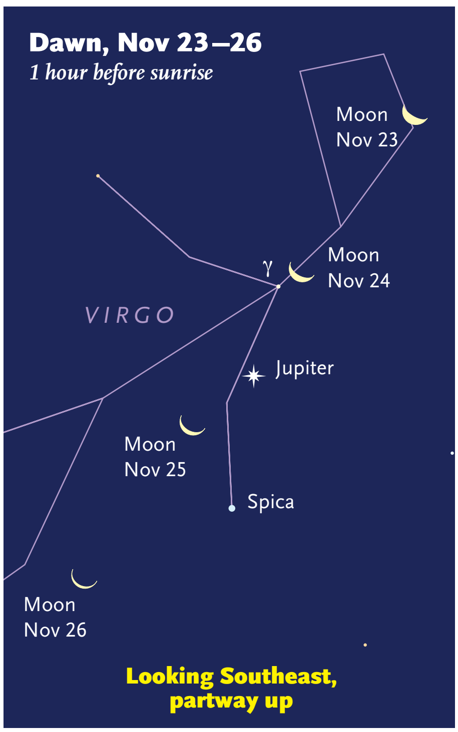
Pluto is too low, too early in the evening, for observation this month. **Neptune**, on the other hand, is at its highest in the south in Aquarius right after evening twilight ends. **Uranus**, in Pisces, is highest in mid-to-late evening. See last month's page 50 for finder charts for these two ice giants.

EARLY MORN TO DAWN

Jupiter is the sole planet visible at dawn this month. It rises only 2½ hours before the Sun as November opens but around 2:30 a.m. standard time as the month closes. On November 1st it stands about 20° high in the east-southeast an hour before sunrise; it's about 30° high on the 30th. The steady-shining giant remains at nearly its dimmest and smallest this month, but that still means a bright magnitude –1.7 to –1.8 point of light and a 32″-wide disk — big enough to show at least its two dark equatorial belts even in small telescopes on unsteady nights.

Look below Jupiter for Spica — the 1st-magnitude star comes into higher and easier view in the east-southeast at each dawn. Jupiter steadily narrows the gap between itself and Spica as the month progresses, closing from 13° apart on November 1st to 8° on the 30th.





MOON PASSAGES

The **Moon** is a lovely thin crescent well to the right of Venus and Saturn on the evening of November 1st and a subtly heavier crescent about 3° degrees above Saturn the next evening. A thick waxing crescent Moon rides to the upper right of Mars on November 5th and farther upper left of Mars on the 6th.

On November 14th at 6:30 a.m. EST, the Moon, only 356,509 km from Earth, is the closest it has been and will be to us at any time between 1976 and 2020; it reaches full later that morning. The Moon is in the Hyades on the American dawn of November 15th. The last-quarter Moon hangs just below Regulus on the morning of November 21st.

The waning lunar crescent is well upper right of Jupiter and close to Gamma (γ) Virginis at dawn on November 24th. On the 25th a skinnier crescent forms a fairly large triangle with Jupiter and Spica.

Just 30 to 40 minutes after the Sun sets on November 30th, use optical aid to look low in the southwest for an extremely thin Moon about 7° upper right of Mercury. ✦

Pulsing Stars in Cepheus

Check in on these happening stars, both famous and obscure.

The far-northern field of T Cephei and the Iris Nebula. To assemble this very deep image, Frank S. Barnes III took 89 15-minute exposures through LRGB filters robotically, using a 106-mm apo refractor at Sierra Remote Observatories in central California. North is up. This is just part of the full frame.

High overhead toward the north on fall evenings is Cepheus, a constellation that's probably best known for hosting the prototype Cepheid variable star. Delta Cephei is easy to follow with the naked eye. Less well known are two other noteworthy pulsing variables here — one also naked-eye, the other more obscure.

Delta (δ) Cephei ought to be on every skywatcher's quick-glance-up list. It varies from visual magnitude 3.5 to 4.4 and back every 5⅓ days. Like most Cepheids it brightens faster than it fades; it takes about 1⅓ days to swell from minimum to maximum, then 4 days to fade back down again.

You can follow its changes even through moderate light pollution, especially because two excellent comparison stars are right close by. Delta at maximum is about as bright as Zeta (ζ) Cephei; at minimum it's a trace fainter than Epsilon (ε). Our connect-the-dots pattern for Cepheus, as shown on the constellation chart in the

middle of this issue, and partly on the top chart here, shows the King's blocky head in profile, with a triangular hat and a ponytail. Delta is his upper lip, Zeta is the corner of his mouth, and Epsilon is his lower lip.

This little three-star asterism, 2½° wide, is easy to spot. If your light pollution is too severe for Epsilon, that just means Delta will pulse in and out of view!

John Goodricke discovered and tracked Delta's periodic variations in 1784; he speculated that they might be caused by dark marks on the star rotating in and out of view. Not until 1912 did the importance of Cepheid variables begin to dawn on astronomers. That year Henrietta Leavitt at Harvard College Observatory, studying many variables in the Small Magellanic Cloud at the same distance from us, announced her finding that the longer a Cepheid's period, the greater its true luminosity. The relationship was very tight and reliable. The Cepheid "period-luminosity relation" became a crucial link in the complex, interlocked cosmic distance scale by which astronomers were coming to measure distances throughout the wider universe.

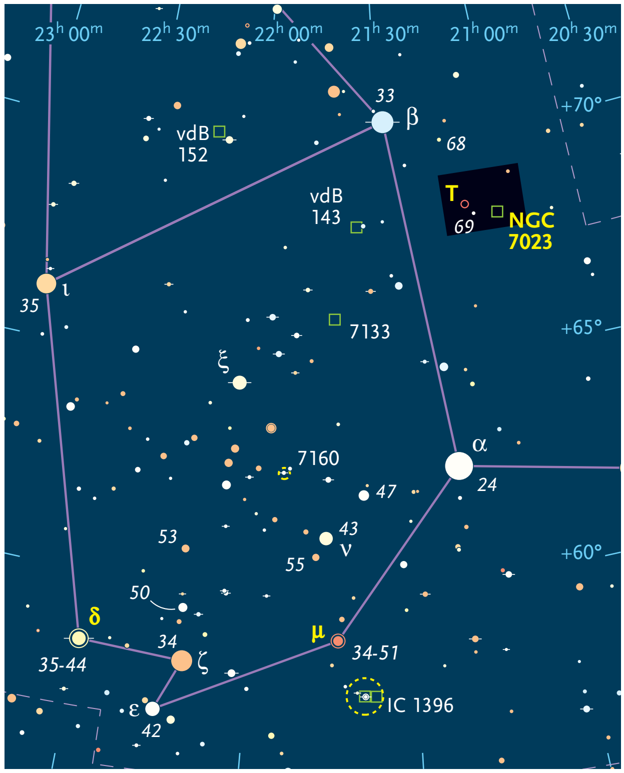
Delta Cep itself is 900 light-years from us. It's a yellow-white supergiant with a spectrum that varies from *F*5 at maximum to *G*1 at minimum.

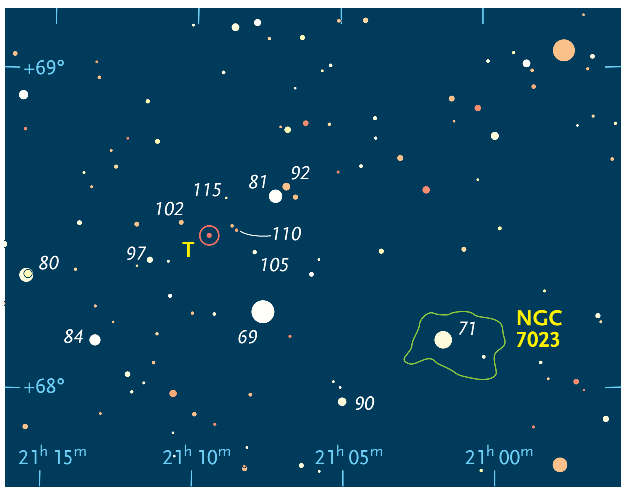
It also happens to be one of the finest double stars for small telescopes. The secondary star, magnitude 6.3, lies 40″ south of the primary. It shows fairly distinctly in high-quality, firmly mounted binoculars, especially when the primary is near minimum light. The pair is wide and easy in any telescope, and the secondary star's pale bluish tint contrasts with Delta's slight yellow.

Mu (μ) Cephei, 6° to Delta's west, is William Herschel's "Garnet Star": a slow, semiregular variable that has ranged from magnitude 3.4 to 5.1 but spends most of its time around 4. It's one of the largest and most luminous red supergiants known, and it's also one of the reddest that's not a carbon star. Its spectral type is a run-of-the-mill *M*1 or *M*2, but we see its light severely reddened — and dimmed about 2 magnitudes — by both circumstellar and interstellar dust. It lies in the northern edge of the huge, dim IC 1396 emission nebula, which deep images show to be rimmed with wispy dark nebulae. See page 41; Mu is just outside the top edge.

I can just detect Mu's color naked-eye. Binoculars show it much better. "According to some observers," says *Burnham's Celestial Handbook,* "the star varies in color as well as in light. It usually appears a deep orange-red but on occasion seems to take on a peculiar purple tint. Since human eyes vary in color sensitivity, and because color is affected by atmospheric and instrumental factors, it is still uncertain whether such changes are real." For one thing, a star's color tends to appear deepest with a small aperture, if the telescope collects enough light for color to be perceived at all. Through a large scope, we see bright stars looking paler, "overexposed."

T Cephei, 10° north-northwest of Mu, is less famous but well worth a look — especially because the reflection nebula NGC 7023, the Iris Nebula, awaits you 1° to the





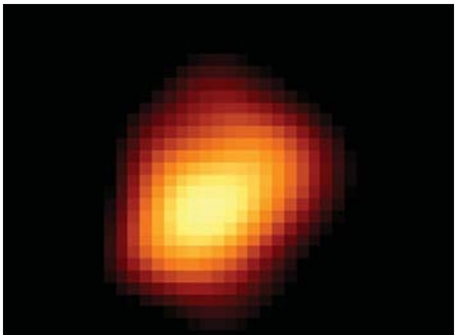
Cepheus is high in the north on the evening constellation map in the center of this issue. Above, north is up. Numbers with stars are their visual magnitudes (to the nearest tenth, decimal points omitted) for judging the brightness of δ, μ, and T. The small black box at top shows the area of the T Cephei closeup.

west-southwest. T is a Mira variable, a pulsing red giant that in this case swings from 6th to 10th magnitude (usually) with a period of 13 months. You ought to find it at minimum light in October. Since it's circumpolar, 22° from the north celestial pole, you can follow it all the way through its rise to its predicted maximum next June.

When I last looked in on it (at magnitude 7.9), it looked even redder than Mu. It has an unusually cool, "late" spectral type: *M*5.5 at maximum, *M*9 at minimum. Moreover, an orange or red giant star appears redder than a dwarf with the same spectral type.

Estimating a variable star's brightness well takes very close attention. Find comparison stars on your charts that are just a little brighter and fainter than the variable. Interpolate its magnitude between them as carefully as you can. Then try to convince yourself that different values might be better, until you're pretty sure that your final estimate is the best.

In this age of automated sky surveys, you might think that long-period variables no longer need amateurs to track their behavior visually. Not so! That day is coming, but we're not there yet. Elizabeth Waagen of the American Association of Variable Star Observers writes that of the 381 Mira variables that AAVSO observers have tracked for decades, "73% received fewer than 100 observations last year." These "all need better coverage, particularly around minimum. Some have minima no one has ever seen. If we are to determine dates of minimum accurately, we need to know how these light curves look throughout their cycle." To get involved, visit **aavso.org**.



Omicron Ceti, the prototype Mira star, revealed itself to the Hubble Space Telescope as an irregular blob about 60 milliarcseconds wide. Mu and T Cephei are probably also nonspherical. The largest, coolest red giants and supergiants have the weakest surface gravity of any stars, so they shed mass readily and can easily be distorted out of round by convection or other internal processes.

NASA / MARGARITA KAROUSKA / CFA

Scoping the Tints of Uranus and Neptune

Summer is fun, but the return of early darkness for northern skywatchers means there's more time to pursue your observing "to do" list. The solar system's two outer mini-giant planets are now in fine evening view: Uranus in Pisces and Neptune in Aquarius. The charts on page 50 of last month's issue show where to pinpoint them among the stars. Charts are also at **SkyandTelescope.com/urnep**. Kevin Bailey described cutting-edge amateur observations of markings on Uranus in the September issue, page 52.

But most of us will never see these planets as more than tiny blobs or, in low-power instruments, as pinpoints.

Uranus and Neptune are often called twins; they're more alike than any other two planets of the solar system. But they appear decidedly different in the nighttime sky. Uranus, at magnitude 5.7 in October and November, is an easy score through binoculars even under fairly heavy light pollution. The same cannot be said for Neptune. At magnitude 7.9 it's within the grasp of decent-size binoculars but can be a challenge to distinguish from nearby stars. This season Neptune remains 2° or 3° southwest of orange Lambda (λ) Aquarii, magnitude 3.7. Use

SKY & TELESCOPE / ITELESCOPE.NET / J. KELLY BEATTY

The pale hues of Uranus *(far left)* and especially Neptune can be a challenge to see visually. *S&T*'s J. Kelly Beatty took these identical color exposures minutes apart using a remote 6-inch refractor. Each frame is ¼° across, similar to a high-power telescopic field.

November Meteors

All October and November, keep a lookout for the sparse but occasionally bright **Taurid meteors**. Occasionally the shower includes spectacular so-called "Halloween fireballs." These may grab attention anytime for several weeks, not just on Halloween.

The southern component of the Taurid shower peaks in mid-October, the northern component in mid-November. They overlap; each runs for many weeks. During this time their large, diffuse radiants migrate all the way from southeastern Pisces across southern Aries to well east of the Pleiades. The radiant regions climb the eastern sky during evening, so no post-midnight vigils are required.

But if it weren't for the possibility of fireballs, this would be considered a modest shower of minor interest. You might count only a dozen Taurids per hour even under the most ideal observing circumstances.

The Taurids are bits of debris from Comet 2P/Encke. They strike the atmosphere at a relatively slow 31 km per second.

Much briefer is November's **Leonid shower**. The spectacular Leonid displays from 1998 through 2001 are a distant memory; now we settle for a few faint flashes per hour. Moreover, this year's peak on the morning of November 17th comes just three days after a full Moon, so any swift Leonids you might see will be just a lucky bright few.

The International Meteor Organization (imo.net) recently added the **November Orionids** to its calendar of annual showers. For a week or two centered on November 28th, careful observers have consistently recorded a few meteors per hour radiating from a point above the Hunter's head.

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your map carefully to determine which of the tiny specks there is it.

Telescopically, Uranus and Neptune are definitely nonstellar: they're 3.7″ and 2.3″ in diameter, respectively. Both have methane (CH_4) in thick, clear upper atmospheres above a deeper cloud layer. Methane absorbs red light strongly, giving each a pale-blue tint with possibly a touch of green. Don't be misled by the strongly saturated Voyager and Hubble pictures you've seen — the coloration is subtle. It's pretty easy to see Uranus as slightly blue or aquamarine, perhaps even in binoculars, but perceiving color in Neptune is more challenging. Sensitivity to color in dim light is one of the most variable properties of the human eye from one person to the next. What, exactly, do you see? What about someone else looking into the same eyepiece?

On August 6th I took the identical wide-field exposures of Uranus and Neptune at left, running a 6-inch robotic telescope and camera remotely via iTelescope. These enlargements make the colors look pretty vivid, while the colors in the background star field show no obvious signs of being overdone. But don't be surprised if you *see* Neptune as just gray. ✦

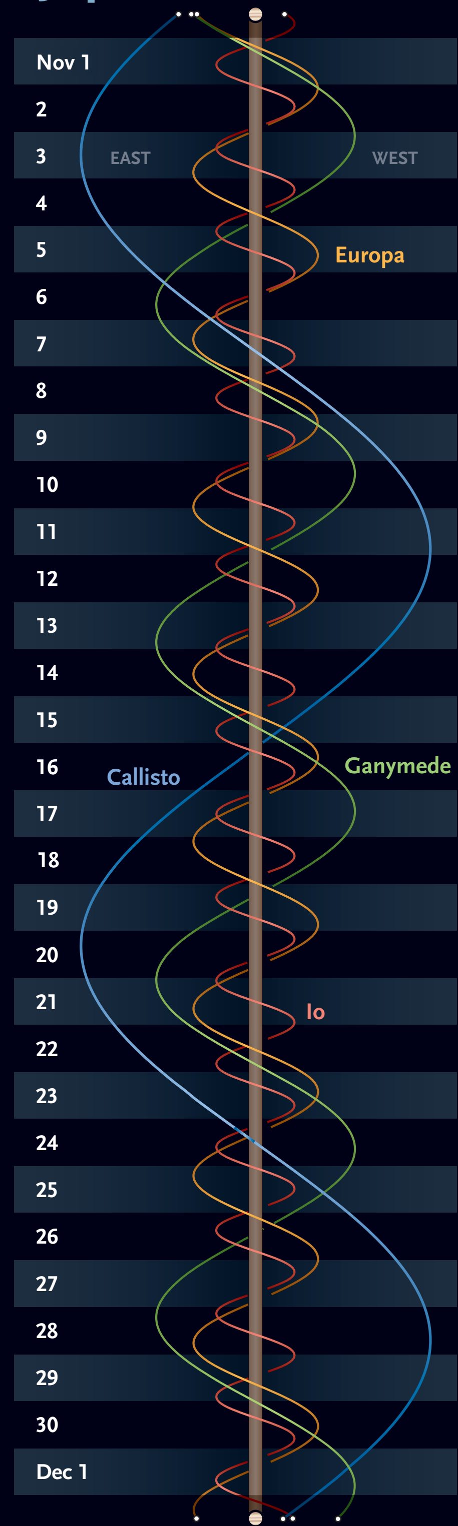
— *J. Kelly Beatty*

Minima of Algol

Oct.	UT	Nov.	UT
2	17:45	3	6:42
5	14:34	6	3:31
8	11:23	9	0:19
11	8:11	11	21:08
14	5:00	14	17:57
17	1:49	17	14:46
19	22:38	20	11:35
22	19:26	23	8:24
25	16:15	26	5:13
28	13:04	29	2:02
31	9:53		

These geocentric predictions are from the heliocentric elements Min. = JD 2452500.179 + 2.867335*E*, where *E* is any integer. Courtesy Gerry Samolyk (AAVSO). For a comparison-star chart and more info, see SkyandTelescope.com/algol.

Jupiter's Moons



The wavy lines represent Jupiter's four big satellites. The central vertical band is Jupiter itself. Each gray or black horizontal band is one day, from 0^h (upper edge of band) to 24^h UT (GMT). UT dates are at left. Slide a paper's edge down to your date and time, and read across to see the satellites' positions east or west of Jupiter.

“Last Contact”

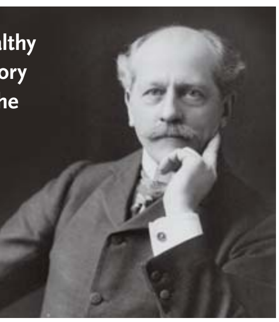
Percival Lowell made his final observation 100 years ago this month.

“Last Contact” and “Certainly Now” would be the last lines ever penned by Percival Lowell in his observing logbook, on November 11, 1916. By the following evening, the iconic American astronomer was dead, at the age of only 61 years 8 months.

Lowell seemed to be in good health, typically brimming with project ideas, as he entered what would be the final year of his life. Although 1915 ended with a heavy snowstorm in Flagstaff — the depth at the observatory reached 50 inches — the New Year began with a run of clear skies.

Mars, always a chief preoccupation on Mars Hill whenever it was well placed, came to a February opposition that year. Lowell and staff astronomer E. C. Slipher divided their time between the Red Planet and Saturn, whose satellites and subtle ring divisions they'd been measuring for over a year.

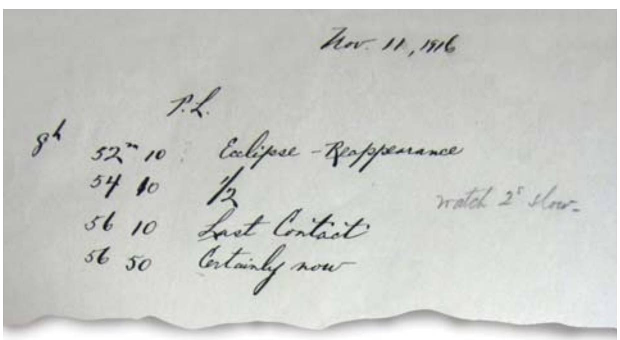
Lowell believed he had made an important discovery. Astronomers had found that the Cassini Division maintains a 1:2 orbital resonance with Saturn's innermost known moon, Mimas. Lowell and Slipher had recorded more subtle ring divisions that seemed to be in sync with other Mimas resonances — except that they were consistently located too far out. Invoking a nifty bit of celestial mechanics, Lowell showed that the discrepancy could be explained if Saturn consisted, beneath the outer rind of its clouds, of a series of nested shells of different oblateness that spun at different speeds. Saturn was, he said, “rotating like an onion in partitive motion.”



Percival Lowell (1855–1916), a wealthy Bostonian, built a major observatory in Flagstaff, Arizona, from which he intensely studied the planets.

Below: The night before he died, Lowell recorded this observation of Io's reappearance from within Jupiter's shadow.

LOWELL OBS. / JAMES E. PURDY



LOWELL OBS. / PUTNAM COLLECTION CENTER

If Saturn had such an interior structure, why not Jupiter as well? This was one of the burning questions Lowell hoped to answer as the giant planet neared opposition in late 1916.

On October 19th, returning to his Flagstaff observatory after an exhausting barnstorming lecture tour of colleges in the Pacific Northwest and the West Coast, he and Slipher began a nightly vigil of the moons of Jupiter. As the divisions of the rings of Saturn had seemingly disclosed the internal structure of that planet, Lowell hoped that the moons of Jupiter would do the same for its gas-giant cousin.

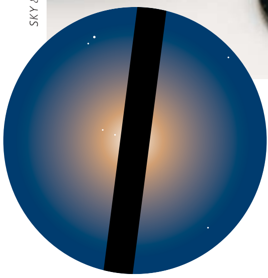
Although many of their measurements were of the already well-studied Galilean satellites, they also hoped to lay the wires of their filar micrometer on little Amalthea, the fifth satellite of Jupiter, which had been discovered visually by E. E. Barnard with the 36-inch refractor of Lick Observatory in September 1892 and whose motion was not at the time completely understood. Circling just 110,000 kilometers from Jupiter's cloudtops, Amalthea seemed an ideal probe of the gravitational field around the giant oblate spheroid of the planet.

But would it even be visible in the 24-inch Clark?

It would certainly be challenging. Amalthea can only be seen near its western and eastern elongations, at which its maximum separation from the planet's disk never exceeds one Jupiter diameter. Also, since it's four million times brighter, Jupiter completely swamps Amalthea (magnitude 14.1 at best) in its glare.

To disclose the shy little moon, special techniques are needed. Lowell and Slipher employed an eyepiece occulting bar to block Jupiter. Their strategy succeeded; indeed, they observed Amalthea at its eastern elongation on the very night that Lowell returned from his demanding lecture tour.

For the next several weeks, during which the skies stayed persistently clear, Lowell and Slipher scrutinized the Galileans and the tiny inner moon at every opportunity. On Saturday evening, November 11th, after a long



SKY & TELESCOPE (2)

To see Amalthea visually, you'll need plenty of aperture. Also helpful will be an *occulting bar* — a thin, opaque strip placed at the telescope's focus, used to block the blazingly bright disk of Jupiter (simulated at left).

day of study, Lowell did not arrive in the dome of the 24-inch Clark until sometime after Slipher — and must have been disappointed to learn that he'd just missed an elongation of Amalthea. On the other hand, he had no reason to think that there wouldn't be many more such opportunities.

Just before 9 p.m., Lowell recorded another interesting event: Io's reappearance from its eclipse by Jupiter's shadow. He recorded the following notes:

Nov. 11, 1916

P.L.

8^h	*52^m*	*10*	*Eclipse – Reappearance*
	54	*10*	*½*
	56	*10*	*Last Contact*
	56	*50*	*Certainly now*

The following morning he suffered an intracerebral hemorrhage and passed away in his bedroom at 10 p.m. that evening, without ever regaining consciousness. His wife, Constance, who made sure to keep the bedroom exactly as it was when he died, recorded in chalk on the wall, "Percival Lowell's earthly existence terminated in this chamber upon the green couch."

Slipher carefully rescued the last pages of Lowell's observing notes and put them in a cigar box, after which they were long forgotten. They were rediscovered 97 years later, when Lowell Observatory preservationist Michael Kitt was sorting through piles of material abandoned in the 100-year-old Administration Building (now the historic Slipher Building).

These evocative notes are now housed, along with other precious documents, in the Lowell Observatory's new Putnam Collection Center.

Your Turn to Try

Amalthea has always been the domain of large apertures, and it's far more difficult to see than challenges such as Mars' Phobos and Deimos or Sirius's "pup."

The smallest instrument used for a successful visual observation of which I am aware might have been the 18½-inch refractor at the Dearborn Observatory in Evanston, Illinois — the same telescope used to discover Sirius B — by George Washington Hough in 1892. Perhaps readers of *Sky & Telescope* can beat Hough's record.

Although a tough visual challenge, Amalthea is well within reach of skilled CCD imagers. For instance, professional astronomers recorded eclipses of Amalthea during the marvelous series of mutual events among the Galilean satellites from September 2014 to June 2015.

So did at least one amateur, Bernd Gährken of Germany, who captured Amalthea's April 7, 2015, eclipse by Callisto with the 80-cm telescope at the Bavarian Public Observatory in Munich. Instead of masking Jupiter as usual, he instead subdued Jupiter with a special filter for the methane's strong near-infrared absorption at 890 nm. Then he used an infrared-sensitive CCD detector to bring out reddish Amalthea.

The next series of mutual satellite events won't begin until 2020. But Amalthea still will be there, and amateurs tired of only seeing the Galilean satellites will no doubt enjoy trying to meet the challenge of glimpsing or recording this intriguing little moon — the last one discovered visually and the object of Percival Lowell's final quest. ✦

The Moon • November 2016

Phases

FIRST QUARTER
November 7, 19:51 UT

FULL MOON
November 14, 13:52 UT

LAST QUARTER
November 21, 8:33 UT

NEW MOON
November 29, 12:18 UT

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

Distances

Perigee 356,509 km	**November 14, 11^h UT** diameter: 33′ 31″
Apogee 406,554 km	**November 27, 20^h UT** diameter: 29′ 23″

Favorable Librations

Helmholtz (crater)	**November 3**
Pythagoras (crater)	**November 13**
Byrd (crater)	**November 15**

Circling Northern Lacerta

An abundance of deep-sky sights reside in this tiny constellation.

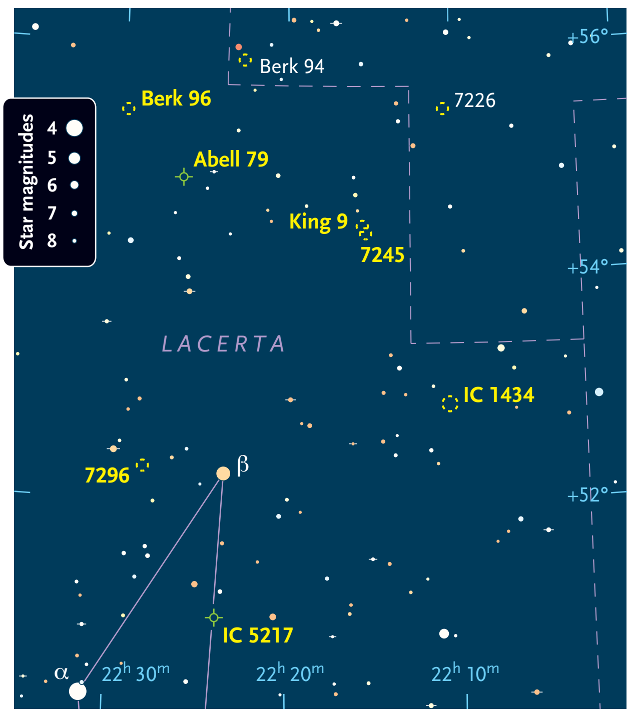
On this month's centerfold chart, you'll find Lacerta, the Lizard, high in the sky between the forefeet of Pegasus and the head of Cepheus. Among the 88 constellations, little Lacerta ranks 68th in area — between Apus, the Bee, and Delphinus, the Dolphin. Although no one has ever claimed that the constellations are shown with correct relative proportions, it's amusing to think of the lizard as smaller than a bee but larger than a dolphin. Lacerta's diminutive size doesn't keep it from hosting a wealth of deep-sky wonders. In the south, the lizard's tail winds through a profusion of faint galaxies, but its head is more deeply buried in the Milky Way, offering us a selection of star clusters and planetary nebulae. Let's visit a few that populate a roughly circular zone in the constellation's northern reaches.

The pretty open cluster **NGC 7245** is a nice place to start. You can pinpoint its location by drawing an imaginary line from Alpha (α) through Beta (β) Lacertae and then extending the line for that distance again. My 130-mm refractor at 37× shows a faint haze enfolding two 11th-magnitude stars: one in the south and the other in the west. A brighter gem rests off the east-northeastern side. Boosting the magnification to 164× adds 15 faint to extremely faint stars. Through my 10-inch reflector at 166×, NGC 7245 is a lovely, diamond-dust cluster of many faint stars. They bunch together in the cluster's central 1½′ and then thin to outliers that expand the group's diameter to 5′.

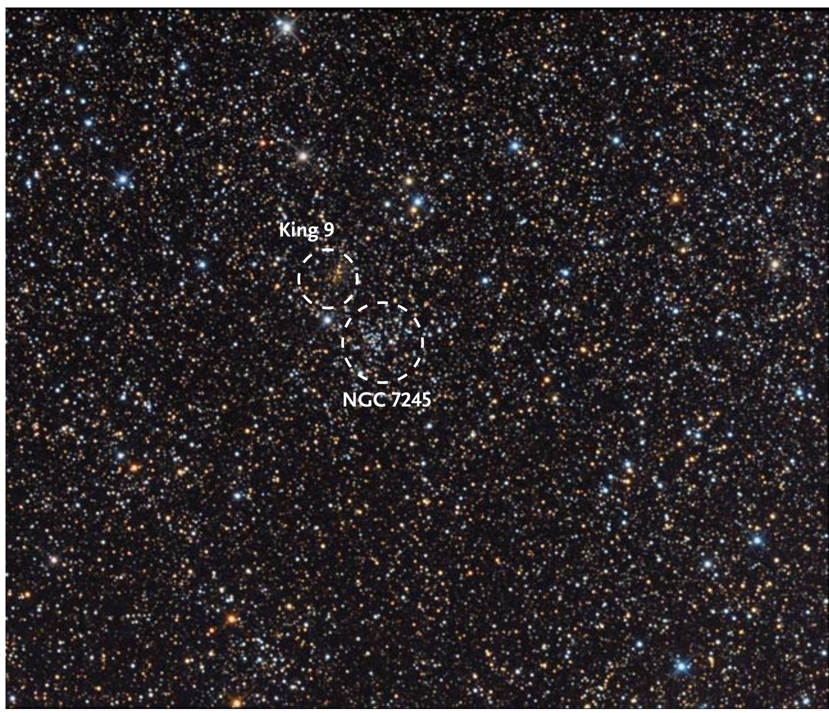
In each of the high-power views described above, NGC 7245 shares the field of view with the open cluster **King 9**, centered just 4.9′ to the north-northeast. In the smaller scope, I see what looks like two or three extremely faint stars in a small, very subtle, hazy spot about 1½′ across. The 10-inch shows a star north-northwest of the cluster's center and a brighter patch near the center that seems a bit lumpy. I intermittently see one to three starlike points.

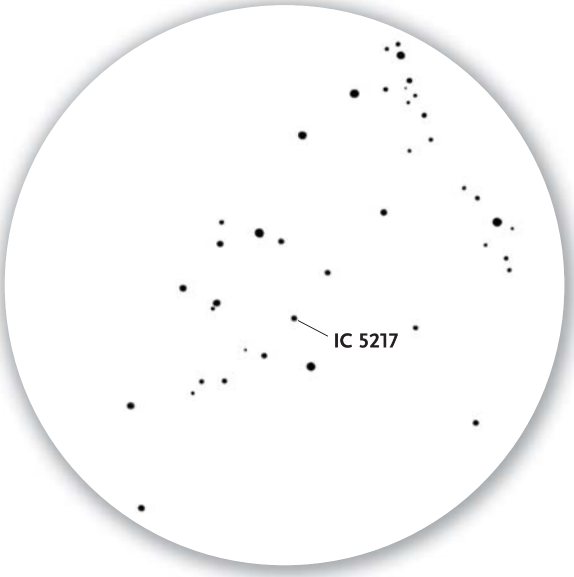
Most of King 9's stars are far beyond the grasp of backyard telescopes. I've often wondered if the few star-

The center of open cluster King 9 lies about 5′ north-northeast of NGC 7245. Look for a faint haze with a brightening at its center. This is a dim one, so aperture is your friend. The LRGB image below shows the two clusters as captured through a 10-inch f/3.8 astrograph with a 20-minute exposure in each channel.



GREGG RUPPEL





Left: **In small telescopes, planetary nebula IC 5217 will appear stellar, but a slight cyan or blue color will reveal its true nature. At 120× in Jaakko Saloranta's 8-inch Dobsonian, it appeared non-stellar, but without detail. Use more aperture and power to tease out its structure.**

Below: **You'll need a large scope to get more than a hazy blue elongation from IC 5217. On a night of good seeing, Uwe Glahn spotted the central star and a slightly expanded glow of nebulosity with his 27-inch f/4.2 reflector at 837× to 1172×.**

like objects I see are actually foreground stars or tiny knots of stars. A paper by Kenneth A. Janes and Sadia Hoq (*Astronomical Journal*, 2011) gives a color-magnitude diagram of King 9, which includes 497 stars within a 1½′ diameter that have a photometric membership probability of more than 50%. Of the brightest stars, there's only one 12th-magnitude, two 14th-magnitude, two 15th-magnitude, and a dozen 16th-magnitude. The authors place King 9 and NGC 7245 at distances of 24,000 and 11,000 light-years, respectively, so although they appear close together on the sky, they are separated by a considerable distance along our line of sight.

Dropping 1.7° south-southwest from NGC 7245 takes us to star-spangled **IC 1434**. Viewed through my 130-mm scope at 23×, this open cluster is easy to spot as a small, granular haze. At 164×, about 30 to 35 stars, most faint to extremely faint, sparkle within a 7′ group. Four eye-catching stars zigzag across the southern confines of the cluster. The 10-inch scope at 43× reveals a few faint stars caught in a misty glow overlaid by a southward-flying kite of four brighter stars. IC 1434 is delightful at 115×, boasting a multitude of faint suns. Several long rays of stars sprout from the cluster and make its borders rather vague.

IC 1434's starfield is heavily contaminated by the background Milky Way. Its status has been called into question, but recent sources favor its classification as an open cluster. A study by Eduardo Bica and Charles Bonatto (*Astronomy & Astrophysics*, 2011) gives a distance of 8,500 light-years, plus or minus 2,000 light-years, for the cluster, while another by Nina V. Kharchenko and colleagues (*Astronomy & Astrophysics*, 2013) offers 10,500 light-years.

Next we come to the petite planetary nebula **IC 5217**, which dangles 1.3° south of Beta. It makes a squat isosceles triangle with a 7.4-magnitude star 14′ to the north-northwest and a deep-orange, 6.5-magnitude star 20′ to the north-northeast. IC 5217 looks starlike in my 130-mm refractor at low power, but its distinctly blue color gives away its true nature. At 102× the nebula no longer appears stellar, yet it's still very tiny, while 164× better shows its diminutive disk. A narrowband or O III filter increases its contrast against the background stars. The O III filter makes the nebula appear brighter than any of the nearby stars, which is useful for identifying IC 5217 if your seeing (image steadiness) blurs the stars into little pseudo-nebulae. Through my 10-inch reflector at 299×, IC 5217 acquires some charm, enticingly exposing interior detail in the form of a more luminous north-south region that's brightest in the middle. At a visual magnitude of about 15.5 and vying with the light of its nebula, this planetary's central star is game only for deep-sky hunters with very large telescopes.

The open cluster **NGC 7296** is just a short hop 41′ eastward from Beta. My 130-mm scope at 37× unveils a pretty little spray of fine stars fanning east-southeast from an orange, 9.7-magnitude star. At 102× I count 15 stars, most arrayed in chains diverging from the bright

POSS-II / STSCI / CALTECH / PALOMAR OBSERVATORY

Triple-star system Stein 2801 (STI 2801) consists of an 11th-magnitude star flanked by two 12th-magnitude suns. This is a relatively tight triple; the dimmer companions are separated from the primary by 6.7″ and 11.6″.

star, neatly packed into a tight group whose longest dimension is only 3.8′. The 10-inch scope at 166× shows me 25 stars within 4′, many of them arranged like the footprint of an eastward-strutting bird.

A recent paper by Elena V. Glushkova and colleagues (*Monthly Notices of the Royal Astronomical Society*, 2013) places NGC 7296 at a distance of roughly 8,000 light-years with an age of 280 million years. Among the other five clusters studied by the authors, **Berkeley 96** also dwells in Lacerta. It's assigned a distance and age of approximately 10,000 light-years and 40 million years.

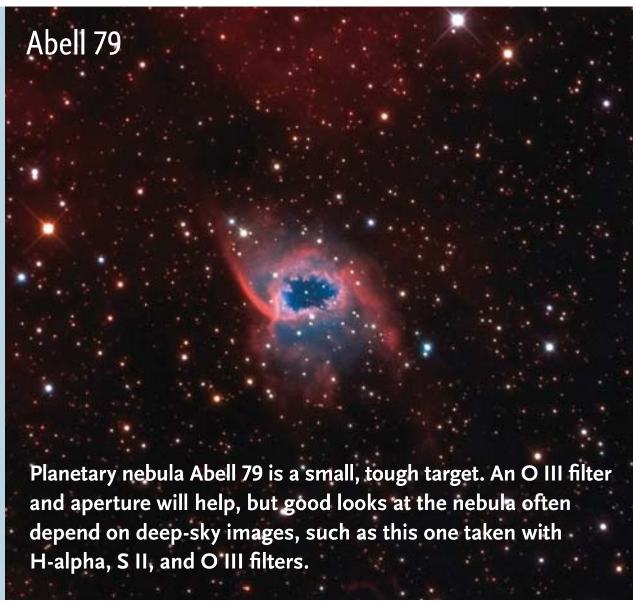
Berkeley 96 hovers 3.1° north of NGC 7296 and contains the tight triple star **Stein 2801** (STI 2801). In my 105-mm refractor at 127×, Berkeley 96 is a scrap of fog with a moderately bright star in its eastern side and a few very faint stars. An outlying 11th-magnitude star is perched 1.2′ north-northeast, and one of 12th magnitude lies the same distance southwest of the cluster's center. My 10-inch reflector at 115× does a better job of showing off Stein 2801, which consists of the moderately bright star and two 12th-magnitude attendants, one northeast and the other a bit east of north. Surprisingly, Berkeley 96 only surrendered eight stars to the reflector. Photographs show a very nice little crowd of stars here, and the available photometry indicates that more of them could be accessible to that scope. Most of the stars are bunched together within the inner 1¼′ of the cluster, with outliers extending the group to 3′. Berkeley 96 strikes me as a tempting target for larger telescopes.

Another target for larger scopes rests 46′ southwest of Berkeley 96. Although I was certain of its exact location, the planetary nebula **Abell 79** remained invisible through my 10-inch scope, with or without filters. My 15-inch reflector revealed its presence, but just barely, and only with a nebula filter and averted vision. The best view was at 117× while using an O III filter, where Abell 79 appeared as a sizeable glow but was far too faint to display structure. A narrowband filter also allowed its presence to be detected, and let some of the faint stars nearby shine through, including one on the nebula's southern edge. Other observers have nabbed this nebula with scopes as small as 8 inches in aperture, and astrophotographers prove that it abounds with intriguing details. ✦

Deep-Sky Objects in Lacerta

Object	Type	Mag(v)	Size/Sep	RA	Dec.
NGC 7245	Open cluster	9.2	5.0′	$22^h 15.3^m$	+54° 20′
King 9	Open cluster	—	2.5′	$22^h 15.5^m$	+54° 25′
IC 1434	Open cluster	9.0	7.0′	$22^h 10.5^m$	+52° 50′
IC 5217	Planetary nebula	11.3	7.0″	$22^h 23.9^m$	+50° 58′
NGC 7296	Open cluster	9.7	4.0′	$22^h 28.0^m$	+52° 19′
Berkeley 96	Open cluster	—	2.5′	$22^h 29.9^m$	+55° 24′
Stein 2801	Triple star	10.6, 12.1, 12.1	6.7″, 11.6″	$22^h 29.9^m$	+55° 24′
Abell 79	Planetary nebula	15.0	2′ × 1.5′	$22^h 26.3^m$	+54° 50′

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



Planetary nebula Abell 79 is a small, tough target. An O III filter and aperture will help, but good looks at the nebula often depend on deep-sky images, such as this one taken with H-alpha, S II, and O III filters.

MAKIS PALAIOLOGOU / STEFAN BINNEWIES / RALF KREUELS / JOSEF PÖPSEL

Alan Whitman

The Dark Creatures of Cepheus

Up the aperture to track down the Seahorse and Elephant Trunk Nebulae.

How often have we read that the complex of Milky Way dust clouds composing the Great Rift broadens into the Northern Coalsack, then ends at Deneb? Yes, the most prominent section of the rift ends at Deneb, but in a fine sky the unaided eye can trace our edge-on galaxy's dust lane past Cassiopeia and all the way to westernmost Camelopardalis! The rift zigzags around the northwestern side of Deneb and the North America Nebula, crosses the great 12°-long black gash of the Funnel Cloud Nebula (Le Gentil 3), and continues through Zeta (ζ) and Iota (ι) Cephei. The chain of dust clouds passes a few degrees poleward of Epsilon (ε) Cassiopeiae, and finally peters out near BK Camelopardalis. This is almost 55° of galactic longitude past Deneb! The brighter side of the Milky Way lies to the south of the dust clouds, but north of the rift the fainter side of the Milky Way extends up to Polaris.

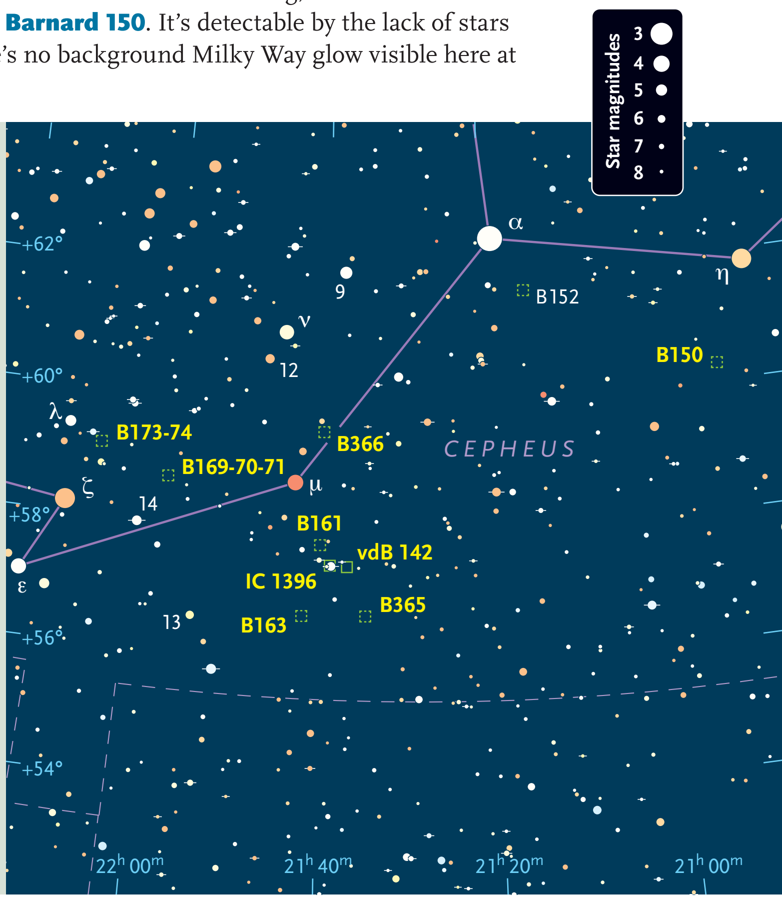
At the first Mount Kobau Star Party in 1984, my observing partner Jim Failes made a naked-eye discovery of a band of dust clouds that he calls the **Polaris Superhighway**. It begins in the galaxy's central rift near Epsilon Cas, passes immediately east of the three-star chain of 46, 48, and 50 Cas, and loops tightly around Polaris. It continues as a broader highway in a concave loop to the Draco side of Beta (β) Cephei, makes a convex arc around Beta, and then continues in another concave loop passing between Alpha (α) and Eta (η) Cephei, where it reconnects to the rift's dust clouds. Find a site where M33 is visible with the unaided eye and you should then be able to see the Polaris Superhighway.

My favorite telescopic dark (absorption) nebula in Cepheus is the well-named 90′-long, sinuous Seahorse Nebula, **Barnard 150**. It's detectable by the lack of stars — there's no background Milky Way glow visible here at

Nebulae Dark and Bright

Object	Type	Opacity	Size	RA	Dec.
B150	Dark Nebula	5	60′	20h 50.7m	+60° 18′
IC 1396	Emission Nebula	—	170′ × 140′	21h 39.1m	+57° 30′
B365	Dark Nebula	4	10′	21h 34.9m	+56° 43′
B161	Dark Nebula	6	3′	21h 40.4m	+57° 49′
B163	Dark Nebula	4	4′	21h 42.2m	+56° 42′
vdB 142	Reflection Nebula	—	49′	21h 36.0m	+57° 24′
B366	Dark Nebula	3	10′	21h 40.4m	+59° 34′
B169	Dark Nebula	3	60′	21h 58.9m	+58° 45′
B170	Dark Nebula	4	15′	21h 58.1m	+58° 57′
B171	Dark Nebula	5	91′	22h 01.3m	+58° 52′
B173	Dark Nebula	6	4′	22h 07.5m	+59° 40′
B174	Dark Nebula	6	19′	22h 07.3m	+59° 04′

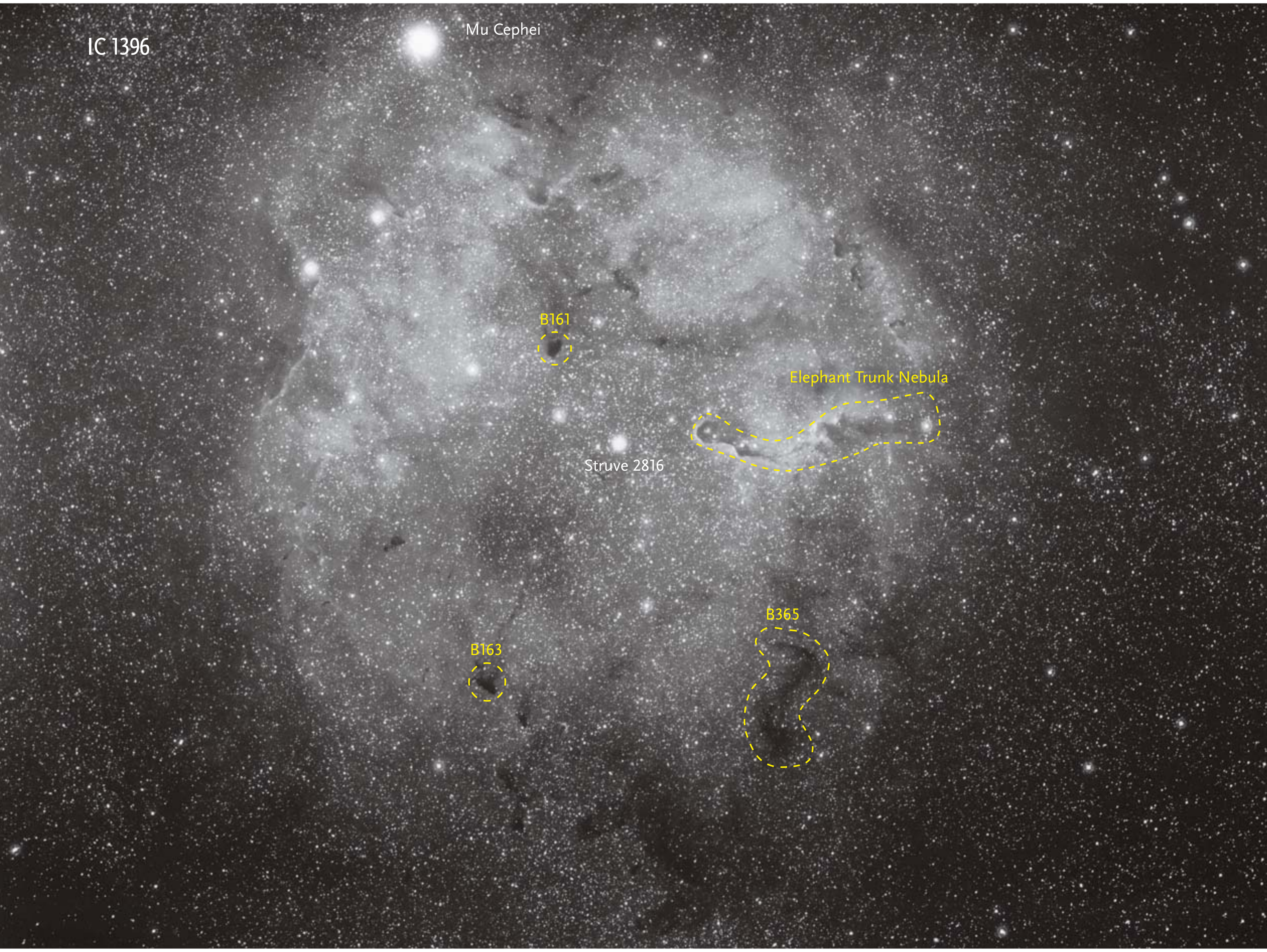
Opacity is measured on a scale from 1 to 6, where 1 is least opaque and 6 is most opaque. Angular sizes are from recent catalogs. Visually, an object's size is often smaller than the cataloged value and varies according to the aperture and magnification of the viewing instrument. Right ascension and declination are for equinox 2000.0.



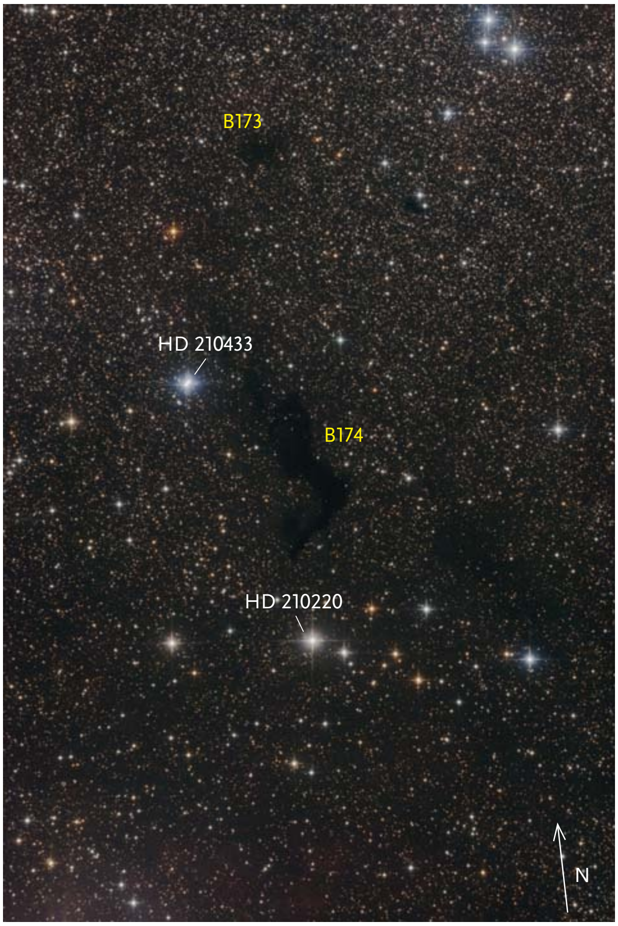
the eyepiece. In my 16-inch Newtonian at 96× B150 was tough at its southwestern end but reasonably obvious in the section between about RA 20^h 49^m and the short line of three stars (centered by HD 199097) plotted on the northern edge of the dark nebula at RA 20^h 52^m on *Millennium Star Atlas* chart 1074. (I find MSA to be the best atlas to use when observing dark nebulae.) At B150's eastern end, the Seahorse's head was less apparent but was visible with some effort. Tiny B148 and B149 are adjacent to the Seahorse, but I failed on them.

Several dark nebulae are silhouetted against the dim 3°-wide glow of the Cepheus emission nebula **IC 1396**, if you keep the deep orange supergiant Mu (μ) Cephei (popularly known as Herschel's Garnet Star) out of the field of view. The nebulosity is energized primarily by the *O*5 lucida of the central triple star, Struve 2816 (HD 206267). I used the black-and-white image of IC 1396 taken by Rajiv Gupta shown below, since red images of nebulae become invisible when using dim red flashlights. At 96× winding **B365** is subtle, but I traced its full length, except for the very thin northern streak.

HIGH CONTRAST **Successful deep-sky observing often depends on black-and-white images. The red hue in color images of nebulae is difficult to see if you're using a dim red flashlight to preserve your eyes' adaptation to dark.**



RAJIV GUPTA



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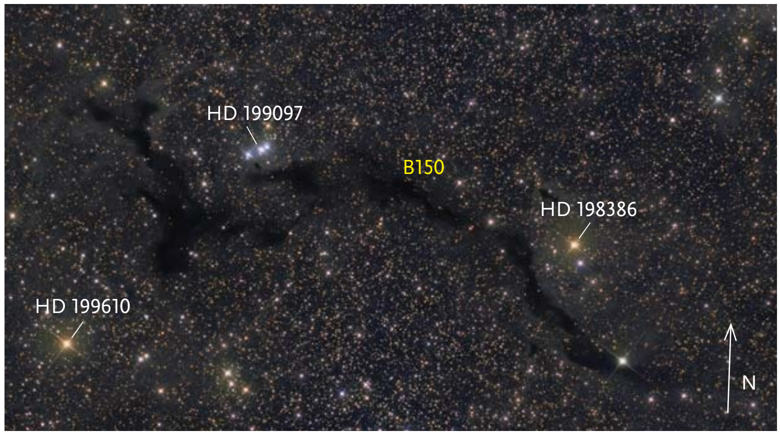
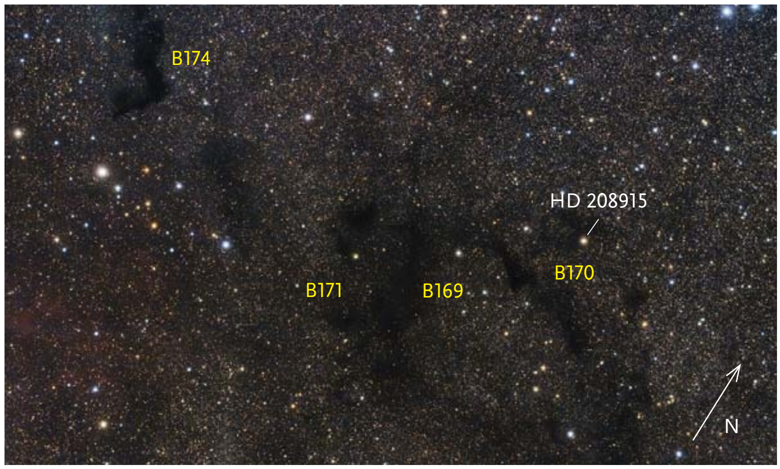


GIOVANNI BENINTENDE



LORENZO COMOLLI

Left: **Together, B173 and B174 compose a rough S-shape that trends north-south. Find B174 north of 6th-magnitude HD 210220; use low power to get as much contrasting starfield in the eyepiece as possible.** ***Upper right:*** **The sinuous form of B150, better known as the Seahorse Nebula, varies in opacity. If you're having difficulty finding it, look for the void south of HD 199097.** ***Bottom right:*** **The 8th-magnitude star HD 208915 sits north of the darkest clouds of B170. Move south to the broad oval of B171, the east-west axis of which stretches some 91′.**

B365 curves eastwards near its northern end. The most prominent absorption nebula within IC 1396 is the dark pore at the southern tip of **B161**.

I needed a UHC filter for IC 1396's other details. V-shaped **B163** was tough. I made out only the northeastern end of the V. Close scrutiny revealed three segments of **van den Bergh 142**, the Elephant Trunk Nebula: the two darkest parts in its western half as well as the energized bright rim on the southern side of the broadening at the eastern end, adjacent to the east-west pair of 8th- and 9th-magnitude suns. (This broadening is mislabeled B142 on MSA charts 1073 and 1087, rather than vdB 142. The real B142 is part of Barnard's E in Aquila.)

My unfiltered 8-inch Newtonian at 44× showed B365 and the dark pore of B161 just as well as the 16-inch does. There's an X-shaped open cluster involved, also labelled IC 1396, but it's so large and sparse that it's apparent only in my 7×50 binoculars and small rich-field scopes.

North of IC 1396, **B366** is a very subtle darkening visible through the 16-inch. You wouldn't notice B366 if you were just sweeping through the field, but the oval dark nebula can be detected at 76× by the paucity of stars in comparison to the richer fields beyond its plotted borders. Bright stars spangle the **B169**–**B170**–**B171** complex, but much of its shape is detectable by the relative absence of faint embers. I expected that long, narrow, S-shaped **B173**–**B174** would be too thin to see, but the ultra-low power of 45× showed the southern half as a lack of faint stars combined with a very subtle darkening; it's visible northwards as far as the headlight double star (HD 210443 and HD 210432, 21′ apart) at the nebula's midpoint. ✦

The International Astronomical Union recognized Contributing Editor ***Alan Whitman*** *this year by giving asteroid 21330 the name Alanwhitman.*

 Jerry Lodriguss

The Stellarvue SVA-130T

This premium 5.1-inch apochromat is aimed at observers and imagers alike.

LET ME WAX LYRICAL about the joys of a quality 5-inch refractor. I think they are quite possibly the perfect telescope. There are few things quite as pleasing as the pinpoint stars formed through the optics of a fine refractor; they are like icy needles whose brilliant pinpricks of light go straight through your soul.

A 5-inch refractor is ideal for high-resolution visual use on the Sun, Moon, and planets. Its resolving power of 0.9 arcseconds is perfect for sampling the typical seeing of 2 to 3 arcseconds common at most amateur observing locations and is well-matched for high-resolution solar imaging in the daytime.

An excellent 5-inch apochromat is nearly the perfect instrument for deep-sky astrophotography. There are literally thousands of objects in the night sky to photograph with them. I've shot through 5-inch refractors for more than 30 years, and I'm just reaching the point where I don't have anything new left to shoot, at least from the Northern Hemisphere.

Other benefits of 5-inch refractors: you don't need a huge mount to hold them. They cool down quickly, and they aren't as susceptible to poor seeing as larger scopes. There are no contrast-reducing obstructions as in Newtonians, Schmidt-Cassegrains, or Maksutovs.

So when offered the opportunity to review the Stellarvue SVA-130T, my question was, is it a great refractor? Let's find out.

Fit and Finish

The Stellarvue SVA-130T Apo Triplet Refractor is a 130-mm, air-spaced f/7 triplet available in several configurations. The "SVA" designation indicates an advanced optical design made with a super-low-dispersion ED glass center element and a Lanthanum rare-earth rear element to correct for spherochromatism. Its lens is mounted in an adjustable, temperature-compensating steel cell. Light scatter and internal reflections are minimized using 6 baffles inside the optical tube. I measured its focal length to be 911 mm. Stellarvue claims each SVA-130T has 0.95 or better Strehl ratio, and the company includes a test report with every scope. The report for the scope we borrowed showed a Strehl of 0.961.

The SVA-130T base model (SVA130-25SV) weighs 16.8 pounds and comes standard with a 2½-inch, dual-speed, rack-and-pinion focuser with 80 mm of travel. Included with purchase is a soft-sided travel case, mounting rings, a metal dust cap, and a 2- to 1¼-inch compression-ring eyepiece adapter.

The scope is also available as an imaging system (SVA130-IS) for $4,090. This package comes with a 3-inch Feather Touch focuser and matched SFFR.72-

WHAT WE LIKE:

Excellent optics

Solid imaging focuser

WHAT WE DON'T LIKE:

Switching from visual to imaging configuration

Stellarvue 130 mm f/7 Apo Triplet Refractor

U.S. price: $3,195

Available at stellarvue.com

The Stellarvue SVA-130T triplet apochromatic refractor is a premium refractor built to last a lifetime — and then some.

ALL PHOTOS BY THE AUTHOR

130-3FT-48 focal reducer/field flattener with either 42- or 48-mm threads to attach your camera. I recommend the 48-mm version for imagers using large-format sensors to minimize any potential vignetting.

With the optional Starlight Instruments 3-inch Feather Touch focuser, the tube measures 32 inches long with the dew shield retracted, and 38 inches fully extended. Its all-aluminum construction has an attractive white pebble texture finish. The imaging scope weighs 19.4 pounds, while tube rings and a dovetail mounting plate add another 4.8 pounds, topping off at just over 24 pounds. Astrophotographers should consider a hefty mount when using this setup. I tested it on an Astro-Physics Mach1, which held it with no problems.

As an imaging system, the SVA-130T covers a 3°-by-2° field on a full-frame 36-by-24-mm sensor. Based on my measurement of images, the reducer yields a 0.75× reduction, making the scope f/5.238 with a focal length of 681 mm. Back focus is about 57 mm from back thread of the adapter, or 69 mm from back of reducer/flattener without adapters, so there's plenty of room for a filter wheel or other accessories.

Through the Eyepiece

My first nights with the SVA-130T were dedicated to visual observations. One of my favorite things to do with a new refractor is to split tight double stars. On a night of average seeing, I used the scope at 300× to see how it would perform on a list of doubles that were visible at the time with separations of 0.5 to 2.5 arcseconds.

I started with Alrakis (Mu Draconis), an equally bright 5.6-magnitude pair of F7 dwarfs 2.3 arcseconds apart that were cleanly split in the scope, looking like two bright headlights. I then observed Mu Cygni with a separation of 1.9 arcseconds but with unequal magnitudes of 4.75 and 6.18, respectively. Again, it was easily split in the SVA-130T, with black sky between them.

The Dawes limit for a 130-mm aperture scope is 0.9 arcseconds. Were the optics good enough for the scope to resolve down to this criterion? I next went to 16 Vulpeculae to find out. This magnitude 5.8 and 6.2 pair is separated by just 0.85 arcseconds, a little less than Dawes limit. This tight pair was seen separated with a classic Dawes "split" showing the two stars as distinct but overlapping with the fainter star to the southeast. Very nice! It was quite a testament to the quality of the SVA-130T that I could split doubles this tight even in mediocre seeing.

To really try the scope on fine planetary detail — a test of resolution, contrast, and light scatter, I had to observe on many nights. I finally got a period of good seeing one night when the fog rolled in. Fog is often indicative of a stable atmosphere that can yield excellent views for planetary work. This was what I had been waiting for, and the scope really performed. I got some marvelous views of Saturn and the third-quarter Moon, even though neither were very high from my location in New Jersey.

Saturn was simply magnificent at 300× with very high contrast, displaying subtle colors and hues on the disc of the planet. The darker Northern Equatorial Belt stood out, and Cassini's division could be seen all the way around the rings. I also detected subtle shading in the outer A ring where the Encke minima is located, as well as brightness variations in the B ring.

The imaging version of the SVA-130T includes a heavy-duty, 3-inch Feather Touch focuser. This dual-speed focuser can be rotated 360° and is locked in place with three knurled brass knobs spaced at 120° intervals around its base.

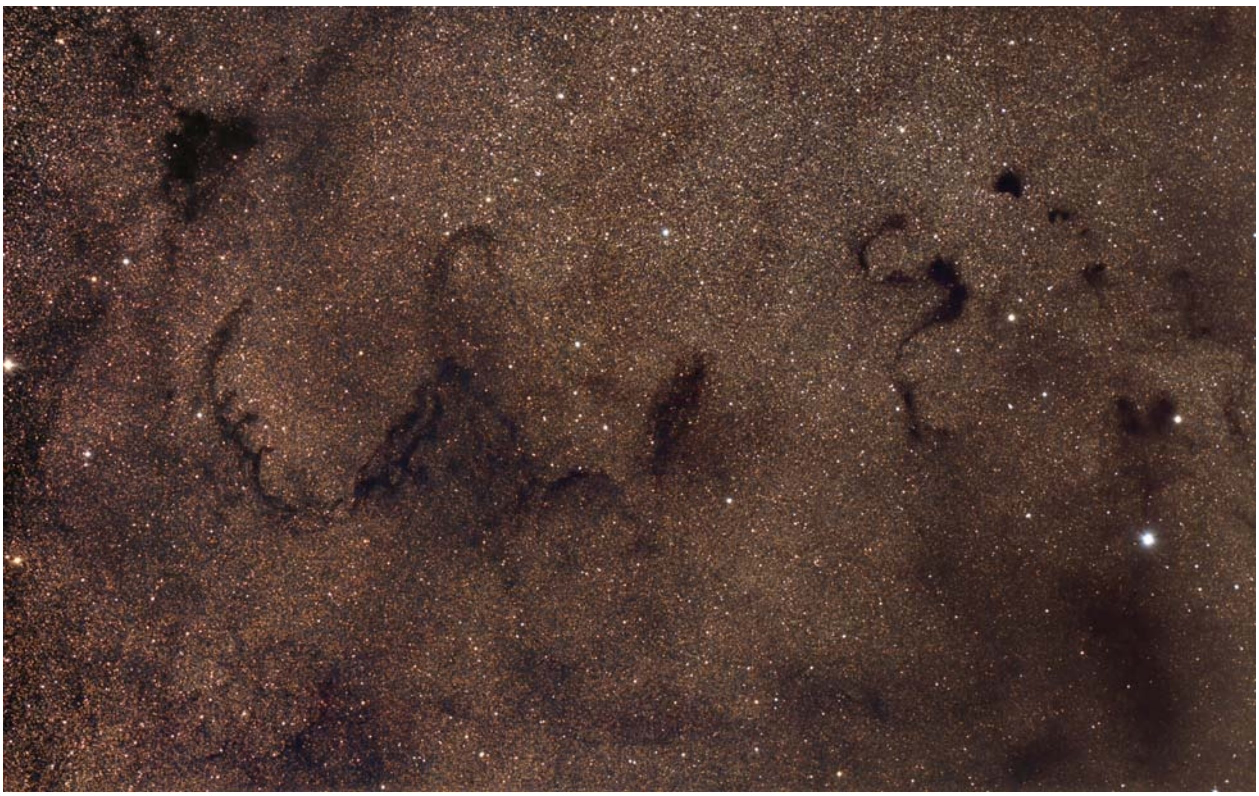
The scope's objective is an air-spaced triplet made with a super-low-dispersion ED glass center element and a Lanthanum rare-earth rear element.

The focal reducer/field flattener attaches to the Feather Touch 3-inch focuser using a custom adapter that also includes collimation adjustments, though the unit is collimated at the factory.

Optical performance of the SVA-130T is designed to be stable as the temperature drops, because the construction of the steel lens cell closely matches the expansion coefficient of the objective. The Feather Touch focuser was superlative with absolutely no image shift or slop when focusing.

A star test revealed a perfectly circular and symmetrical pattern with similar brightness on both sides of focus. The Fresnel pattern was slightly mushy outside of focus, but I have seen this even in the best refractors; what truly matters is what the star looks like when in focus. There was no spurious color at focus on brilliant Vega, and there were no signs of astigmatism, spherical aberration, or spherochromatism. I didn't detect any light scatter in the shadows of craters on the Moon, nor anywhere in the field when the Moon was placed slightly outside of the field of view — a testament to the scope's excellent baffling.

***Top:* Switching between visual and photographic configurations requires removing the focuser and the 110-mm-diameter threaded extension tube, replacing the focuser, and then adding the SFFR.72-130 large-format field flattener/focal reducer, followed by your camera's adapter. *Bottom:* The ruggedly constructed C130HD hard case made from PVC-laminated ⅜-inch plywood with metal-reinforced corners and edges is available for an additional $300. The case is lined with custom-fitted foam and includes caster wheels, weighing in at a hefty 28.6 pounds.**



Images captured through the SVA-130T, such as this field in Ophiuchus — including the dark nebulae B72, the Snake Nebula (right) — displayed well-corrected stars nearly to the corners of a 24-by-36-mm detector.

A close-up of the center and corners of an image recorded with a Canon 6D full-frame sensor and the flattener/reducer shows minor aberrations on bright stars in the extreme corners of the field.

Imaging Performance

Stellarvue's matched SFFR.72-130 focal reducer/field flattener produces a large, well-corrected and -illuminated field for large-format sensors. You can use 48-mm filters directly coupled to the reducer/flattener with an additional adapter from Stellarvue, though you'll need to get the spacing right to achieve best performance.

Attaching the reducer/flattener requires removing the 60-mm-long, 110-mm-diameter threaded extension tube that sits between the tube and focuser.

An exceptionally nice feature of the scope is its modularity. Stellarvue makes adapters for all kinds of cameras that screw everything together so there is no chance of slop, non-orthagonality, or spacing problems — everything is very rigid and perfectly aligned. Stellarvue also auto-collimates the SFFR.72-130 to the main objective for each individual scope — an outstanding touch!

The SFFR.72-130 is not for visual use, so it is a bit of extra effort to switch back and forth between photo and visual configurations because you need to completely remove the focuser to deal with the extension — probably not the kind of thing you would want to be doing in the middle of the night at the scope. Note that the scope is very heavy towards the objective end with the focuser removed, so be very careful.

Stellarvue's smaller 2-inch focal reducers and field flatteners will work with the SVA-130T with the standard 2.5-inch focuser and cameras with APS-C-sized sensors.

I used the scope with a Canon EOS 6D full-frame sensor, as well as another camera with an APS-C sensor. Performance of the scope with the SFFR.72-130 was very good with round stars to the corners of the full-frame sensor but with some minor aberrations visible on bright stars in the corners. Vignetting was minimal and easily corrected with flat-field calibration frames. Star elongation in the corners of the APS-C sensor without a field flattener, while present, was not objectionable.

Summing Up

I was quite impressed with the mechanical build and optical quality of the SVA-130T, especially with its ability to split tight doubles and reveal subtle details on the Moon and planets with no spurious color. The flexibility of using it as an astrograph that can cover a large sensor makes it a dual-purpose instrument. The price of $3,195 for a high-end 130-mm triplet apo is an eye-opener compared to others currently available.

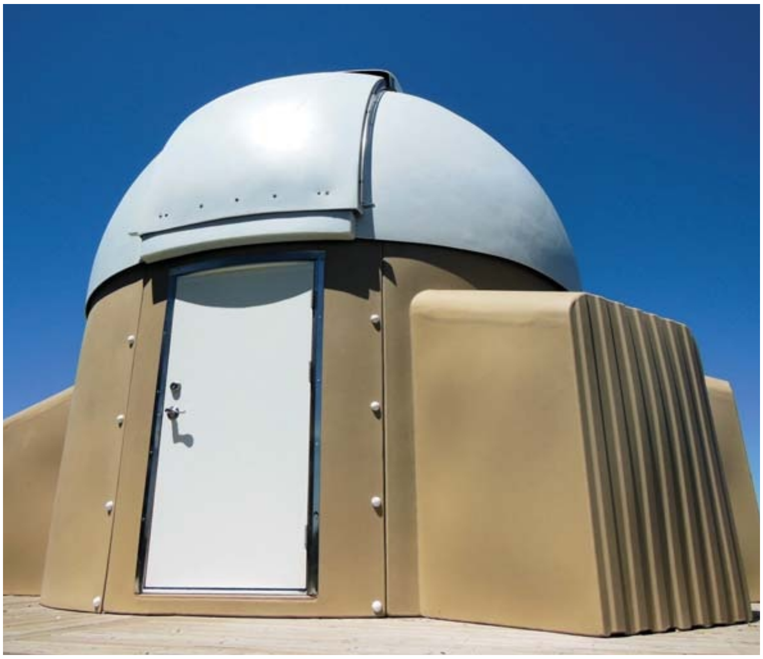
The SVA-130T was a pleasure to use and is a great refractor in my book. ✦

Sky & Telescope *Contributing Editor* ***Jerry Lodriguss*** *continues to shoot the night sky with 5-inch refractors.*

New Product Showcase

▼ **MID-SIZED DOME** SkyShed announces the SkyShed POD MAX ($13,995). This 12½-foot dome is built to accommodate large amateur telescopes and includes a 44-inch-wide slot with a shutter that opens 22 inches past the zenith. The POD MAX incorporates a modular base design, allowing users to add up to 6 additional bays. The dome is manufactured from 3M high-density polyethylene that is resistant to extreme temperatures. The interior of the dome and bays are black-lined, and a large fiberglass residential-style door with deadbolt lock is included with the base model.

SkyShed
519-272-9081; skyshedpodmax.com

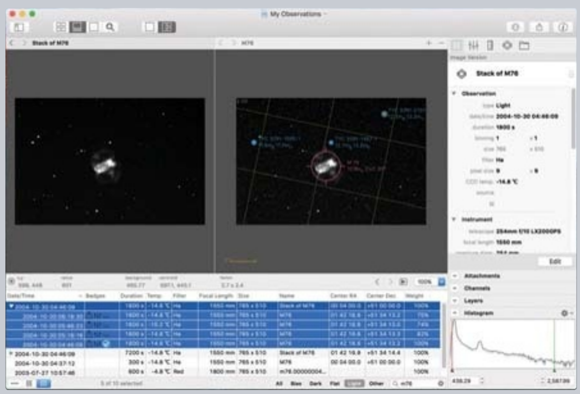


▲ **VERSATILE MOUNT** Sky-Watcher USA announces the Virtuoso Mount ($250). This programmable alt-azimuth platform is designed to capture panoramic photos or smooth panning video. Powered by 8 AA batteries (not included), the mount features brackets to attach just about any camera, from your DSLR to your iPhone. Its dual-axis encoders enable you to move the mount by hand without losing alignment. The Virtuoso also includes a 90-mm f/13.9 Maksutov-Cassegrain tube assembly with 10- and 25-mm eyepieces, a 90° star diagonal, a full-aperture solar filter, and a solar finder. See the manufacturer's website for additional details.

Sky-Watcher USA
475 Alaska Ave., Torrance, CA 90503
310-803-5953; skywatcherusa.com

MAC CONTROL Code Obsession unveils Observatory ($79.95), an image management and processing software for Mac computers. Observatory helps you organize, process, and analyze professional astronomical images as well as your own data. The program allows you to search and import raw professional data from NASA and the ESO for research or to process yourself. Observatory supports FITS, SBIG, TIFF, JPG, PNG, or RAW format images, and includes all the tools necessary to calibrate, align, and combine images. The program also has tools to identify the objects in your images, including all the Messier, NGC/IC, PGC, Tycho-2, UCAC4, USNO-A2.0 catalogs. Requires OS X 10.11 or higher.

Code Obsession
Available through the Apple iTunes store
codeobsession.com



New Product Showcase is a reader service featuring innovative equipment and software of interest to amateur astronomers. The descriptions are based largely on information supplied by the manufacturers or distributors. *Sky & Telescope* assumes no responsibility for the accuracy of vendors' statements. For further information contact the manufacturer or distributor. Announcements should be sent to nps@SkyandTelescope.com. Not all announcements can be listed.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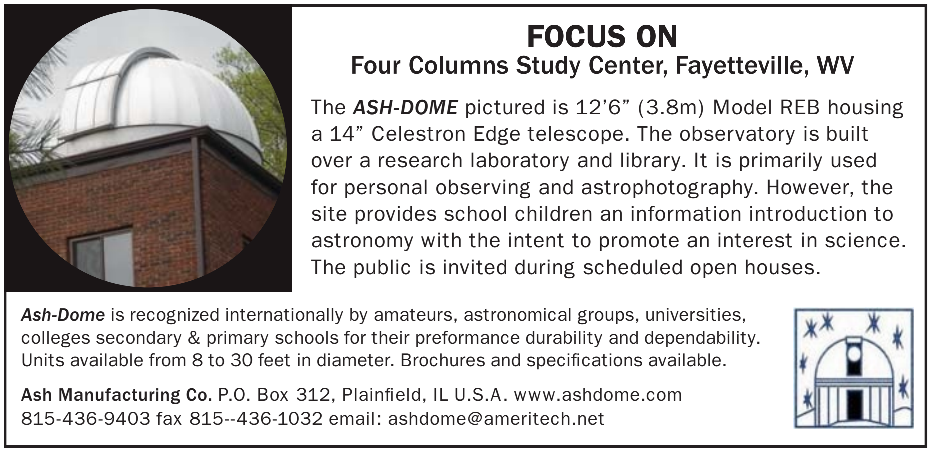
FOCUS ON
Four Columns Study Center, Fayetteville, WV
The ASH-DOME pictured is 12'6" (3.8m) Model REB housing a 14" Celestron Edge telescope. The observatory is built over a research laboratory and library. It is primarily used for personal observing and astrophotography. However, the site provides school children an information introduction to astronomy with the intent to promote an interest in science. The public is invited during scheduled open houses.
Ash-Dome is recognized internationally by amateurs, astronomical groups, universities, colleges secondary & primary schools for their preformance durability and dependability. Units available from 8 to 30 feet in diameter. Brochures and specifications available.
Ash Manufacturing Co. P.O. Box 312, Plainfield, IL U.S.A. www.ashdome.com
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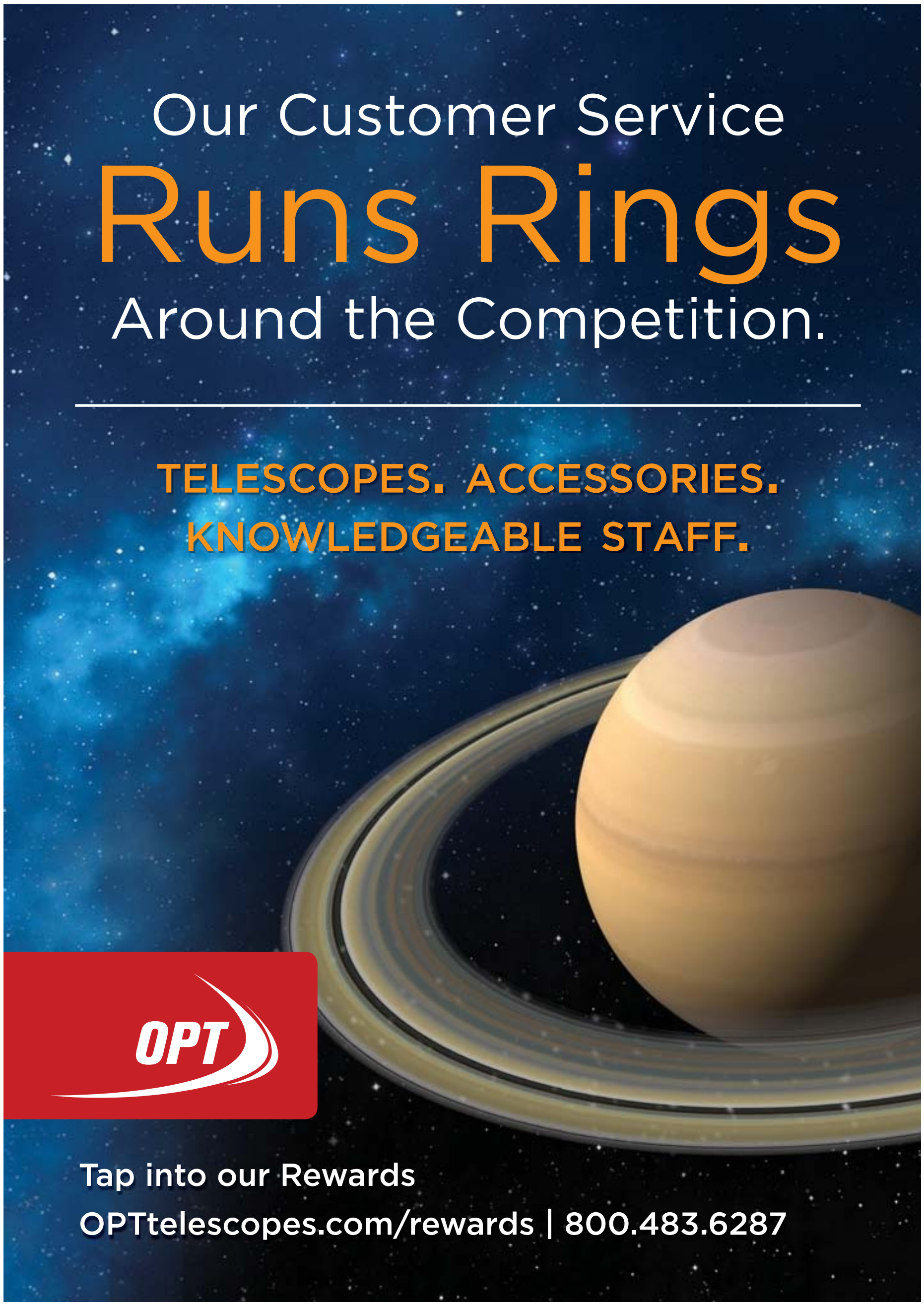
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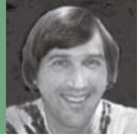


Braking Bad Habits

How to make your lightweight scope behave.

IF YOU'VE EVER USED a lightweight Dobsonian telescope, you've probably experienced the frustration of having the scope head for the zenith when you remove the eyepiece. When a scope is so light that the eyepiece weight is a significant fraction of the total, its removal will throw the balance wildly askew.

Italian ATM Giulio Tiberini has come up with a simple yet elegant solution: a disk brake on the altitude bearing. Normally closed, the brake keeps the scope locked in position until you squeeze the handle, which loosens the brake and allows vertical adjustment. Let go of the handle and your scope won't rise even if you remove the whole secondary cage.

It's an idea that's been staring us in the face for generations. Altitude bearings are perfect disk-brake rotors, just begging for a caliper to hold them firm when you want the scope to stay put. Yet most of the brake systems I've seen involve increasing friction rather than locking the bearing's motion completely. Increased friction just makes the scope harder to move, which isn't an ideal solution to the problem.

Giulio Tiberini with his 300-mm f/6 scope equipped with a disk brake.

ALL PHOTOS BY GIUSEPPE VIARIZZO

The disk brake is a much more elegant answer. As Giulio says, "The presence of side bearings suggests a disk-type brake. Their curved shape of large radius provides a good mechanical moment of resistance, and they seem made to allow a simple and practical installation."

Disk brakes require only two parts: a disk (commonly called the "rotor") and a caliper to squeeze and hold that disk. For his caliper, Giulio used a clamp from a car battery charger and lined the jaws with polyurethane blocks. For the rotor he didn't use the altitude bearing surface itself, because that was too thick for the caliper. Instead he added a steel semicircle, cut with a hand held jigsaw from 2-mm steel plate, to the side of the bearing. He mounted the caliper so the rotor would slide through it freely when the caliper was opened and would be locked tight when the caliper was closed.

That would have been sufficient, but it would require reaching down to loosen the caliper any time he wanted to change the scope's aim in altitude — impossible to do while hunting down or tracking an object unless you're using a very small telescope. But Giulio's scope is taller than he is. He needed to be able to open and close the caliper while looking through the eyepiece, so he installed a bicycle brake lever on one of the trusses where it would be within easy reach. When he wants to move the scope, he simply squeezes the lever against the truss (where he would normally hold the scope anyway) and pushes the scope as he would with any Dobsonian mount. When he reaches the target, he lets go of the handle and the brake locks the scope in place.

Of course, if the scope is imbalanced with the weight of a heavy eyepiece, there's some flexure. As Giulio says, "The mechanical parts can never be perfectly rigid, so there is a little backlash due to the structure of the telescope and the settling of the caliper under load. Thus you learn to adjust your aim a little above the target, but it's easy because the brake is so intuitive to use."

A simple bicycle brake handle mounted to a truss at a convenient position completes the system.

The clamp came from a battery charger, and the rotor is made from sheet metal.

That's what I like to see in a telescope modification: something easy to build and easy to use. Giulio's parking brake is both. Giulio describes it as ". . . a simple little working idea that will not add more cumbersome hardware to assemble and disassemble," and I couldn't agree more. It's the sort of thing that makes perfect sense the moment you see it. And once it's installed you can switch from a 31-mm Nagler to a 10-mm Plössl without rebalancing your scope or even losing your target. That's quite an accomplishment for such a simple modification.

Learn more about Giulio's many ATM projects at **tinyurl.com/grqbgzy**. ✦

Jerry Oltion plans to install a brake on the new travel scope he's building based on last month's column.

Do you have a telescope or observing accessory that *S&T* readers would enjoy knowing about? Get featured in Astronomer's Workbench by e-mailing Jerry Oltion at j.oltion@sff.net.

PUSHING the Limit

Sean Walker

An intrepid astro-imager goes where no amateur has gone before.

AMATEUR ASTROPHOTOGRAPHERS are an insatiable group. They continually strive to improve everything they can with their pursuit, be it constant upgrades to equipment to get the very best performance or developing new and improved processing techniques to squeeze every last photon from their images. Often this leads to some friendly competition, with the ultimate goal of producing the best images possible within their means. Some strive to take the most detailed image of a planet, while others search for undiscovered objects that range from asteroids to distant nebulosity in our Milky Way. Others seek to record the faintest object possible. So how deep can an amateur go?

Going Deep

The question of how deep an exposure you can take dates back to a challenge issued 18 years ago by professional astronomer Bradley E. Schaefer (*S&T:* May 1998, p. 119). Schaefer encouraged readers to tackle a specific, well-studied field in Serpens. Less than one year later, Paul Boltwood of Ontario, Canada, who specializes in faint-object photometry, was pronounced the winner. His 20-hour cumulative exposure using a home-built 16-inch Newtonian reflector and CCD camera identifies objects down to magnitude 24.1.

BIG GUN Johannes Schedler in the Chart32 dome next to its massive fork mount and 32-inch corrected Cassegrain. Note the FLI ProLine PL16803 CCD camera, which appears dwarfed at the instrument end of the telescope.

ALL PHOTOS COURTESY OF JOHANNES SCHEDLER & THE CHART32 TEAM

Boltwood's record stood for close to a decade before being seriously challenged. In 2007, amateurs Johannes Schedler and Ken Crawford joined forces to capture the 24.6-magnitude quasar CFHQS J1641+3755 using 16- and 20-inch reflectors (*S&T:* Feb. 2008, p. 88). With a redshift of 6, light from the quasar left the host galaxy 12.7 billion years into the past. That's looking back more than 90% of the accepted age of the universe!

While a remarkable accomplishment, it required imaging at visible through near-infrared wavelengths, while Boltwood's result was recorded in visible light. So while Schedler and Crawford had bagged the most distant object, Boltwood's record still stood.

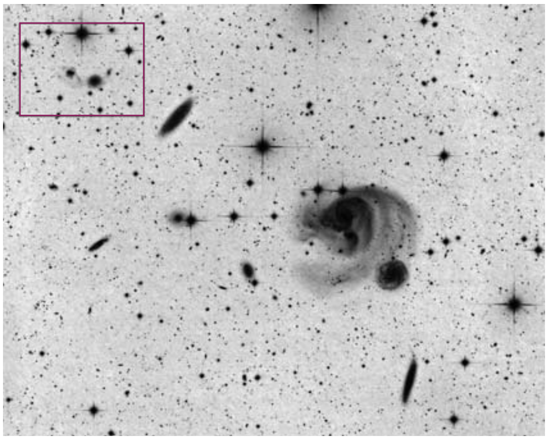
The next challenger came along in 2013. Auckland, New Zealand amateur Rolf Wahl Olson accumulated an unprecedented 120 hours of exposure while imaging the well-studied galaxy Centaurus A over the course of 43 nights with a 10-inch f/5 Serrurier-truss Newtonian reflector and QSI 683wsg CCD camera through Astrodon red, green, blue, and UV/IR-blocked luminance filters (**tinyurl.com/z4o78ca**). His image ultimately resolves objects down to an astounding magnitude 25.4! This was (and still is) an impressive feat, recognized as the deepest amateur image at the time and definitively besting Boltwood's 1998 result.

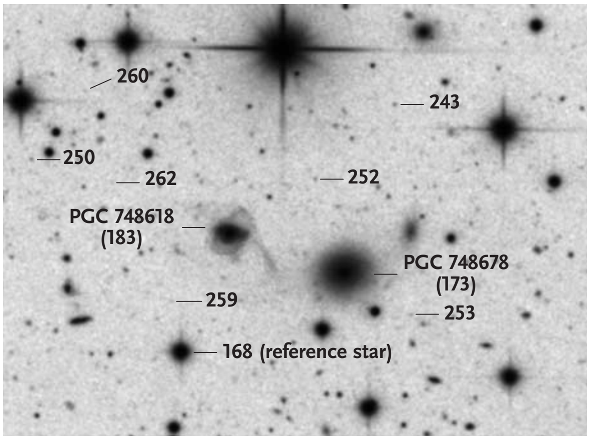
But, as they say, records are made to be broken.

Even Deeper

Earlier this year, Schedler returned to the challenge armed with the Chart32 32-inch Cassegrain (described later) and Finger Lakes ProLine PL16803 CCD camera. He targeted the compact galaxy group Hickson 91 in Piscis Austrinus that contains several interacting spiral galaxies, including NGC 7214. Schedler recorded 17.7 hours of images through red, green, blue, and UV/IR-blocked luminance Astrodon filters.

After combining the data, he noticed a faint, distorted galaxy in the upper-left corner of the image identified using

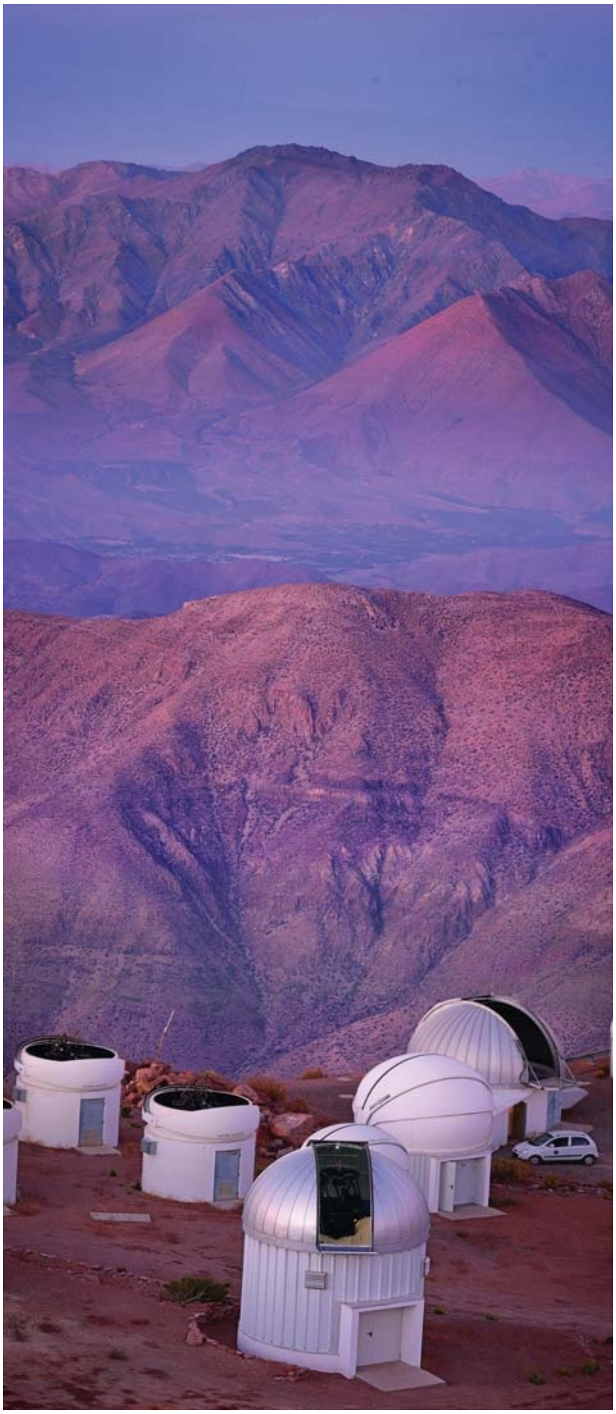




GOING DEEP *Above:* This detailed CCD image of the compact galaxy group Hickson 91 in Piscis Austrinus reveals several spiral galaxies that display evidence of gravitational interaction, particularly the large, face-on spiral NGC 7214 at the middle right of the frame.

ZOOM IN *Left:* Several spiral galaxies are seen in the field, though a faint, distorted object in the top left (inset) caught the interest of photographer Johannes Schedler. *Right:* Photometric measurements performed in *MaxIm DL* show many objects fainter than 20th magnitude in the area surrounding the distorted galaxy PGC 748618, including one object at magnitude 26.2. Magnitude values are shown to the nearest tenth, with decimal points omitted.

TheSkyX as 18.3-magnitude PGC 748618. Schedler then performed photometric measurements on objects in a 3-by-2-arcminute area surrounding this galaxy using *MaxIm DL* calibrated on a magnitude-16.8 white star in the field. He then plotted the magnitude measurements against a log-scaled diagram in *Microsoft Excel*. The result shows conclusively that he unambiguously recorded 26th-magnitude objects with a signal-to-noise (S/N) ratio of 5 and mag. 26.4 objects with a S/N ratio of 2.5 — a new record!



PROMPT 7 **The Chart32 telescope (also known as PROMPT 7) in the foreground resides on the grounds of the Cerro Tololo Inter-American Observatory in the Coquimbo Region of Chile. The additional domes house other robotic instruments in the University of North Carolina's PROMPT telescope network.**

More than Long Exposures

Given these results, taking a deep image might seem like an easy accomplishment — simply record as many images you can and stack them together. But there are limits to what you can do with smaller instruments, and the darkest-possible sky is only part of what you'll need to go extremely deep. Matching your instrument to the local seeing conditions is also crucial to your final output. If your instrument is capable of resolving features smaller than the seeing permits, stars and other small objects will be smeared and thus unresolved in your final result. This is why sites for professional observatories are carefully researched and selected to get the most out of these remote facilities.

Optimum seeing was high on the list of requirements when a group of European amateurs considered locations for their collaborative observatory. In 2007, premier astro-imagers Kostantin Buchhold, Bernd Flach-Wilken, Johannes Schedler, Volker Wendel, and optical engineer Philipp Keller formed Chart32 (Chilean Advanced Robotic Telescope 32″) to establish a large remote telescope operating at a site with conditions that suit a large-aperture instrument. The group entered into an agreement with the University of North Carolina to construct its facility on the school's grounds at Cerro Tololo Inter-American Observatory in Chile, a location well known for its extremely dark skies and frequently steady atmospheric seeing.

Chart32 consists of a 32-inch f/7 corrected Cassegrain designed by Philipp Keller. The telescope and its 5-meter Ash-Dome are built to take advantage of the excellent conditions atop Cerro Tololo. The instrument is mounted 4 meters above the floor to minimize the effects of heat radiating from the concrete pad, and the dome utilizes forced ventilation using two axial fans that reduce dome-induced seeing degradation to nearly imperceptible levels. More details are at **chart32.de**.

Typical seeing values using the Chart32 have been measured at between 0.8 and 1.2 arcseconds, resulting in sharp images at an image scale of 0.33 arcsecond per pixel. The team concentrates its efforts on producing extremely high-resolution images of galaxies, star clusters, and emission and planetary nebulae. Given these results, it might only be only a short time before Schedler or another member of the Chart32 team surmounts this latest achievement. I anxiously await their results. ✦

Sky & Telescope *Equipment Editor* ***Sean Walker*** *often dreams about using robotic telescopes under pristine skies.*

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▲ **BLUE FLAMES**

Ivan Bok

The reflection nebulae Van den Berg 105 (at right) and 106 form part of the Rho Ophiuchi complex. The sky wasn't perfect — smoke from forest fires wafted overhead — when this composite was recorded from Mersing, Malaysia.

Details: *Takahashi FSQ85-ED astrograph, SBIG ST-8300M CCD camera, and Baader LRGB filters. Total exposure: 5¼ hours.*

▶ **THROUGH THE EYEPIECE**

Jordan Walker

This unprocessed view of Jupiter (with its Great Red Spot) and Io shows the kind of detailed image quality achievable by holding a smartphone up to the eyepiece of a telescope. South is up.

Details: *16-inch Meade LightBridge reflector at 285× and handheld iPhone 6s Plus. Exposure: 1⁄30 second at ISO 64.*

Visit SkyandTelescope.com/gallery for more of our readers' astrophotos.

▲ ***Above, left to right***

STARBIRTH IN SCORPIUS

Don Goldman

Brilliant young stars have emerged from the dark interstellar complex Lupus 3 (also known as Bernes 149).
Details: *PlaneWave CDK20 astrograph and SBIG STX-16803 CCD camera with Astrodon Gen 2 E-Series RGB filters. Total exposure: 7½ hours.*

TRIANGULUM'S TRIUMPH

Chuck Manges

One of the sky's smallest constellations holds one of its greatest spiral galaxies: Messier 33, part of the Local Group.
Details: *Celestron EdgeHD 11 aplanatic Schmidt-Cassegrain telescope with HyperStar, QHY23M CCD camera, and LRGB filters. Total exposure: 1.9 hours.*

DARK CROWN

Ron Brecher

Hugging the southern horizon for most northern observers, Corona Australis boasts NGC 6541 (at far right), several reflection nebulae, and dark Bernes 157.
Details: *Takahashi FSQ-106 astrograph, SBIG STL-11000M CCD camera, and Astrodon filters. Total exposure: 8½ hours.*

FAMOUS SISTERS

Rich Hammar

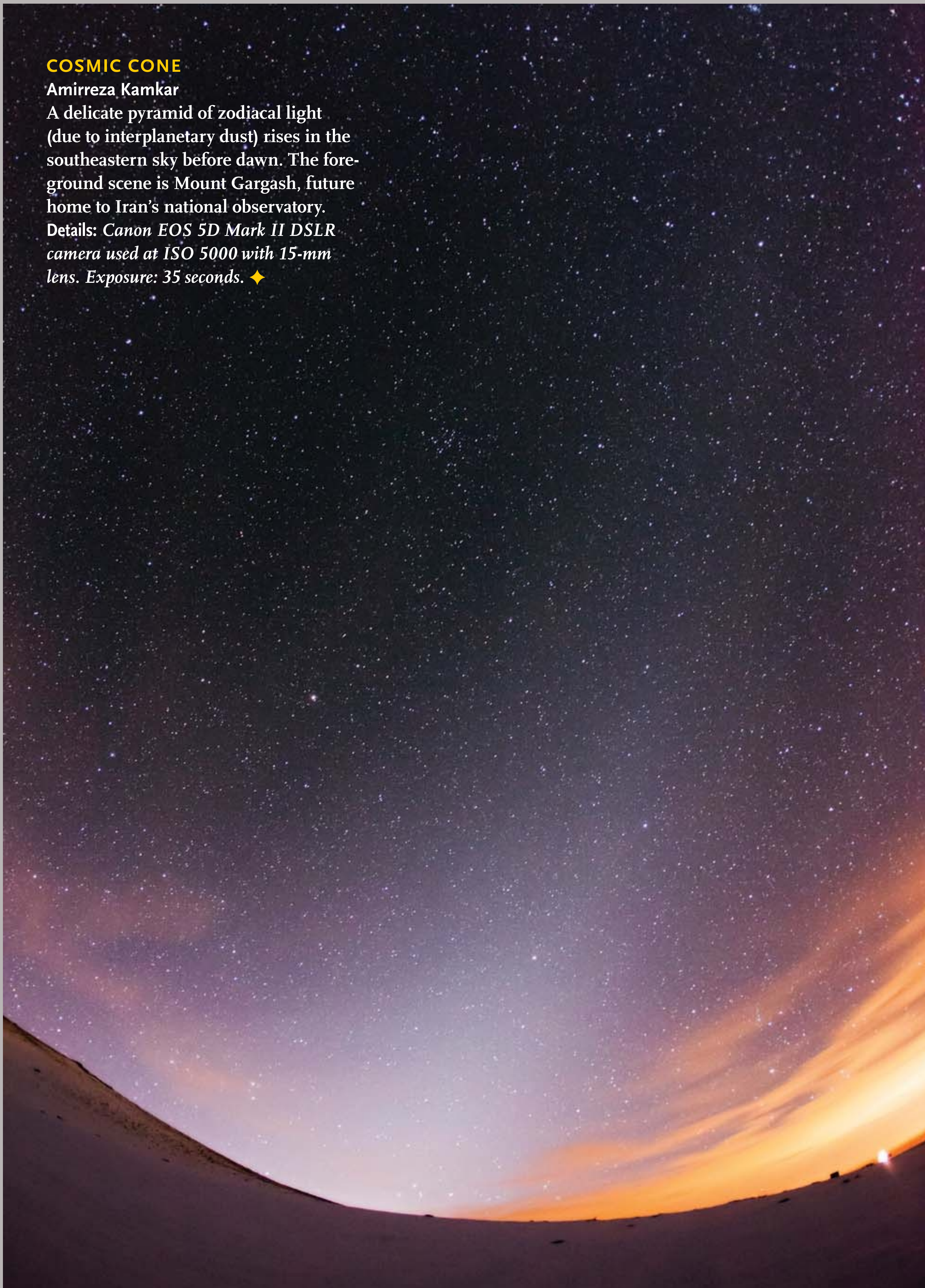
The faint nebulosity enveloping the Pleiades likely isn't part of the cluster but rather due to unrelated interstellar dust.
Details: *Takahashi FSQ-106 astrograph, QSI 683 CCD camera, and Astrodon LRGB filters. Total exposure: 10.7 hours.*

HOME ON THE RANGE

Gary Winckel

The high plains east of Denver provided a picturesque setting last April for this eight-image panorama of the rising Milky Way.
Details: *Canon EOS 5D Mark III DSLR camera used at ISO 3600 with 16-mm lens. Exposures: 30 seconds each.*


HOME ON THE



COSMIC CONE

Amirreza Kamkar

A delicate pyramid of zodiacal light (due to interplanetary dust) rises in the southeastern sky before dawn. The foreground scene is Mount Gargash, future home to Iran's national observatory.

Details: *Canon EOS 5D Mark II DSLR camera used at ISO 5000 with 15-mm lens. Exposure: 35 seconds.* ✦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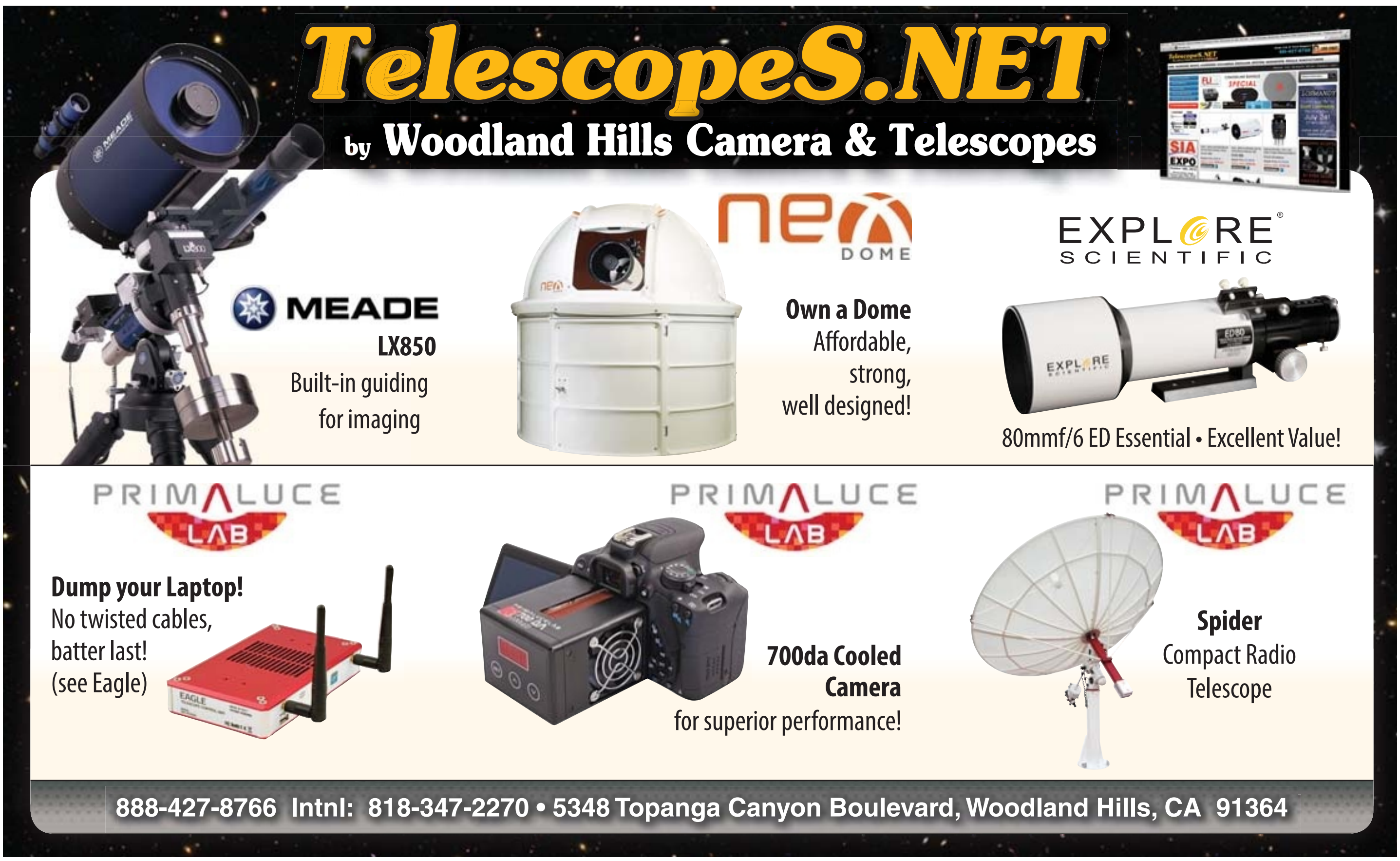
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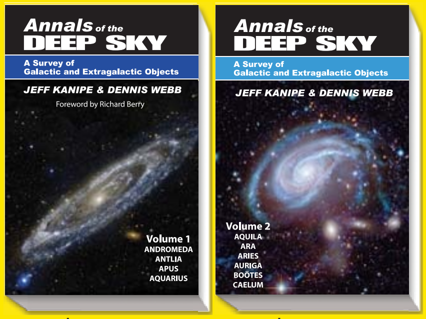

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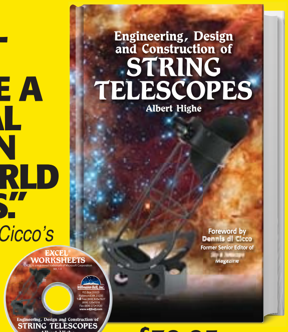

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Glaring Issues with Streetlights

The American Medical Association speaks out on new LED lighting.

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The world is about to undergo a revolution in street lighting. Already about 10% of U.S. cities and towns have replaced their conventional streetlights, primarily high-pressure sodium lamps, with LED streetlights. This is a good thing. LEDs, or *light-emitting diodes*, are highly energy efficient, last for many years, reduce operating and maintenance costs, and are programmable, so they can be dimmed in off-peak hours such as 1 to 5 a.m.

So why are medical practitioners concerned?

It's all in the color of the light. Manufacturers characterize the hue of LEDs by matching their light's apparent color with what an iron poker would look like if it were heated to a specific high temperature. First-generation LEDs, which are still being widely installed, had a color temperature of 4000 kelvin, or 6740°F. (It's only a correlation; LEDs are cool to the touch.)

The issue is that 4000K LEDs produce 29% of their glow in blue wavelengths, and our eyes perceive the combined effect as a harsh white color. Most readers are already familiar with astronomers' aversion to bluer light. But those of us in medicine are worried, too. Short-wavelength blue light scatters more within the human eye than longer, "redder" wavelengths. This means that high blue content can trigger intense *disability glare*, in which stray light reduces our eyes' ability to resolve spatial detail. Such glare can present a hazard for drivers, especially older ones, whose eyes are less able to cope with poorly directed light. If blue-rich light shines in bedrooms at night, a circumstance common in urban areas, it can suppress production of the sleep-related hormone melatonin, resulting in sleep disorders and other health issues.

A number of major U.S. cities, among them Brooklyn, Seattle, and Cambridge, Mass., have met with vocal citizen protests after implementing 4000K LED streetlights. In Davis, California, after residents complained about such newly installed lights, city officials went so far as to replace all of them with 3000K LEDs.

The slightly "yellower" 3000K LEDs emit only 21% of their light in the blue part of the spectrum, yet still appear very white to the human eye. In general, citizens like them much better, and they are just as efficient and no more costly than 4000K LEDs. So everybody wins.

As an elected member of the American Medical Association's Council of Science and Public Health, I proposed — together with Dr. George Brainard (Thomas Jefferson University) and Dr. Richard Stevens (University of Connecticut Health Center) — a report to advise municipalities on optimal LED street lighting to minimize human and natural health effects. The AMA released this report in June. (It is available for free, after creating a username and password, at **http://is.gd/LEDlighting**.) The report builds on our 2012 report on "Human and Environmental Health Effects" (previewed in *S&T:* Sept. 2011, p. 86).

It *is* possible to design lighting that enhances visibility without creating possibly dangerous glare, interrupting human circadian rhythm, or potentially interfering with the lives of nocturnal animals, including birds that migrate at night. I urge manufacturers to test their products on human subjects and verify that the lighting indeed improves visibility. Much street lighting in place today would fail this simple test. ✦

***Mario Motta, M.D.**, is a cardiologist at the North Shore Medical Center in Salem, Mass., and an assistant clinical professor at the Tufts University School of Medicine. He is also an advanced amateur astronomer with a 32-inch reflector in his home observatory (S&T: May 2011, p. 32).*

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