Fighting for Dark Skies p. 30

THE ESSENTIAL MAGAZINE OF ASTRONOMY

SKY & TELESCOPE

SEPTEMBER 2011

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JUNO ART: NASA / JPL
JUPITER IMAGE: NASA;
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On the cover: An artist depicts Juno arriving at Jupiter in 2016. An image of Jupiter is featured in the background.

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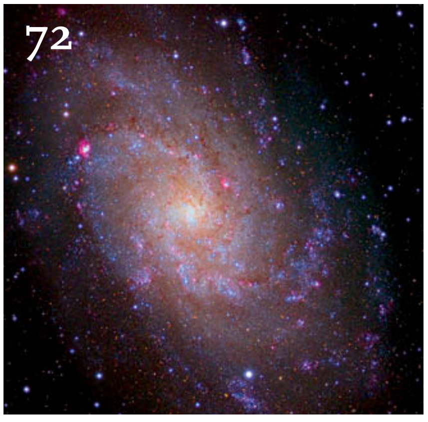

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Star Parties

IN LATE MAY I attended the Society for Astronomical Sciences symposium in Big Bear Lake, California, and came away feeling even more energized about future prospects for amateur science. Right after SAS, I had a wonderful time at the Riverside Telescope Makers Conference, held nearby at a rustic YMCA camp. Vehicles and telescopes were everywhere to be seen, there were plenty of vendors, the talks were excellent, the food was good, and people were clearly enjoying their visit (except when battling strong winds on Saturday). I don't see how the RTMC organizers could have done a better job planning the event.

After RTMC I spoke with Bob Stephens and Ralph Megna at their new remote desert observatory, the Center for Solar System Studies. Bob is one of the organizers of RTMC and Ralph is an organizer of the Nightfall star party in California. Both Bob and Ralph pointed out that RTMC's attendance has been slowly declining in recent years. Other large star parties have witnessed similar downturns. What's going on, and can anything be done to reverse the trend?

Part of the problem is not really a "problem" per se, as far as the overall health of amateur astronomy is concerned. As star parties gained traction over the past few decades, more events sprouted up. And many clubs have developed their own remote observing facilities. People (and vendors) simply have more options, which is driving down attendance at some of the biggest events.

Bob, Ralph, and I also discussed several economic factors that discouraged attendance. At the time of RTMC, gasoline in California was well over $4 per gallon. Those high gas prices coincided with a high unemployment rate. A lot of people who normally would attend probably just didn't feel financially secure enough to shell out hundreds of dollars in gas, especially if they drove RVs.

But there are more worrisome trends. Many amateur astronomy clubs — the traditional base for star parties — are shrinking. Clubs are finding it difficult to replace members lost to attrition, and young people are becoming scarcer.

In contrast to other star parties, Nightfall's attendance has actually been increasing the past few years. Why? Ralph says the organizers focus on the overall guest experience — from the time attendees learn of the event until they depart. Nightfall attracts folks who are willing to spend bigger bucks on an astronomy weekend getaway. It's held at a desert resort with nice rooms, swimming pools, a saloon, a restaurant, and a general store. Each year Ralph surveys attendees at checkout to find out what they liked and disliked about their experience. For example, guest comments from 2010 are leading to a change in the food service and the return of sci-fi movies. Ralph says the venue is important, but that extensive analysis and attention to detail, and the design and execution of the guest experience, are key factors for Nightfall's increasing attendance.

RTMC still draws nearly four times as many attendees as Nightfall, and it will remain a great star party for years to come. But I think Ralph has some keen insights on how star parties, especially smaller events, might evolve and thrive by being flexible in their response to changing socioeconomic forces.

Robert Naeye
Editor in Chief

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Hiratsuka city, in Japan's Kanagawa Prefecture, while a busy commercial and industrial city, is perhaps most famous for its Tanabata festival, which celebrates legendary star-crossed lovers of long ago. So it is fitting that this busy city has a fine planetarium to tell the story of this couple in the sky.

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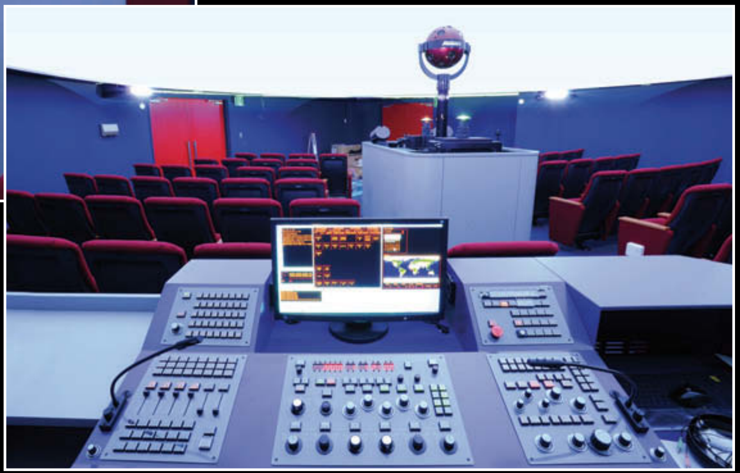

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Letters

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

How Low Can You Go?

We chuckled when we read Fred Schaaf's comment about observing Omega Centauri from latitude 41° north ("A Star by Any Other Name," June issue, page 40). Not because it was silly, but because we have observed and imaged Omega Centauri 90 miles north of that location — in Magnolia, Massachusetts, at latitude 42.58°. We used a Meade LX200 8-inch SCT on the evening of May 24, 1998, on Magnolia's south-facing coast. One of us (Ralph Pass) observed it as the telescope was being set for imaging. We imaged Omega Centauri and Centaurus A that evening with a Meade Pictor 416XT CCD camera. The image of Omega Centauri confirmed our observation.

Omega Centauri was quite hard to detect, and the images would be considered poor if you didn't allow for the object's extremely low altitude. The cluster's center was 10′ below the horizon, not accounting for refraction, which probably raised it about ½°.

We think this is one of the most northerly observations of Omega Centauri, if not *the* most northerly. We called this Limbo Astronomy — how low can you go?

Ralph Pass
Andover, Massachusetts
John Gall
Boston, Massachusetts

A Plea for SAO Numbers

James Mullaney's article "Double Stars of Summer" illustrates a common problem: the lack of Smithsonian Astrophysical Observatory (SAO) numbers for stars (July issue, page 40). Amateur astronomy continues to decline despite advances in technology, and two probable causes are light pollution and lack of leisure time. Modern Go To telescopes overcome the problems of star hopping in a light-polluted environment, and the controllers of most Go To mounts index stars by SAO number. Typical amateurs don't have the half hour needed to look up the SAO numbers. I think the hobby would certainly benefit and expand if you simply included the SAO numbers for all the stars in your tables, as well as nearby "synch stars" for deep-sky objects.

Kurt A. Fisher
Salt Lake City, Utah

Editor's note: *Several readers have expressed this concern. The underlying problem is that so many Go To controllers offer no way to locate stars by their most common designations, such as Bayer letters, Flamsteed numbers, and Struve numbers. We keep hoping that Go To manufacturers will rectify this deficiency. But as things stand, there's no doubt that we would save many readers time by including SAO numbers. The trick is doing so without taking up an inordinate amount of space in the magazine. We discontinued page references to popular star atlases some years ago for precisely that reason. Meanwhile, almost all Go To controllers allow you to locate objects by right ascension and declination — the one genuinely universal reference system. That's one of the many reasons that we supply R.A. and Dec. in all our tables. We are curious what other readers have to say on this subject.*

A Word from the Author

I'm bemused by the letter replies in the June issue to my Focal Point essay ("Science as Human Nature," April issue, page 86). Messrs. Elliot and Reade seem to disagree with things I'm not aware of having written. Certainly modern scientific methodology is something we learn, not something we are born knowing. But concluding from such that science is not inherent in human nature is like concluding that music is not inherent in human nature because nobody is born knowing how to play a Bach Cello Suite.

I was after something more fundamental: our inherent capacity to explore and comprehend the world around us. Curiosity is at the root of science. The question, "What works?" is a key expression of that curiosity and is not limited to applications. Indeed, I used the thread of discovery from Ptolemy to Einstein as an example. Here, what works is simply the description of nature that best fits the available data. While the practical benefits of science are nothing to sneeze at, I didn't suggest that "what works" is only about them.

Ironically, in the same issue as the letters, Mark Devlin and Mark Halpern mention in their article on BLAST that "every generation" has been "compelled to ask" about the nature and origin of the stars ("Having a BLAST in Antarctica," page 20). If science were not "in our soul," why would we have asked such questions since time immemorial? And might we not do better at keeping the young interested in science if we embraced that fact?

Dale E. Lehman
Essex, Maryland

A Different Path

I feel I need to respond to Robert Naeye's editorial in the July 2011 issue ("Neptune, Droid App, and Astrotourism," page 6). While I experienced the same two events described in the editorial, my reaction was exactly the opposite. My small telescope was so bad, all I ever was able to find was Earth's Moon. I also read *The Search for Planet X*, but the description the book gives of Clyde Tombaugh guiding exposures all night long, and then spending his days developing plates and blinking the images, actually turned me off from pursuing astronomy as a career.

I earned a Ph.D. in planetary science and am now a professor of physics and the director of the Oakley Observatory at Rose-Hulman Institute (a college that specializes in science and mathematics).

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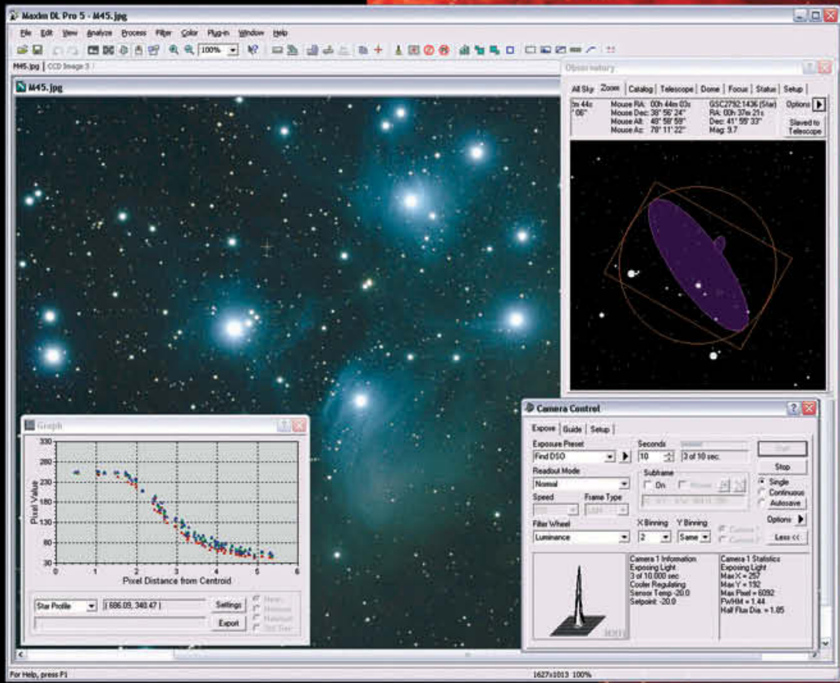

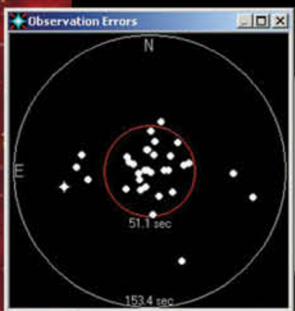

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I got into astronomy when the observatory at Rose-Hulman was scheduled to be torn down. The observatory had been established in 1961 as a Moonwatch sight, but by the early 90s it wasn't being used by the students very much. I was able to save the observatory by acquiring new equipment, which was easier for the students to use. When student use increased, the school actually decided to build a brand new observatory. We now have a campus observatory with eight computer-controlled telescopes equipped both with eyepieces and CCD cameras.

It is interesting to note that at the end of *The Search for Planet X* there is a letter to Tony Simon from Tombaugh. In the letter Tombaugh comments, "Perhaps completely new methods invented in the future will solve the problem of dealing with hundreds of millions of stars in a more practical way. This would make a deeper search feasible and improve the chances of finding another distant planet." New transneptunian objects were only discovered after the invention of the CCD camera and computer-controlled mounts. Those same inventions got me into astronomy and saved the Rose-Hulman observatory.

Richard Ditteon
Terre Haute, Indiana

For the Record

On the all-sky chart for the July issue (page 45), Mars is mistakenly shown just above the western horizon. In fact, Mars is not visible on July evenings.

75, 50 & 25 Years Ago

Roger W. Sinnott

September / October 1936

Interstellar Meteors? "Meteors which possess speeds in excess of this value, at the moment that they enter the earth's atmosphere . . . must be cosmic visitors which happen to run into the earth on their first and only trip into the solar system. A recent investigation made by the Harvard Observatory indicates that at least half the meteors seen are really visitors from interstellar space. This is a surprising and interesting result that leads us to inquire how many of these bodies there are in space and how they came into existence. These problems will undoubtedly require many years to answer."

The simple answer came much sooner than meteor specialist Fletcher Watson expected: the study was wrong. After the war, radar and better photographic surveys would show that essentially all meteoric particles had closed orbits around the Sun.

September 1961

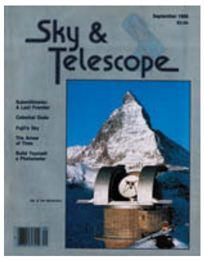
Dawn Comet "Sunday morning, 23 July 1961, I was navigating a Pan American 707 Jet from Honolulu to Portland [at] altitude 29,000 feet. Only a trace of zodiacal light was visible in the east and dead ahead the star Theta Aurigae had just come over the horizon. . . . Following Theta was a faint wisp of light as from a distant searchlight. . . .

"My associates in the airplane were not among the followers of Tycho Brahe and they unfortunately did not appreciate the significance of what we had just observed that morning."

A. Stewart Wilson relied on the rarest of all techniques for discovering comets: the naked eye. Wilson was the first to report Comet Wilson-Hubbard, C/1961 O1.

September 1986

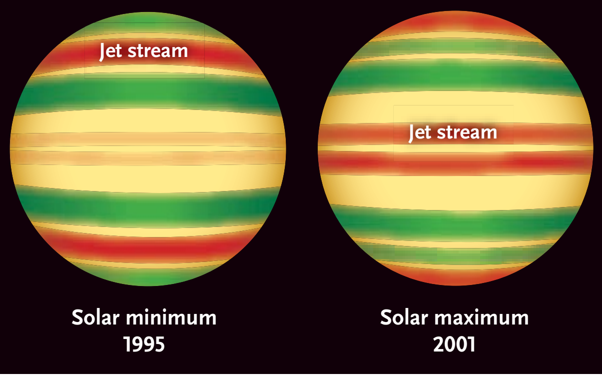
Radio Beats Optical "One of astronomy's oldest and most venerable branches is astrometry, the measurement of star positions [and] proper motions. . . . The prize for proper-motion accuracy, however, has just been claimed by radio astronomers. Very-Long-Baseline Interferometry (VLBI) can detect motions on the celestial sphere that are as small as 20 arc microseconds per year . . . imagine the width of an object 1½ inches across at the distance of the Moon."



Today, VLBI positions of distant extragalactic radio sources define the fundamental reference system, known as ICRS, underlying all other coordinate systems used by astronomers.

To get astronomy news as it breaks, visit SkyandTelescope.com/newsblog.

Is the Sunspot Cycle About to Stop?



Deep "jet streams," 7,000 km below the Sun's surface, move from high latitudes (left) toward the equator as each solar cycle progresses. The streams play an important role in generating surface magnetic fields; sunspots and active areas tend to emerge above them.

S&T: LEAH TISCIONE; DATA: NSO / FRANK HILL

When 320 Sun specialists gathered in June for the conference of the American Astronomical Society's Solar Physics Division, the big buzz was about a claim that the 11-year solar activity cycle may be on the verge of a drastic change.

Four scientists with the National Solar Observatory have reported three separate signs that the solar cycle may be about to go dead. In a press conference at the meeting, they predicted that the current solar Cycle 24 (which began in 2008) will produce only half as many spots as the previous cycle. And, said solar-interior expert Frank Hill, Cycle 25 "may not actually happen."

Cycle 24 is predicted to peak in 2013. Cycle 25 would normally be expected to peak around 2024.

Sunspots are the most visible indicator of the Sun's 11-year cycle of magnetic activity. This activity includes solar flares and coronal mass ejections that bombard Earth and its environs with protons, X-rays, and gusts of solar wind — causing auroras, radiation spikes that can harm satellites, and magnetic turbulence that can wreck electric power systems. The solar cycle remains full of mysteries. In particular, sunspots nearly disappeared from about 1645 to 1715, an event known as the Maunder Minimum, for reasons unknown.

At the meeting, the four researchers explained the three suspicious signs on which they base their predictions.

1. The next jet stream is missing. Frank Hill uses solar seismology, or helioseismology, to see what is going on inside the Sun. Hill has long noticed a slight variation from the general pattern of the Sun's rotation at a depth 7,000 km below the surface. This "torsional oscillation" shows up as matching east-west zonal currents, or "jet streams," under each hemisphere. Sunspots and other surface activity appear above the jet streams. The streams begin each solar cycle at high latitudes and move equatorward until the cycle ends, as shown above.

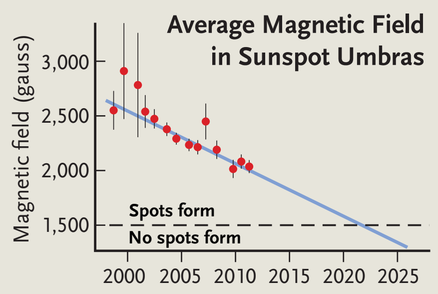
The streams themselves get started long before surface activity begins. Hill's data show that the streams for the recently begun Cycle 24 first appeared (at high latitudes) all the way back in 1997, when the sunspots of Cycle 23 were still beginning to ramp up at lower latitudes.

Similarly, now that we're seeing spots of Cycle 24, solar seismologists should see the formation of the new jet streams that will cause Cycle 25. But so far there's no trace of them, as shown in the data plot at the bottom of the facing page (see the right-hand corners). They're now three years overdue.

Moreover, the streams for Cycle 24 moved from high to lower latitudes more slowly than those one cycle earlier. This slower movement exactly matched, and presumably explains, the surprising delay in the start of Cycle 24 in the last few years. Hill concludes that with the next high-latitude stream completely absent so far, the necessary precursors for a new cycle after the current one are missing and we may have no Cycle 25 at all, or at least a greatly reduced one.

2. The "rush to the poles" hasn't happened. Richard Altrock (Sacramento Peak Observatory) has long observed the solar corona, the Sun's very hot, outermost atmosphere, which is shaped by magnetic-field loops rooted in the Sun's interior. In the previous three solar cycles, the corona at high latitudes performed what Altrock calls a "rush to the poles" when each new jet stream began forming deep below it. But this time the rush to the poles failed to occur.

3. Sunspot magnetism is steadily weakening. Matthew Penn and William Livingston have measured the average magnetic fields in the umbras of sunspots since 1999. They find that since about 2000, the average field strength has declined from 2,500 or 3,000 gauss to about 2,000 gauss now. Penn and Livingston expected Cycle 24's new spots to appear with rejuvenated field strength, but they didn't. The average magnetic field in the centers of sunspots has continued a more-or-less unbroken decline.



DATA: NSO / M. PENN / W. LIVINGSTON

The average magnetic field strength in sunspot umbras has been declining for more than a decade.

Where the field on the Sun's surface is less than 1,500 gauss, spots do not appear at all. If the current trend keeps up, the Sun would cross this line around 2022, after which its face would be blank.

If the coming solar maximum is weak and the next one is even weaker, a lot of people will breathe a sigh of relief.

Space-weather experts have been warning that satellites and the power grid are insufficiently hardened against major solar outbursts even as the world grows ever more dependent on high-tech infrastructure (*S&T:* February cover story). The three findings could mean we have less chance of losing crucial satellites or major parts of the power grid in the coming years.

Then there's the perennial question of whether solar activity affects Earth's climate. The Maunder Minimum corresponded to the "Little Ice Age," a global cooling of about 0.2°C on average but as much as 1°C or more in unlucky parts of Europe (*S&T:* March 2009, page 30). But the situation was complicated by volcanic dust that also caused global cooling.

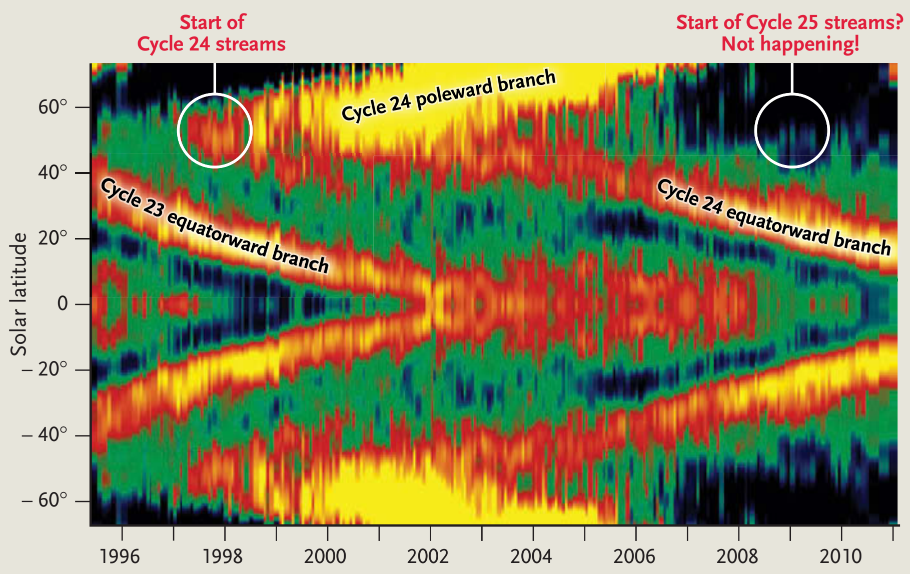
So, could a long-duration quiet Sun help to moderate global warming? Hill said that he is "an agnostic" on whether solar activity can influence temperatures on Earth. "I have not seen enough evidence to know either way," he said. "But if Cycle 25 does not occur, we will have a splendid opportunity to find that out."

Is this radical prediction premature? "They may be right," says David Hathaway of NASA's Marshall Space Flight Center. But he points out that we have only a few cycles or less of the data that the prediction is based on. "As for myself, I'm going to wait until we see more of Cycle 24."

Others note that the first signs of Cycle 25 could start at any time, just a bit late.

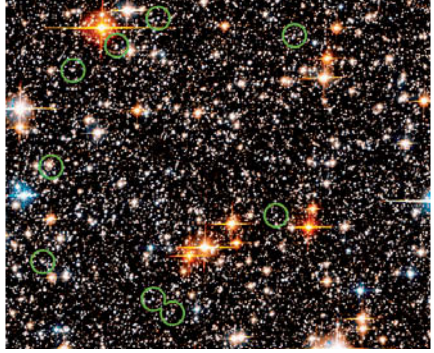
In any case, astronomers will be watching the Sun's behavior now with a good deal more interest.

— *Jay Pasachoff and Alan MacRobert*



The observed latitudes of the deep jet streams (red and yellow) are plotted from year to year. New streams typically form at about 50° latitude, as around 1998 for Cycle 24, long before they start causing sunspot outbreaks about a decade later. The new jet streams for Cycle 25 should have formed up in 2008 — but haven't started even now.

DATA: NSO / FRANK HILL



NASA / ESA / W. CLARKSON / K. SAHU

The Hubble Space Telescope had to peer through some 20,000 light-years of foreground stars to examine stars of the Milky Way's central bulge. "Blue stragglers" (circled) showed up there once similar-looking foreground stars were eliminated by their motions.

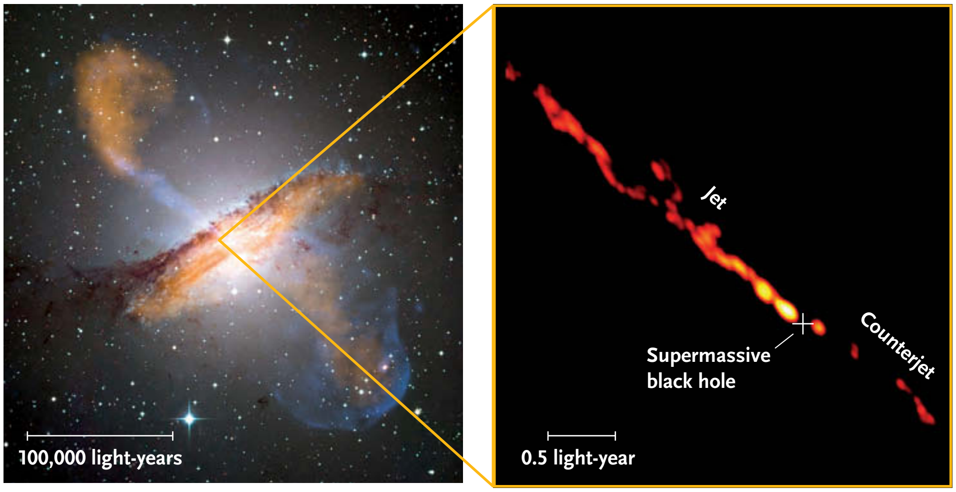
Blue Stragglers in the Galactic Bulge

Five years ago astronomers used the Hubble Space Telescope to watch vast numbers of stars in the Milky Way's central bulge to look for stellar transits caused by exoplanets. The project saw signs of 16 Jupiter-mass planetary candidates — and according to a new analysis, 42 oddly bright blue stars identified with the bulge. Many of these are thought to be "blue stragglers": old stars that burn as hot and bright as if they were part of a young stellar population. But bulge stars are supposed to be very old.

Blue stragglers have intrigued astronomers since 1953, when Allan Sandage discovered them among the ancient stars of the globular cluster M3. Stars that form at the same time, such as in a cluster, should evolve together. But blue stragglers look rejuvenated, long after their equally massive peers have aged into red giants or on to white-dwarfhood. The standard explanation is that a blue straggler acquired fresh new mass late in life from another star. This could be due to a collision of two stars or, perhaps more likely, a near miss that resulted in a close binary in which one star transfers mass to the other. Either scenario would only be expected where stars are much closer together than in the Sun's vicinity.

Will Clarkson (Indiana University and UCLA), who led the study, says that while blue stragglers are common in globular clusters, this is the first time they've been clearly identified in the bulge. He notes that these oddballs have much to tell astronomers about the formation and evolution of stars and the mysterious bulge.

Close-up of a Black-Hole Powerhouse



ESO / WFI; RADIO: MPI / ESO / A. WEISS, ET AL.; X-RAY: NASA / CXC / R. KRAFT, ET AL

TANAMI / C. MÜLLER, ET AL. / A&A

The nearest active galactic nucleus is the one 12 million light-years away in the peculiar giant galaxy NGC 5128, also known as Centaurus A from the early days of radio astronomy. Southern Hemisphere telescope users know it as a 7th-magnitude spherical glow with a dark lane dividing it in two. But when viewed at radio wavelengths, it lights up the sky. It balloons to a length of 6°, with a pair of opposed radio jets (brown at right) betraying an accreting supermassive black hole in its center. The nucleus is also emits high-energy radiation with occasional extra outbursts, the death throes of matter spiraling into the 55-million-solar-mass black hole.

Now astronomers have a new look at this powerhouse's close surroundings. Images of the inner jets at centimeter-wave radio frequencies (8.4 and 22.3 gigahertz) resolve details only about 15 light-days across, or about 0.5 milliarcsecond. The images come from an array of radio telescopes in Australia, South Africa, Chile, and Antarctica known as TANAMI (Tracking Active Galactic Nuclei with Austral Milliarcsecond Interferometry). The array has resolved blobs and small features that appear to be streaming away from the core at roughly a third the speed of light. Different parts of the inner jets show different radio colors (different strengths at the two wavelengths), posing a challenge to theorists.

The Milky Way's New Arm Pieces

Every portrayal of how our Milky Way Galaxy would look from the outside involves a lot of guessing. That's because we're inside the galaxy's dust-ridden disk, which blocks our view of its distant reaches. Radio, infrared, and other techniques have fleshed out a lot of the picture, but the far side of the Milky Way remains especially poorly known.

A few years ago, Robert Benjamin (University of Wisconsin) and others used NASA's Spitzer Space Telescope to deduce that our galaxy has just two main spiral arms, not four as had been thought; the other two arms are weaker. The main ones, the Scutum-Centaurus and Perseus arms, appear to connect up nicely with the ends of our galaxy's central bar. The Sun lies along a minor offshoot known as the Orion Spur. Scutum-Centaurus passes between us and the galactic center; Perseus is on the other side of us, farther out.

But there's been little hard evidence to prove that the galaxy's two majestically sweeping arms continue around to its far side — until now. Thomas Dame and Patrick Thaddeus (Harvard-Smithsonian Center for Astrophysics) traced millimeter-wave emission from the carbon monoxide (CO) in giant molecular clouds to identify an arm segment on the far side's outer margin, roughly 50,000 light-years from the Milky Way's center. It's about 60,000 light-years long. Dame and Thaddeus think this is the distant end of the Scutum-Centaurus arm, which would mean that the entire arc is more than 200,000 light-years long and wraps more than 300° around the galactic center.

EUROPEAN SOUTHERN OBSERVATORY (2)

Left: **The European Southern Observatory recently released this image of NGC 6744 in Pavo as "the Milky Way's Twin," but already the resemblance seems imperfect. The Milky Way is now thought to have just two clearly dominant arms, perhaps like M83 in Hydra *(right)*.**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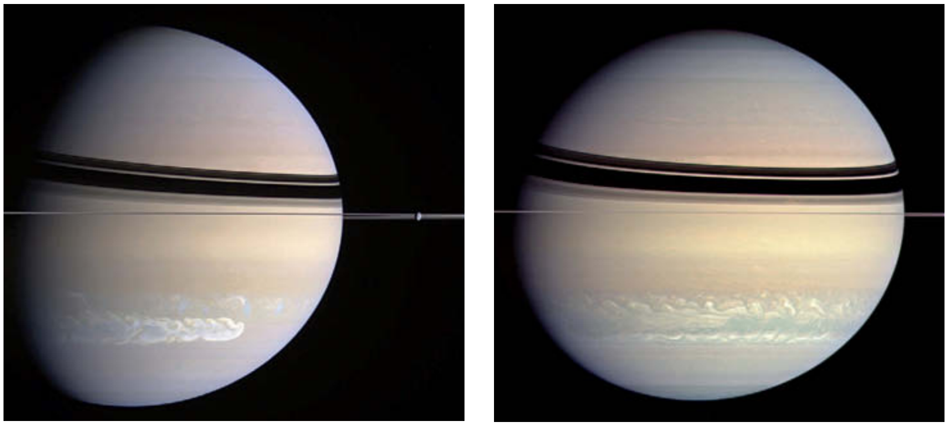


NASA / JPL / SPACE SCIENCE INST. COLOR COMPOSITING BY SEAN WALKER

Images from Cassini taken on December 24th last year *(left)* and on May 15th *(right)* show the evolution of the massive white storm in Saturn's atmosphere. South is up

Dissecting Saturn's Big Storm

For planetary imagers, the most exciting event earlier this year was the long-lasting white outbreak on Saturn. On December 5, 2010, NASA's Cassini spacecraft orbiting Saturn picked up signals from a thunderstorm brewing in the planet's northern hemisphere. Three days later, amateur Sadegh Ghomizadeh in Iran spotted a new white atmospheric disturbance. Saturn's winds rapidly spread the clouds eastward. Within a few months they girdled the globe, even while new white material continued to rise up from the point of origin.

Storms of this size seem to occur once every Saturnian year (29.4 Earth years). This is only the sixth recorded since 1876. The previous five could only be studied in reflected sunlight, but this time astronomers had a spacecraft on the scene and could also probe below the clouds at infrared wavelengths from Earth. Where the storm showed up, Cassini found a 7- to 9-kelvin drop in temperature. Thermal imaging shows that the rising gases cooled a 5,000-km-wide vortex and warmed its periphery. Above parts of the vortex were warm streaks, dubbed stratospheric beacons.

As clouds continued to spew up into the stratosphere, atmospheric layers were displaced upward by about 20 km. The displacement set off a churning that depleted acetylene (C_2H_2) over the heart of the storm, while phosphine (PH_3) showed a sudden enhancement.

"Our new observations show that the storm had a major effect on the atmosphere," says Glenn Orton (NASA/JPL), a paper coauthor, "transporting energy and material over great distances, modifying the atmospheric winds — creating meandering jet streams and forming giant vortices — and disrupting Saturn's slow seasonal evolution."

The show isn't over. Planetary scientists think the uplift vortex will linger for a few years and continue to present a visible white spot long after the storm loses most of its steam. For Earthbound observers, Saturn comes back into good view before dawn in November and December.

Tagish Lake Meteorite's Organic Brew

The events in northwestern Canada on January 18, 2000 — and in the critical days following — may be one of the most important in the science of meteoritics. A 50-ton chunk of interplanetary debris exploded in the early-morning sky, dropping dark meteorites onto the frozen, snow-covered landscape. An alert local resident named Jim Brook carefully collected nearly a kilogram of them using clean plastic bags, then kept them in his freezer, ensuring that the samples were never contaminated by human fingers nor had a chance for their insides to thaw after the cold of space. Other teams later scoured the frozen surface of Tagish Lake for more.

Due in part to Brook's carefulness, the Tagish Lake meteorites — crumbly, black, and carbonaceous — are providing a unique window on how complex organic materials were forged as the solar system came together.

From the outset, cosmic chemists were puzzled. Some of the fragments' interiors are riddled with carbonate minerals created when water percolated through the material multiple times. Yet adjacent sections bear almost no traces of water's influence. Chemists also expected the black stones to teem with exotic hydrocarbons, but analyses turned up a disappointing yield.

Now researchers have used the meteorites to solve a long-standing puzzle about the source of the solar system's original organic material. A team led by Christopher Herd (University of Alberta) reports that much of the organic content consists of monocarboxylic acids (MCAs), and amino acids, which are essential to biochemistry. A careful analysis of four Tagish Lake fragments showed wide variations in the types of MCAs from stone to stone, beyond what other researchers had previously observed in the same meteorite.

Herd's team thinks this diverse organic collection was cooked up in place within the meteorite's parent body, depending only on how the compounds were exposed to liquid water and to modest heat (no higher than 240°F) from rapidly decaying radioisotopes such as aluminum-26.

"We're saying that amino acids are actually the result of geology happening in the asteroid," rather than earlier in interstellar space, says Herd.

Also, the "insoluble" organic matter in the samples maps well to nearly the entire compositional range of other primitive meteorites — supporting the idea that the solar system's organics arose from a single, common process. ✦

NASA / MIKE ZOLENSKY

The dark interiors of the Tagish Lake meteorite pieces come from dusty minerals, including sulfides and clays. The cube is 1 cm on a side.

Peering Beneath

Jupiter's Clouds

NASA's Juno mission will give scientists their first in-depth view of Jupiter's deep interior.

JON ZANDER

Easily outshining stars in our night sky, we can appreciate why Jupiter is the namesake of a Roman god. In 1610 German astronomer Simon Marius chose names from Greco-Roman mythology for the newly discovered Galilean moons. He named the innermost satellite Io, for a priestess of Jupiter's wife, Juno. In legend, Io attracted Juno's suspicions when Jupiter seduced the priestess and surrounded their tryst with clouds.

Today, Jupiter's roiling interior continues to hide behind a cloudy veil. Starting in 2016, scientists will peer through the gas giant's thick atmosphere for the first time with Juno, a mission in NASA's New Frontiers program that was built on schedule and on budget. With a launch window opening on August 5th, the $1.07-billion Juno orbiter will investigate the planet more thoroughly than any previous spacecraft.

We have figuratively only scratched Jupiter's surface because the planet's deep interior has never been thoroughly investigated. Whereas NASA's Voyager and Galileo missions examined Jupiter's visible cloud tops and several of its moons in detail, Juno will focus almost entirely on the planet's interior to answer questions remaining since the earlier flights: How did Jupiter form? Does it have a solid core? What is the planet's internal structure? What are the dynamics of its atmosphere?

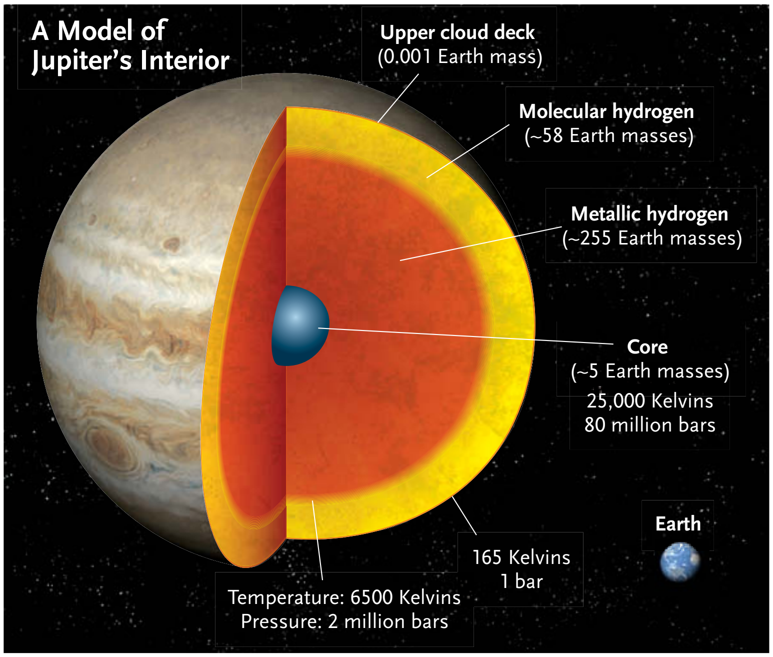
To extract details from deep within the Jovian clouds, Juno will spend part of its orbit close to the planet, skimming just 5,000 kilometers (3,100 miles) above the atmosphere during a typical close approach. Juno will spin about 250 times during the two hours it flies from pole to pole along the dawn/dusk line; this will help maintain stability while allowing the nine scientific instruments to sweep across Jupiter twice per minute to observe all latitudes of the visible cloud tops from multiple angles. The 11-day polar orbit will enable the spacecraft to avoid the most intense regions of Jupiter's radiation belts, which girdle the planet's equatorial region from the cloud tops to beyond Europa's orbit.

Water Is the Key

One of Juno's primary tasks is to help scientists gain insight into Jupiter's origin — a crucial unsolved problem in planetary science. As theorist Alan Boss (Carnegie Institution of Washington) explains, "Jupiter is the largest planet in our solar system, and so understanding how it formed is crucial to knowing how the smaller planets

JUPITER ARRIVAL ***Left:*** **An artist depicts Juno's arrival in the Jupiter system in October 2016. If all goes well, Juno will complete 32 orbits before its electronics and instruments are degraded by the harsh radiation environment, forcing flight controllers to put it on a course to burn up in Jupiter's upper atmosphere.** ***Right:*** **Technicians in Titusville, Florida, stow solar array #2 against Juno's body. Three giant solar arrays are needed at Jupiter's distance to intercept enough sunlight to power Juno.**

LEFT: SPACECRAFT ART: NASA / JPL; JUPITER PHOTO: NASA; IMAGE PROCESSING BY BJÖRN JÓNSSON
RIGHT: NASA / JPL-CALTECH / KENNEDY SPACE CENTER



S&T: LEAH TISCIONE; SOURCE: TRISTAN GUILLOT

such as Earth formed, and it will help us determine why there's no planet in the asteroid belt." Juno's detailed studies of Jupiter can also shed light on how gas giants form and influence the evolution of other planetary systems.

Astronomers have developed several Jupiter formation theories that make different predictions for the abundance and distribution of oxygen compared to elements such as nitrogen and carbon. Astronomers have discovered that nitrogen and carbon are both about four times more abundant (relative to hydrogen) in Jupiter's upper atmosphere than they are in the Sun. But the abundance of oxygen remains unknown.

Oxygen should be present in the form of water (H_2O) vapor and ice, but astronomers have not yet detected significant amounts of water in Jupiter's clouds. NASA's Galileo mission carried an atmospheric probe that survived a descent to about 22 bars of pressure (about 97 miles). It detected much less water than anticipated, but it sampled only a single location. As Juno project scientist Steven Levin (NASA/Jet Propulsion Laboratory) says, "We have learned a lot about the composition of Jupiter's atmosphere, but one critical number still eludes us — we don't know how much water Jupiter contains."

One theory proposes that Jupiter formed at a great distance (30 to 40 astronomical units, or a.u., from the Sun) from the solar nebula's left over gas and from icy planetesimals. The planet later migrated to its current orbit at 5.2 a.u. as it gravitationally scattered small bodies to the Oort Cloud and interstellar space. If Jupiter formed at such a large distance from the Sun, the temperature would have been so low that icy planetesimals would have contained all the heavy elements in the same proportions as the Sun, but frozen as ice. If this theory is correct, oxygen will be enriched by the same amount as nitrogen and carbon.

But there's a complicating factor. If Jupiter formed near 5.2 a.u., low-temperature, solar-composition planetesimals could have moved in from colder regions and impacted the growing planet, producing an oxygen enrichment that Juno could easily measure. So an enhanced oxygen measurement could lead to some confusion about how

Juno's 9 Science Instruments

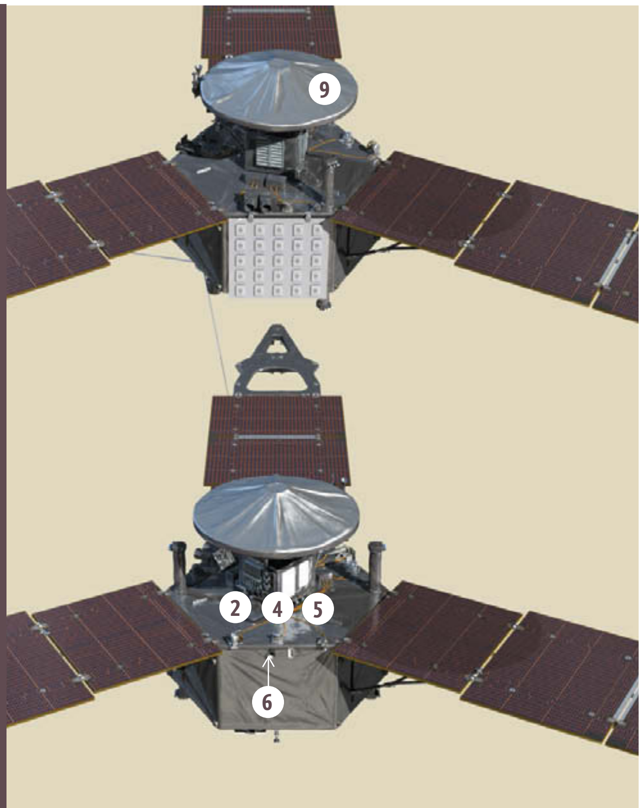
1. **Magnetometer (MAG): measures the magnitude and direction of the magnetic field and resolves the 3-dimensional structure of the polar magnetosphere. An advanced stellar compass provides pointing information about Juno while mapping the magnetosphere orientation.**

2. **Jovian Auroral Distributions Experiment (JADE): reveals the plasma structure in Jupiter's magnetosphere and auroral region by measuring the distribution of low-energy electrons and the velocity and composition of ions.**

3. **Microwave Radiometer (MWR): searches deep into Jupiter to measure water abundance by measuring the planet's thermal emissions using 6 radiometers set between wavelengths of 1.3 and 50 cm.**

4. **Jupiter Energetic-particle Detector Instrument (JEDI): measures the energy and angular distribution of high-energy electrons and ions.**

5. **Ultraviolet Spectrograph (UVS): records the wavelength, position, and arrival time of ultraviolet photons during each rotation of Juno; also provides spectral images of polar ultraviolet auroral emissions.**



and where Jupiter first started to assemble.

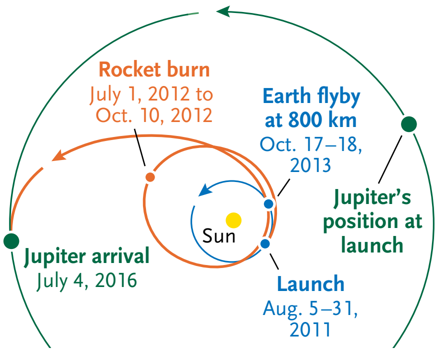
A second model postulates that Jupiter formed near its current orbit and was bombarded with icy planetesimals rich in ice-like solid materials known as clathrate hydrates, which are common in the outer solar system. Clathrate hydrates have crystalline lattice structures that easily trap gases inside. According to this alternative model, clathrate hydrates captured elements at somewhat higher temperatures and formed icy planetesimals that impacted Jupiter near 5.2 a.u. If this theory is correct, Jupiter will be enriched a lot more in oxygen than carbon and nitrogen because the clathrates delivered a supersolar abundance of water ice.

If Juno finds that oxygen is less plentiful in Jupiter than in the Sun, then theorists will have to go back to the drawing board. But it's also possible that one of their models is on the right track, and that the excess oxygen combined with silicon to form silicates, which settled into the planet's core and has remained hidden from view.

Juno's microwave radiometer (MWR) will determine the water abundance by measuring the amount of microwave energy from Jupiter's deep atmosphere over a range of latitudes. The amount of atmospheric water influences both the atmosphere's temperature and transparency to microwaves. MWR will observe Jupiter's atmosphere at many different angles and at six different frequencies to decipher the temperature profile and global water abundance. As Juno principal investigator Scott Bolton (Southwest Research Institute, San Antonio, Texas) says, "This will be the first deep sounding below Jupiter's clouds."

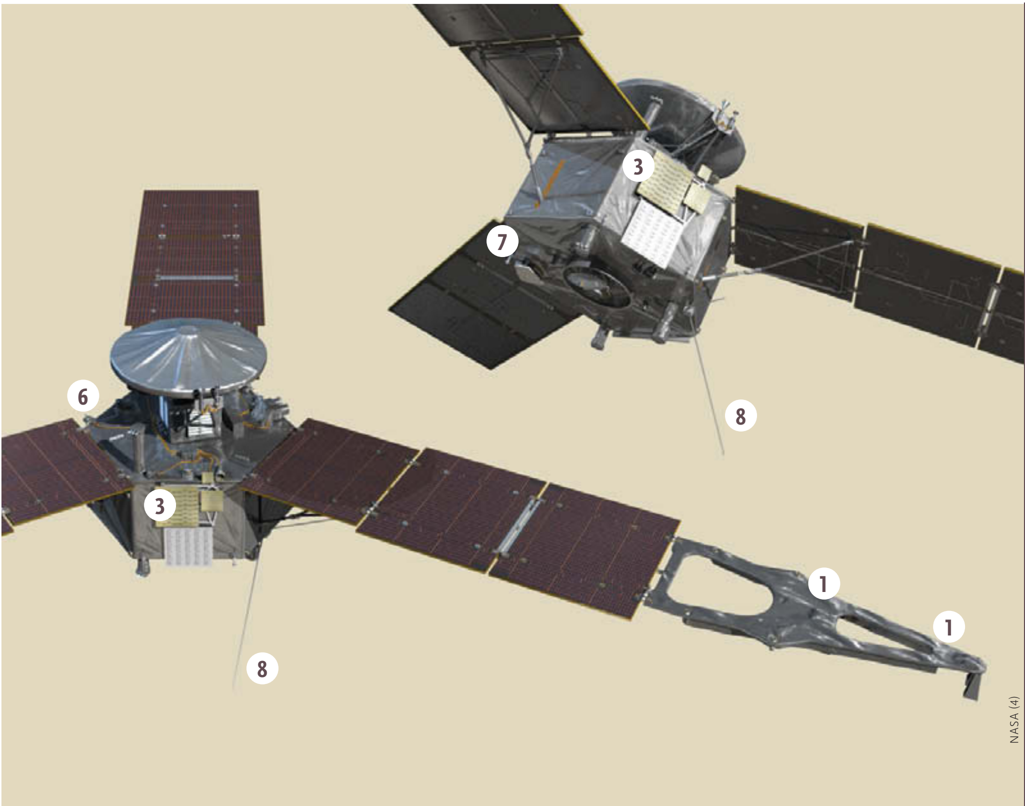
Probing the Internal Structure

Juno will measure the radio emission from Jupiter's atmosphere below the cloud tops to depths greater than 100 bars at all latitudes, unveiling the structure and dynamics of the global atmospheric composition, temperature, and cloud opacity. Spacecraft observations will help scientists ascertain how deeply Jupiter's colorful storms, zones, and belts extend into the interior. "We can see enormous storms and bulk motions of Jupiter's atmosphere, with belts and zones rotating around the planet at different speeds. But we don't know how deep those structures go, and there's a lot of uncertainty about the internal motions and structure of Jupiter," says Levin.



INTERPLANETARY CRUISE **Juno will traverse 2.8 billion kilometers (19 a.u.) of interplanetary space before reaching Jupiter in 2016. The 5-Earth-year trip should be relatively uneventful, except for a course-correction rocket burn in 2012 and a close Earth flyby in October 2013 to boost the craft's velocity.**

S&T: LEAH TISCIONE; SOURCE: NASA / JPL



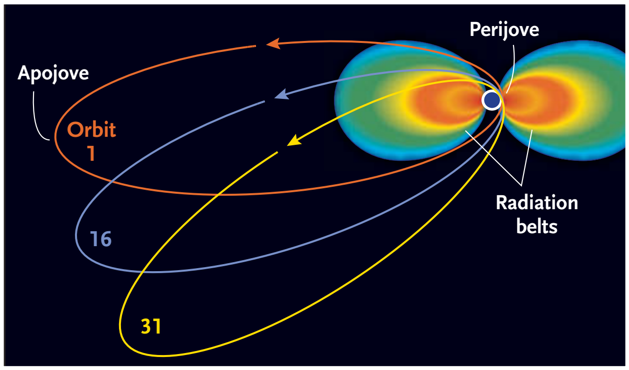
NASA (4)

6 JunoCam: provides three-color images to the public of Jupiter's cloud tops.

7 Jovian Infrared Auroral Mapper (JIRAM): takes infrared images and spectra to investigate the upper layers of the atmosphere down to 5 to 7 bars; also studies the dynamics and chemistry of auroral regions and their link to the magnetosphere.

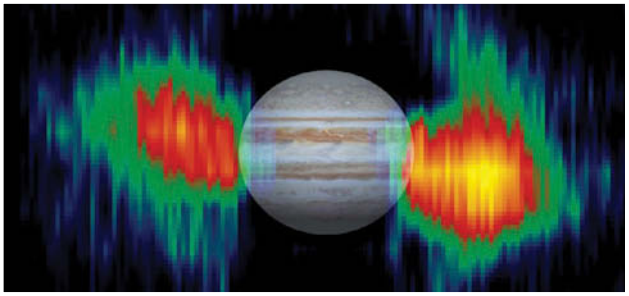
8 Plasma Wave Instrument (Waves): measures plasma and radio emissions associated with the polar magnetosphere.

9 Gravity Science (GS): will probe the properties of Jupiter's mass and determine the internal structure by measuring the gravity field via Doppler tracking between Juno and NASA's Deep Space Network antennas on Earth.



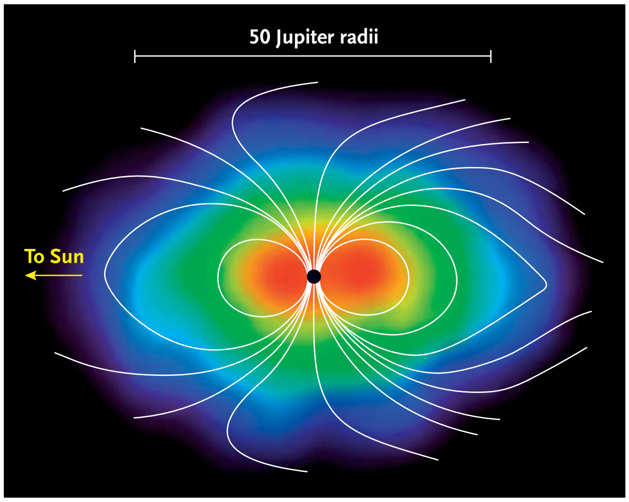
S&T: LEAH TISCIONE; SOURCE: NASA / JPL

JUNO'S ORBIT Juno will revolve around Jupiter in a highly elongated 11-Earth-day orbit that will avoid the most intense radiation belts while allowing the craft's solar arrays to catch direct sunlight almost the entire time, and to give it a close view of the poles. At its very closest approach, the spacecraft will zoom 3,700 km (2,300 miles) above the cloud tops. If Jupiter were the size of a basketball, Juno would approach within 0.8 cm (0.3 inch).



NASA / JPL

RADIATION BELT While flying by Jupiter, Cassini's radar instrument captured microwaves from high-energy electrons moving at near-light speed in Jupiter's harshest radiation belt. Scientists converted that signal into the yellow-red-green part of this image. Juno will dive between the planet and this dangerous region.



S&T: GREGG DINDERMAN; SOURCE: NASA / JPL / JHU-APL

MAGNETOSPHERE Cassini's ion and neutral camera captured this image of charged particles trapped by Jupiter's powerful magnetic field. If we could see Jupiter's magnetosphere, it would appear two to three times the size of the full Moon. Juno will provide much greater detail about its structure, strength, and origin.

Several Juno instruments will study the energetic interactions that occur when charged particles caught in Jupiter's powerful magnetosphere slam into Jupiter's upper atmosphere, generating auroras that dwarf their terrestrial counterparts in scale and intensity. These results should help scientists better understand auroras on other planets as well.

Astronomers also want to know the size and nature of Jupiter's core. "We don't know whether or not Jupiter has a distinct core of rock, metal, and possibly ice, or how big it is if it exists," says Boss. "Two competing theories for Jupiter's formation are core accretion, where the core forms first (slowly), and disk instability, where the core forms after the protoplanet forms (rapidly). Both models could be in trouble if Jupiter has no sizable core."

To find out if Jupiter has a solid core, Juno's telecommunications system will send data to NASA's Deep Space Network antennas to measure the Doppler shift as the craft orbits the planet. Subtle variations in these signals compared with those expected from an unperturbed orbit will enable scientists to map Jupiter's gravitational field. Analysis of these data will show how material is internally distributed. Combined with observations made by other instruments, scientists should be able to establish whether the planet has a solid core or condensed gaseous material all the way down to the center.

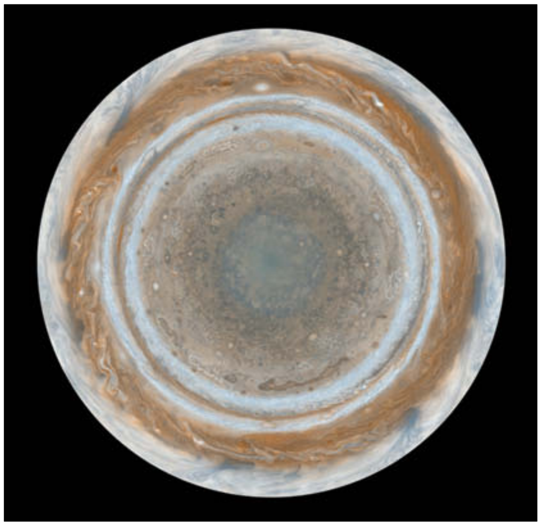
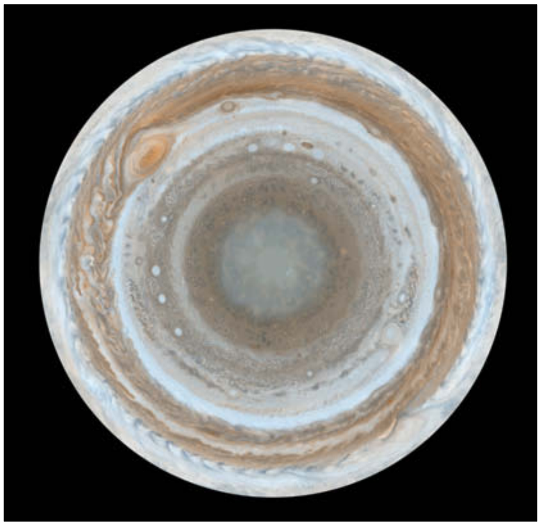
Boss, however, sounds a cautionary note. The main uncertainty in models of Jupiter's interior is the behavior of hydrogen and helium at the temperatures and pressures of the deep Jovian interior. These conditions are difficult to duplicate in the lab, and are equally hard to predict with calculations. "Juno could be a complete success at meeting its goals," says Boss, "but we still might not know what is inside Jupiter until these other problems are solved."

In addition to searching for a core and examining the atmosphere, Juno will map the global magnetosphere all the way down to the dynamo that generates the magnetic field deep in the interior. At a certain depth, the pressure becomes so intense that it compresses hydrogen, where it becomes metallic and behaves like a fluid. "We think Jupiter's powerful magnetic field is generated by an enormous ocean of liquid metallic hydrogen," says Levin, "but we don't really understand how that works, and in fact Jupiter still has a lot to teach us about how planetary dynamos generate magnetic fields."

To obtain the best possible measurements, Juno's magnetometer is positioned on the far end of a solar array. This will keep electromagnetic "noise" from the craft's electronics from interfering with the measurements and avoid the need for a separate boom.

Surviving a Harsh Environment

Looking at Juno, you can't ignore the three large solar arrays. With an overall span of 20 meters (66 feet), they

NASA / JPL / SPACE SCIENCE INSTITUTE (2)

POLAR REGIONS Juno will greatly improve our knowledge of Jupiter's polar regions. These mosaics of the north *(far left)* and south polar regions come from images taken by Cassini during its distant Jupiter flyby in December 2000. The images resolve features about 120 km across. At close approach, Juno's Camera will resolve features only 50 km across at the poles and 3.5 km across at the equator.

give Juno a markedly different appearance from previous Jupiter explorers. Following a conventional launch on an Atlas V 551 rocket, the ship will mostly coast to Jupiter with a gravitational assist from Earth along the way. Juno will be the most distant solar-powered spacecraft ever flown, necessitating that it never falls into the planet's shadow. Because Jupiter is 5.2 times farther from the Sun than Earth, Juno will receive only 1⁄27th as much sunlight, requiring large solar panels facing the Sun as often as possible to power the science and flight systems. Pushing forward solar-power technology, Bolton and his team decided to use solar arrays for Juno rather than develop new mini-nuclear reactors known as radioisotope thermoelectric generators (RTGs).

Some NASA interplanetary missions find new purposes after meeting their initial objectives, and this has become the expectation in the public's mind. Unfortunately, Juno will not get to enjoy a lengthy extended mission. After about an Earth year of diving down near Jupiter's cloud tops during each orbit, flight controllers will command the spacecraft to plunge into the clouds. This will avoid any possibility of contaminating one of Jupiter's moons, one or more of which might harbor life. The plan is to dispose of Juno before its electronics become eroded from repeatedly passing through high-radiation zones, where ions, protons, and electrons whirl around at near-light speed. Never before has NASA sent a spacecraft into such a treacherous environment, where Juno will have to withstand the equivalent of more than 100 million dental X-rays, or roughly 100 times the radiation dose lethal to humans.

Vital spacecraft components are protected in a washing-machine-size box with ½-inch-thick titanium walls. Engineers shielded Galileo's electronics and avionics to resist Jupiter's environment, but not to the same degree needed for Juno to survive one year in a much harsher radiation. These protective measures will reduce Juno's radiation exposure by a factor of 800, providing the critical amount of time needed for Juno to achieve all of its science objectives before succumbing to the energetic particles that will penetrate the titanium shielding and damage internal systems.

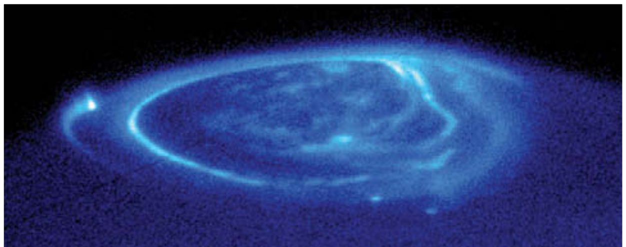
If all goes as planned, Juno will survive about 32 orbits. But during that relatively short period, Juno will unlock some of Jupiter's deepest mysteries, and force scientists to rethink how our solar system formed, and perhaps other planetary systems as well. ✦

A Jet Propulsion Laboratory Solar System Ambassador since 2004, ***Jon Zander*** *has spent the last three JPL Open House events helping staff the Juno team display.*

Online interview with key player

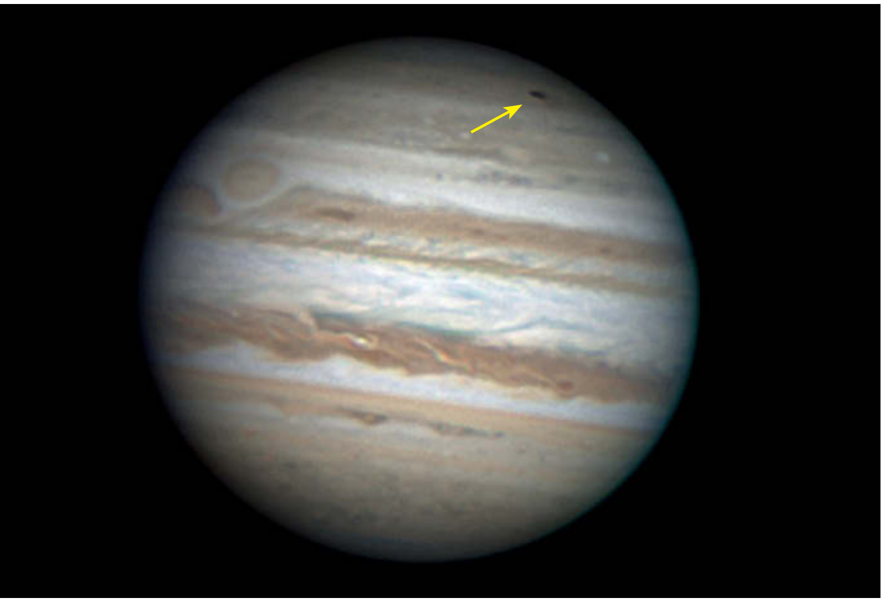
NASA

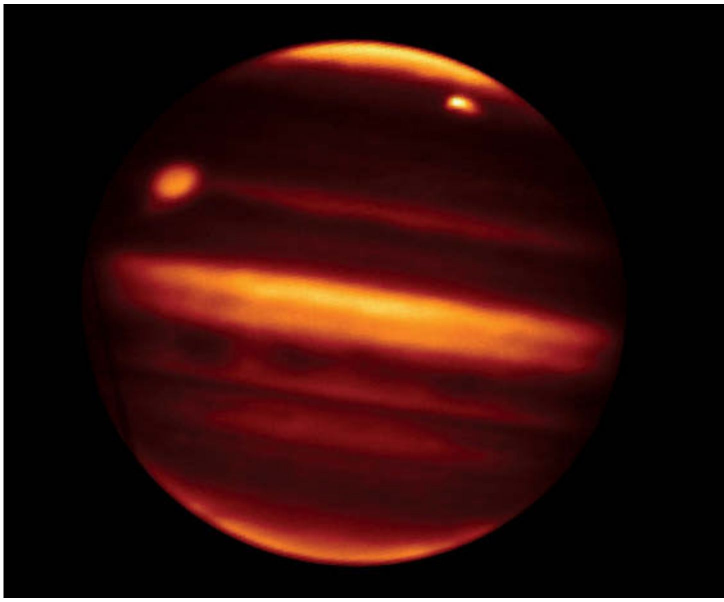
To listen to an audio interview with Juno principal investigator Scott Bolton, visit SkyandTelescope.com/Juno.



NASA / ESA / JOHN CLARKE (UNIVERSITY OF MICHIGAN)

JUPITER'S AURORA Juno carries instruments specifically designed to study the structure, composition, and origin of Jupiter's aurora. This Hubble Space Telescope ultraviolet image shows an enormous auroral oval surrounding the magnetic north pole, along with three magnetic "footprints" induced by currents from the moons Io (bright spot at far left), Ganymede (just below and right of center), and Europa (to the lower right of Ganymede's spot).





NASA / IRTF / JPL-CALTECH / UNIV. OF OXFORD

Planetary Sentinel

While keeping watch on the planets, Australian amateur astrophotographer Anthony Wesley discovered two impacts on Jupiter.

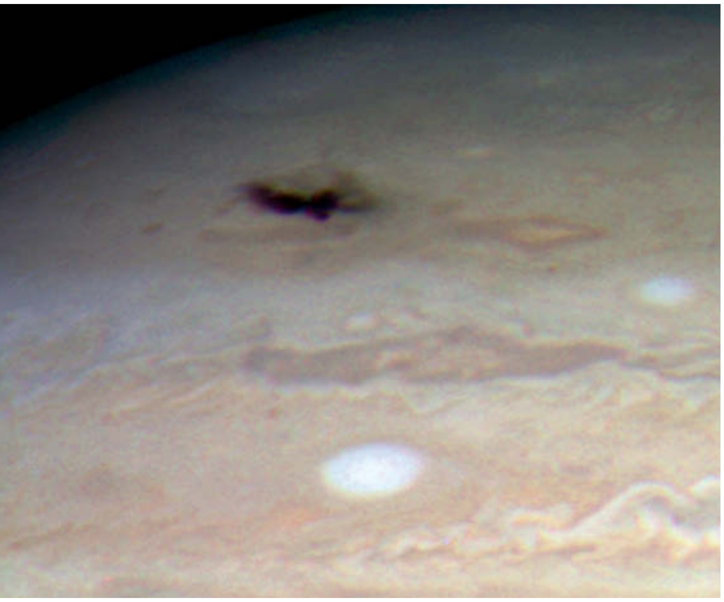
GREG BRYANT

AUTHOR PHOTO: GREG BRYANT

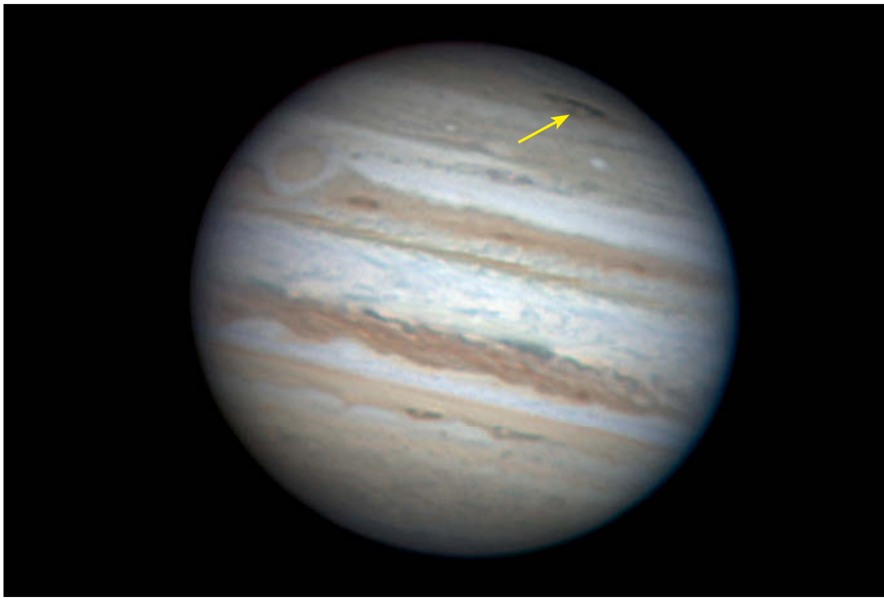
IT TAKES DEDICATION to image for several hours in the middle of a winter's night. On the evening of Sunday, July 19, 2009, Australian astrophotographer Anthony Wesley set up for a routine planetary-imaging session at his home in Murrumbateman, a rural village in New South Wales about a 30-minute drive north of Canberra. It was a cool winter's night, and though the skies were clear, a strong jet stream was flowing overhead. Wesley worried about the poor prospects for steady seeing.

Wesley is one of a growing band of talented amateurs worldwide who image the planets at high resolution whenever circumstances are favorable. For Wesley, a clear night cries out to be outside capturing photons, so he began shooting Jupiter around 11:00 p.m. He found the results acceptable despite the atmospheric conditions, but was on the verge of giving up after a marked deterioration around midnight. It was a 50/50 decision that saw him instead take a break for half an hour, instead of shutting down and retiring inside to watch television.

When Wesley returned, he noticed on his earlier videos an interesting dark spot coming into view in Jupiter's south polar region. Wesley's initial reaction was that it was just a Galilean moon shadow, but he quickly realized it was at too high a latitude, nor was it moving at the right speed. Since the dark spot was moving in synch with a nearby white-oval storm, it had to be an atmospheric feature.



NASA / ESA / HEIDI HAMMEL / JUPITER IMPACT TEAM



ALL IMAGES COURTESY OF ANTHONY WESLEY UNLESS OTHERWISE CREDITED

BIRD STRIKE **Anthony Wesley discovered the first impact on another planet since Shoemaker-Levy 9 in 1994. *Far left:* Wesley took this image of Jupiter at 15:06.5 UT on July 19, 2009. It shows a dark splotch (arrowed) at a high southerly latitude, well outside the zone where Galilean moons cast shadows. The splotch rotated at the same rate as nearby storms, proving that it was an atmospheric feature. *Above left:* At about 9:00 UT on July 20th, NASA's Infrared Telescope Facility in Hawaii caught a bright spot on Jupiter at the same location as Wesley's dark spot, confirming that it was from an impact. *Above:* The Hubble Space Telescope took this visible-light image on July 23rd, clearly resolving the backsplash of debris from the impact. *Above right:* This Wesley image, taken on August 3rd, shows that Jupiter's high-altitude jet stream has spread out the impact debris. By early 2010, the impact debris had disappeared even to Hubble's sharp eye. South is up in all planetary photos in this article.**

"It took awhile for me to believe I was seeing something extraordinary," Wesley later recalled. The distinctive blackness in all the channels that Wesley was imaging reminded him of the impact scars from the fragments of Comet Shoemaker-Levy 9 fifteen years earlier, timing that Wesley described as a "bizarre coincidence." Indeed, the week was busy enough with the 40th anniversary of the Apollo 11 lunar landing, and the longest total solar eclipse of the 21st century taking place in Asia.

Had Jupiter been hit again, this time without warning? More images over the next few minutes built the excitement, and a check of an image from two days earlier of the same area showed nothing comparable. Wesley wanted to keep imaging, but he realized that if this was an impact spot, he had to immediately inform astronomers around the world.

Early Days

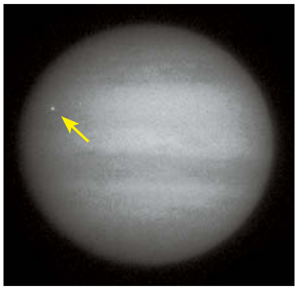
Wesley, 45, became interested in astronomy as a youngster. Born in 1965, his young parents still had the travel bug in them, working wherever they could, and so they decided that he would be raised mostly by his grandparents in the small country town of Glen Innes, in the northeastern reaches of New South Wales. His grandfather was fascinated by astronomy, and subscribed to a number of science-oriented magazines. With all that information lying around the house, and a keen mentor, Wesley developed a keen interest in everything from electronics to chemistry to radio — with astronomy at the top of the list.

At about age 8, Wesley remembers being driven to a family friend's house that had a large Newtonian telescope of about 16 inches in aperture. That was a surprisingly large amateur telescope for the early 1970s, especially for a small Australian country town. Later that decade, as a young teenager, Wesley received his own telescope for Christmas — a small refractor.

More than 30 years later, the impressions of those first nights with the refractor remain vivid in Wesley's mind. "I spent many nights outside looking at the sky with it, with no real

GRAEME MULDOON

SCHOOL SCOPE **While attending high school in the small town of Glen Innes, Wesley dabbled in deep-sky film astrophotography with this Celestron C8. Another student is pictured using the telescope.**



CHRISTOPHER GO

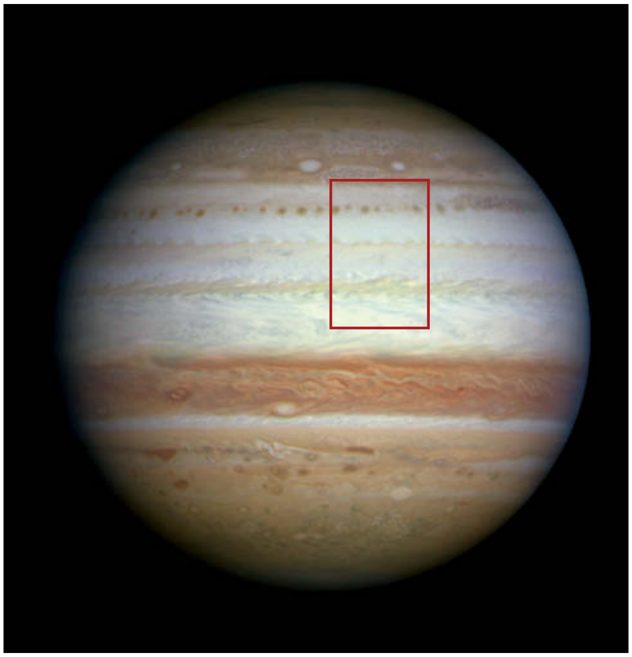


IMAGE AND INSET: NASA / ESA / M. H. WONG / H. HAMMEL / A. SIMON-MILLER / JUPITER IMPACT SCIENCE TEAM

THE SEQUEL ***Upper left:*** **While shooting a video from a friend's patio at 20:31:29 UT on June 3, 2010, Wesley captured a 2-second flash (arrowed) in Jupiter's upper atmosphere.** ***Upper right:*** **At exactly the same time, Christopher Go in Cebu, the Philippines, captured the event, dispelling all doubts that Jupiter had been struck yet again.** ***Far right:*** **Hubble imaged Jupiter on June 7th.** ***Near right:*** **A detail of the Hubble image of the flash site (circled) failed to yield any trace of dark material, suggesting that the incoming body was only about 10 meters across and exploded in the upper cloud deck before it plunged deep enough to dredge up debris.**

idea of anything or what I was looking at, but just for the joy of looking. I remember the amazement of stumbling across Saturn and being able to see the rings, and the equatorial belts of Jupiter, and lots of nebulosity in the Milky Way."

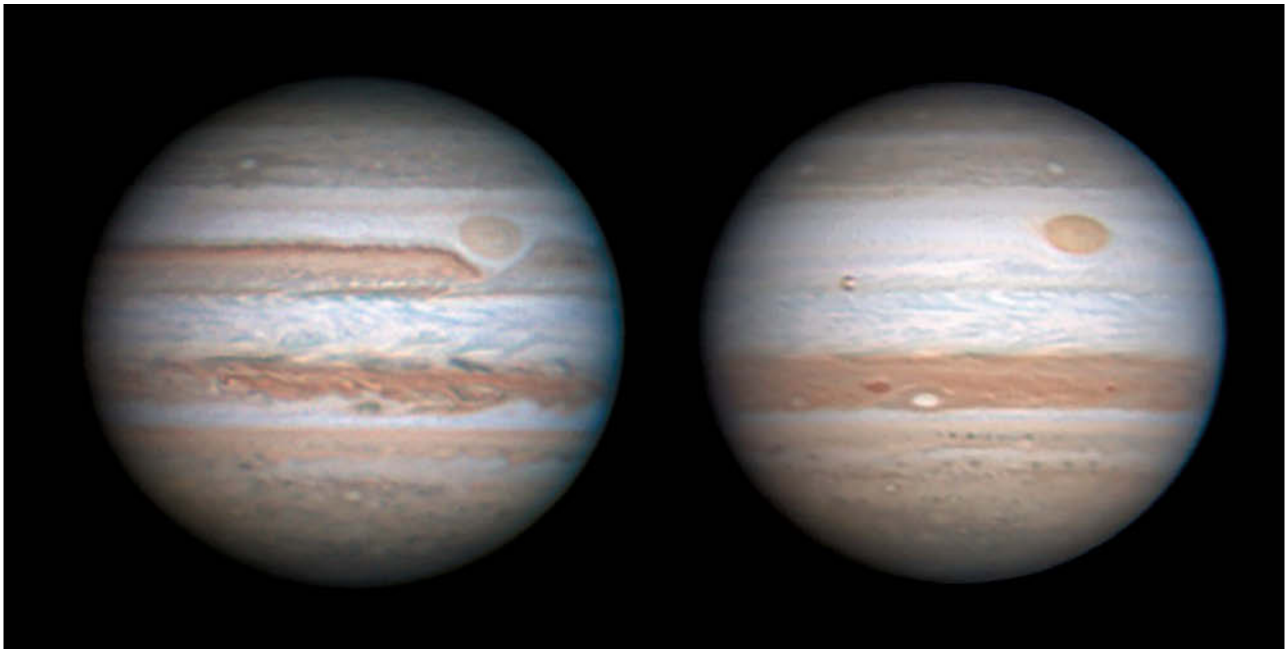
The next step in exploring the universe came courtesy of his science teacher at Glen Innes High School. The teacher recognized that Wesley and a few others had a serious interest in astronomy, and so, as Wesley describes it, "He blew the school's science budget one year to purchase a very expensive scope for the time — a Celestron orange-tube C8. There were three of us who were seriously addicted to astronomy, and we had pretty much free reign to use this scope. We spent many nights taking it out of town to dark sites, hand guiding film exposures for various deep-sky objects."

In 1984 Wesley had finished school and was taking a year off (to recover and "let the dust settle") before attending the University of New England at Armidale, New South Wales, where he majored in both computer science and mathematics. He considered studying astronomy or electronics, but he would have had to travel farther afield.

Following graduation, Wesley remained mostly a visual observer, while also tracking and recording satellite trajectories for an American group that was pinning down satellite orbits. His astronomy focus changed in 2003, though, with Mars's great opposition, when the Red Planet's diameter reached a staggering 25.1 arcseconds. He bought a Philips ToUcam video camera and a laptop, and began experimenting with video astronomy. Entering a Mars imaging competition run by Oceanside Photo & Telescope, he earned 12th place, which he recalls was the first time he'd won anything. Since then, says Wesley, "Every year I have acquired newer and more expensive toys and upgrades, chasing the ever-elusive goal of high-resolution imaging."

Wesley has been supported through his imaging projects by his wife Leisa, herself a keen amateur astronomer. They met in 1990, and Wesley recalls she had a large Voyager 2 poster of Neptune on the wall above her computer. She bought a 10-inch Dob from Astro Optical

MARS AND SATURN **Wesley doesn't limit himself to shooting Jupiter. He routinely captures exquisite images of Mars and Saturn when they are well positioned, and he occasionally images the Moon. As a planetary specialist, he has not dabbled in deep-sky photography since the 1980s. North is up in the Moon photo.**



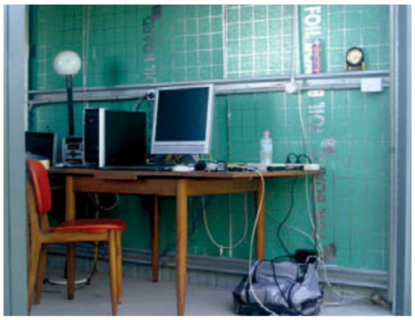
JUPITER COMPARED Wesley's images of Jupiter often have scientific importance even if they don't contain evidence of impacts. He took these images on July 9, 2009 *(left)* and May 18, 2010. The pictures show dramatic changes in Jupiter's atmosphere, particularly the fading of the South Equatorial Belt and the intensification of the Great Red Spot.

Supplies (one of Sydney's telescope retailers) in 1991, and they were married in 1992. They moved a few years ago from Canberra to Murrumbateman to pursue their hobby under darker skies.

As Wesley built up his expertise in planetary imaging, he began posting his images on forums such as Cloudy Nights and IceInSpace, to the Association of Lunar and Planetary Observers' mailing lists, and to dedicated e-mail groups that promote professional-amateur collaboration on imaging Jupiter and Saturn. These images also end up on the International Outer Planet Watch database (www.pvol.ehu.es/pvol).

First Strike

Glenn Orton, a specialist in gas-giant atmospheres at the Jet Propulsion Laboratory, was on Wesley's e-mail list. Orton was reading his e-mail shortly after Wesley began notifying people about the possible impact on Jupiter. Orton's team fortuitously had time allotted on NASA's Infrared Telescope Facility on Mauna Kea the following night. Wesley was able to join the observing session remotely. When the infrared images showed a bright mark at the location of Wesley's dark spot, it became apparent that it was an impact, caused by what is now thought to have been a 100- to 500-meter-wide asteroid.



HOME OBSERVATORY ***Above left***: Anthony Wesley's telescope and computers reside inside this small building, located in a sparsely populated residential neighborhood in Murrumbateman, a town of about 1,800 residents. ***Above right***: These computers are the nerve center of Wesley's setup. Being a skilled computer programmer by profession, Wesley writes some of the software he uses to process his images. ***Right***: Wesley poses with his wife Leisa Condie, who is also an avid amateur astronomer. The couple met in 1990 through their shared interest in astronomy, and married two years later.

Interest in the impact was so overwhelming that Wesley's website crashed under the load, though fortunately it was transferred over to another site. Wesley's online avatar name is "Bird," which comes from the grandparents' surname "Berger" that he adopted during his early school years, and the impact was quickly nicknamed the "Bird Strike."

The mainstream media quickly pounced on the story, and Wesley spent many hours being interviewed by journalists in Australia and other countries. He described it as being swamped by media from before dawn till midnight, when the phone "literally didn't stop ringing," and photographers descended on his home and observatory. He did radio interviews in Australia, with the BBC World Service, and via a live phone hookup with CNN, to name just a few. One of his impact images made NASA's Astronomy Picture of the Day. More and more telescopes turned to Jupiter, and even the Hubble Space Telescope was aimed at the impact site.

The media storm eventually subsided, but Wesley didn't rest and recover — he continued his imaging program.

WESLEY'S PROFESSIONAL CAREER

Anthony Wesley has worked as a software programmer since 1990, when he established his own software consulting company and did freelance software development, networking, mail and web-server installation, and other projects. Since 2003 he has worked for the company Smart Networks, still doing essentially the same type of programming work.

Second Strike

Nearly a year later, Wesley was visiting fellow planetary imager Trevor Barry in Broken Hill, New South Wales. On the morning of Friday, June 4, 2010, as they imaged together at Barry's house (Barry inside his observatory and Wesley on an adjoining concrete slab), Wesley recorded a fireball in Jupiter's atmosphere that lasted a few seconds. Barry missed the fireball because he had just finished capturing a data set, whereas Wesley was about 15 seconds into an imaging run.

"I thought he might have been bitted by a Redback [poisonous Australian spider]," Barry recalls when he heard Wesley call out. He describes Wesley as a "pretty

Wesley's Imaging Gear

Anthony Wesley uses a homemade Newtonian reflector that he's nicknamed "Nemesis." He's engaged in an ongoing personal research project to improve his imaging. For example, the aluminum in the tube is not painted, which minimizes thermal currents. The primary in recent years has been a 14.5-inch f/5 mirror made by R. F. Royce in Connecticut (www.rfroyce.com), but Wesley is now working with a 16-inch Royce mirror in the same tube with a custom cooling system. The telescope sits atop a Losmandy Titan mount. At the time of the 2009 Jupiter impact, the telescope had been in use for only a few weeks, but Wesley had been happy with the results.

Since Wesley began imaging Mars in 2003, he's developed his own technique. He uses his software programming skills to keep the telescope centered on the planet he's imaging, and also to control the filter wheel, image capture software, and focuser. Whenever Wesley rotates the filter wheel, the system automatically reloads values such as exposure time, frames per second, and focus position for each filter position. This allows him to concentrate more on capturing images, while spending less time on the more mundane tasks of recentering or resetting parameters.

To image the planets, Wesley currently uses a Point Grey Research Flea3 mono camera and Astrodon I-series RGB filters. At the time of the first Jupiter impact, he was imaging for 60 seconds through each filter at 47 frames per second. He captures images through *Coriander* software and processes them in *Ninox*, *RegiStax*, and *Astra Image*. He has invested about $20,000 in his setup.

NEMESIS Wesley poses with his reflector at his rural home in Murrumbateman, New South Wales. The optical-tube assembly currently houses a 16-inch mirror made by R. F. Royce in Connecticut.

reserved bloke not prone to such exclamations. I was quite taken that he was just so genuinely disappointed that I had not also captured it. I don't think there would be a lot of people who in that situation would have had the humility to spare a thought for anyone else."

It's an assessment that's shared by another Aussie planetary imager, Mike Salway, who has known Wesley since 2005. "Even when he made his discoveries, he didn't try to make money from it or draw attention to himself," says Salway. "His focus is always on the greater understanding of our solar system and to advance the cause of amateur astronomy. It's great seeing him go about his business. Being a computer programmer, he has an analytical mind. This helps him in his thoroughness, attention to detail, and image processing. He needs to understand how things work, and if necessary, build things himself to make it work the way he wants it to."

Although Wesley is a "down-to-Earth character" according to Barry, and soft spoken, he's always happy to help others. He has given talks on planetary imaging at astronomy club meetings, star parties, as well as speaking at this year's inaugural Australian Astro Imaging Conference (www.aaic2011.com).

Reaction To The Fireball

As Wesley notified people of this second Jupiter impact, he had to tell them, "This is not a hoax." He saw the fireball in real time as he was imaging. "I couldn't believe it" was his reaction.

This time, he wasn't alone, even though Barry had missed it. Filipino planetary imager Christopher Go also captured the fleeting fireball, which left no scar like the July 2009 impact because the incoming object was probably only about 10 meters wide. The simultaneous detections ruled out alternative explanations for Wesley's flash.

Last year Wesley entered his 2009 and 2010 Jupiter impact images into the David Malin Awards astrophotography competition. Held annually in Australia, the Awards cover a number of categories and are judged by the world-renowned astrophotographer David Malin (formerly of the Anglo-Australian Observatory, but now renamed Australian Astronomical Observatory). Wesley won the category for Solar System Hires photography and received a Canon PowerShot G11 digital camera in recognition, with Malin himself noting, "These are terrific contributions to the study of Jupiter's interactions with bolides of various kinds, and shows what can be done by a keen amateur with care and diligence."

Listen to a conversation with Anthony Wesley

To listen to an audio conversation between *S&T* imaging editor Sean Walker and Anthony Wesley, visit SkyandTelescope.com/Wesley.

DENIS CRUTE

FROM ONE IMAGER TO ANOTHER On July 17, 2010, Anthony Wesley received the David Malin Award for Solar System Hires photography directly from the world-renowned astrophotographer himself.

Further recognition came a few months later. In 1997 the Planetary Society established the Gene Shoemaker NEO grant program to support amateurs (and professionals) in the study of near-Earth objects. Last year the scope of the program was extended, and the committee donated $2,500 to Wesley so he could upgrade and continue his observing program.

What lies ahead for Wesley? "Even though I've gone way farther than I ever thought I would as a young kid, there is still an endless road ahead of increasing resolution and image quality, thanks to improvements in modern cameras, optics, and software," he says. "I really have no idea where this is all going to end up in another 10 years or so, but personally I'm looking forward to 2018, when we'll have Mars, Jupiter, and Saturn all at good oppositions for Australian viewers in the same year."

Since professional astronomers don't have the telescope time to monitor Jupiter and Saturn on a nightly basis, even though they certainly have the desire, this is an area where amateurs can help in an important way, keeping watch and being planetary sentinels, on the lookout for something out of the ordinary. One thing is for certain — we can all continue to enjoy and be inspired by incredible amateur images of the planets from talented astrophotographers such as Anthony Wesley. ✦

***Greg Bryant** is Editor of* Australian Sky & Telescope. *He continues to marvel at the planetary images that amateurs can produce today.*

The Battle to Control Light Pollution

There's never been a better time than now to make the case for preserving the night sky.

Bob Parks

The International Dark-Sky Association (IDA) has been on a quest to preserve and protect the night sky for almost a quarter century, yet light pollution rises about 6% every year. Astronomical observing sites near major cities continue to succumb to skyglow. The time it takes most of us to escape from urban areas to truly dark sites is now measured in hours, not minutes. It might be easy to give up hope.

When swimming against the tide, progress can be difficult to recognize. The last few decades have seen unprecedented urban development and a corresponding growth of unregulated outdoor lighting. But as counterproductive as this seems, it's difficult to predict how bad the night sky would look now if the IDA hadn't spent the last 22 years making light pollution a recognized issue.

Today, the astronomical community remains the most sensitive to encroaching light pollution. The perceived lack of progress toward darker skies is a concern voiced by some of the most dedicated dark-sky advocates, and it's the most common explanation amateur astronomers give when asked why they aren't members of the IDA. "Why bother?" they ask. "IDA hasn't made any difference in my neighborhood." But is has.

Thanks to IDA and its volunteers, more than 300 cities and towns now have lighting ordinances. The majority of outdoor lighting fixtures sold today are fully shielded and the percentage rises each year. Many U.S. energy standards now include requirements for reducing light pollution. Outside of the U.S., national laws for outdoor lighting have been passed in the United Kingdom, Italy, Slovenia, and the Czech Republic. Without IDA's early and consistent effort, many of these measures would likely not yet exist.

Years of light-pollution advocacy are paying off. Recent breakthroughs promise to irrevocably change how the public and regulators regard light pollution. Right now, energy concerns and technological advances are merging with conservation imperatives to create a real change in public perception. The general public is becoming increasingly aware that the night sky is disappearing, and measures are being taken to get it back.

For its entire history, IDA has advocated that light pollution is a waste of energy. Now elected officials all over the world are considering changes in outdoor lighting as a way to conserve. It took a surge in the price of oil and the resulting increases in electricity costs to elevate the issue in cash-strapped cities around the globe.

IDA estimates that in the U.S. more than $3 billion is wasted annually on 58,000 gigawatts of unnecessary lighting. To generate

Photo by Tunç Tezel

that amount of electricity, predominately coal-fired power plants produce approximately 15 million tons of carbon dioxide. Unnecessary lighting makes neither economic nor environmental sense.

Across the country, IDA volunteers are convincing local governments trying to combat climate change that outdoor lighting is a significant source of wasted energy and greenhouse gases. Inefficient outdoor lighting is also economically irresponsible. Why are cities facing budget deficits laying off teachers, police officers, and firefighters, while continuing to spend huge sums of money illuminating the undersides of airplanes?

Many cities are considering upgrading street lighting to new energy-efficient solid-state lighting (SSL). Rapidly evolving lighting technologies based on light-emitting diodes (LEDs) have surpassed the energy efficiency of older technologies such as high-pressure sodium and metal-halide lights. Not only do these new lighting fixtures save energy, they can also be controlled in ways that older fixtures cannot. Cities such as San Jose, California, are testing remote-management systems that monitor the energy consumption of each fixture and dim or turn off lights to save energy when less lighting is appropriate. The combination of these technologies may allow cities to reduce energy consumption for outdoor lighting by 40% to 50% and at the same time dramatically reduce light pollution.

The transition to a broad-spectrum LED lighting, however, has potential pitfalls. While this type of lighting can lead to a vast reduction in energy consumption, it also creates the opportunity for increased lumen levels and brighter signs. History shows a consistent trend of efficiency gains being cancelled by increased energy use. In the past, new energy-efficient technologies that could reduce energy consumption while providing equivalent illumination have instead been used to provide more light. IDA realizes this danger and is implementing plans that correlate reductions in energy expenditure with reductions in night-sky brightness.

IDA is also aware of technological limitations. In 2010 the organization released a report on the effects of blue-rich LED lighting and has worked with the lighting industry to create and promote high-efficiency "warm" LEDs that have less impact on the night sky. This is the kind of cooperation and collaboration IDA has sought. [As this issue went to press, the IDA and the Illuminating Engineering Society jointly approved a Model Lighting Ordinance aimed at improving future outdoor lighting in North America. Details are available on the IDA website.]

The medical community has also revealed serious health consequences related to light at night (LAN). Research has shown that LAN can cause sleep disorders and interrupt the internal body clock, called circadian disruption, which has been linked to hypertension, attention-deficit disorder, obesity, diabetes, and heart disease. The World Health Organization identified shift work as a carcinogen in 2007. In 2009 the American Medical Association issued a resolution warning of the public safety hazard of unshielded streetlights (see page 86).

The health implications of excessive outdoor lighting will draw increasing government scrutiny. There is a tremendous need for additional research to pinpoint the correlation between LAN and human health. Similar research on wildlife and ecology is also necessary, as LAN has profound impacts on the natural environment as well.

The effects of light as a pollutant were given increased publicity at the fall 2010 meeting of the American Geophysical Union in San Francisco. Harald Stark (National Oceanic and Atmospheric Administration) presented new research linking light pollution and air pollution. This ground-breaking study revealed that artificial skyglow reduces a naturally occurring nitrate radical that helps

LAURENT LAVEDER

London's light pollution blots out stars near the horizon in this view from the coast of France, more than 125 miles (200 km) from the English capital.

cleanse the atmosphere of exhaust and ozone. Scientists previously knew that sunlight inhibits the nitrate radical, but the new research shows that light pollution can significantly reduce the function of the nitrate radical, resulting in higher levels of air pollution.

The ramifications of this study are epic. Air quality is regulated by the Environmental Protection Agency (EPA) under the Federal Clean Air Act. If light pollution can be shown to directly increase air pollution, the EPA will be required by law to take action to reduce the source of the air pollution. At long last the EPA will need to address light pollution as a pollutant. IDA, backed by several members of the U.S. House of Representatives, petitioned the EPA to address this issue in 2008 and to date has received no official response. IDA will leverage the new research when it renews its efforts to enlist Congress to increase pressure on the EPA to act. This singular development has the potential to change everything.

Sark Island: Europe's First Dark-Sky Community

The IDA's International Dark-Sky Places (IDSPlace) program is recognized worldwide as a permanent commitment to the nighttime environment and an important achievement in conservation. People visit IDSPlaces in part for innovative programs and "stellar" sky quality. Site-specific activities reflect local flavor, while interpretative programs, nocturnal wildlife tours, or night hikes emphasize the benefits of dark skies at these locations.

Steve Owens, a member of the British Astronomical Association's Campaign for Dark Skies and a driving force behind the IDSPlace designations for Scotland's Galloway Forest Park and Sark Island (a small island in the English Channel off the coast of Normandy, France), thinks that enthusiasm for dark-sky conservation is helping reawaken the UK's interest in astronomy. Owens notes that as a coordinator for the International Year of Astronomy 2009, "We struggled to place astronomy stories in the mainstream media, except when it came to dark skies." Progress toward Galloway's designation seemed to be fueling press interest in astronomy programs, not the other way around. By the time the designation was awarded in November 2009, "There was nothing we could do to stop the publicity," recalls Owens.

The media frenzy is far from subsiding. The January 31, 2011, announcement of Sark Island's IDSPlace designation as Europe's first International Dark Sky Community made headline news. Already devoid of automobiles and public lighting, Sark Island's IDSCommunity status enhances the unique attractions offered by this tourist destination.

Open Skies

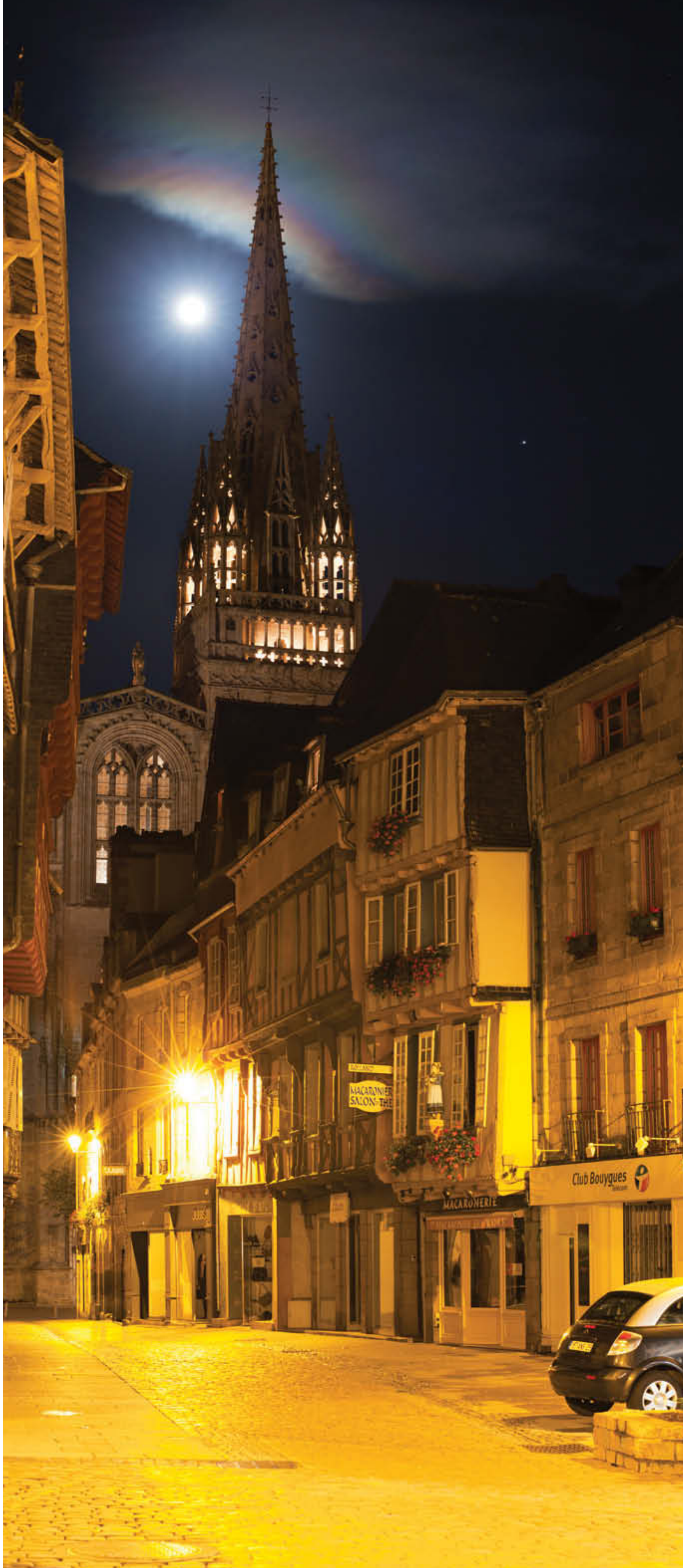
In 2006 IDA established the International Dark-Sky Places (IDSP) program to establish lasting protection for pristine dark skies. Patterned after the U.S. National Parks system, the program will protect this natural resource by designating areas that still have dark skies with the intent of preserving them for future generations. The program includes designations for Dark Sky Parks, Dark Sky Communities, and Developments of Distinction. Today, there are almost a dozen sites around the world, and applications for new sites to be designated as an IDSP are submitted on a regular basis.

While it is essential to preserve remote sites that show how nature intended the night sky to appear, many stargazers will never visit them, just as many people have never spent time in Yosemite or Glacier National Park. A whole generation of children is growing up in urban environments where light pollution blots out all but the Moon and a few of the brightest stars and planets. These kids don't have the chance to be inspired by the grandeur of the heavens because they simply can't see them. Long ago the IDA recognized that raising awareness of light pollution was the primary tool available to reduce it. If you've never see a beautiful night sky, how would you know what you're missing?

IDA is currently developing an initiative called Suburban Outreach Sites (SOS). A coalition of IDA volunteers, astronomy clubs, and educators is coordinating a worldwide network of observing sites that will serve as windows to the universe. By combining dark-sky awareness and astronomy outreach, we hope to energize both astronomy enthusiasts and IDA volunteers. The program establishes observing sites within an hour's drive of cities and towns where parents and teachers can take their kids to see the night sky. Local astronomy clubs have already selected many sites.

Once a location is designated a SOS, IDA will provide educational materials and financial support to retrofit the site's outdoor lighting. In some cases, telescopes and other observing equipment will be provided, as well as a night-sky brightness monitor (NSBM), which is exactly what it sounds like: a device to measure sky quality. There are several important reasons to do this, not the least of which is establishing a baseline of sky quality that can serve as a starting point for future light-pollution calculations.

A generous donation from a longtime IDA supporter, together with a grant from the National Science Foundation, enabled IDA to develop the NSBM project. The program will continuously monitor the quality of the night sky and feed that information to a web-accessible database that anyone can access in real time and evaluate changes



LAURENT LAVEDER

Urban lighting reduces the majesty of the night sky. This photo shows light pollution in Quimper, a city in northwestern France.

in conditions. The first installations of NSBMs will happen this year at observatories, universities, and national parks. Future sites will include schools, IDSPs, and SOS, and the plan is to have hundreds in place during the next few years. As the installations grow, so will the ability to accurately model trends in light pollution. Because the data will be public, anyone can use it to assess degradation of dark skies and warn governments of trends. This will enable officials to take steps to reverse sky degradation, as well as to document improvements due to positive steps to reduce light pollution by communities nearby.

You Can Make a Difference

The campaign against light pollution is working and has yielded significant progress. Facts suggest that we are entering a critical period and a possible tipping point. Outdoor-lighting technology is experiencing a once-in-a-century transformation at the exact time that the attention on energy efficiency, environmental concerns, and economic stresses are forcing cities and governments to rethink how outdoor lighting is used.

This convergence may be a moment in time where the "stars align" and make tremendous changes possible. The need to think differently about lighting has never been as obvious to so many diverse parties as it is today. The one key ingredient to push the issue over the top is public opinion and involvement. Nothing motivates communities to make needed changes like informed and engaged advocates.

The opportunity of a lifetime is before us. IDA needs your help and support. You can make a difference. The amateur astronomy community is estimated to be millions worldwide. United, its combined voice for change would be difficult to ignore. This is a clear opportunity, and without making a commitment to be heard, we may let the possibility of reversing the trend of more outdoor lighting slip through our fingers. If we don't tell our leaders that we want sustainable, energy-efficient outdoor lighting, it will not happen.

When it comes to outdoor lighting, our primal fear of darkness can sometimes override solid evidence proving that more light does not improve safety. IDA has always promoted using just the amount of lighting necessary, directed toward the ground where it will be effective, and to use it only when needed.

I invite readers to join IDA now and let your voice be heard. With your support, together we will make sure that the balance finally tips in our favor, returning the night sky to the majestic beauty of the past. Please help a new generation become inspired by the grandeur of the Milky Way. ✦

An avid amateur astronomer and past president of the Northern Virginia Astronomy Club, ***Bob Parks*** *was appointed Executive Director of the IDA in June 2010.*

Download a FREE BONUS PODCAST

IDA

To listen to a podcast interview with Bob Parks, visit SkyandTelescope.com/lightpollution.

Success in West Texas

The Big Bend region of southwest Texas, known for the open vistas of the Chihuahuan Desert, is gaining fame for its campaign to protect some of the darkest skies in the continental U.S. With a limiting naked-eye magnitude of 7.0, a 12½-inch telescope there reaches to magnitude 16 or 17 on a clear night, of which there are many. Viewing at the nearby McDonald Observatory (pictured below) typically occurs more than 300 nights per year.

In 2009 developer Gil Bartee formed a coalition within the town of Alpine's Chamber of Commerce to bring the economic and environmental benefits of the region's superb skies into focus for civic and business leaders. The movement's snowballing success came when it merged existing dark-sky awareness programs promoted by McDonald Observatory and astronomy clubs with benefits to local business.

DAMOND BENNINGFIELD

Sierra la Rana, near Alpine, earned IDA's Development of Distinction award in 2009. The communities of Alpine and Lajitas are preparing to apply for the IDSCommunity designation. In June 2010, Alpine unanimously passed an ordinance requiring full shielding for new outdoor lighting, with the town of Van Horn approving identical legislation. Action in Marfa and Lajitas is underway.

Big Bend National Park's wide-scale lighting retrofits, which helped it earn the IDSPark award, extend to nearby businesses, where the switch to dimmable LEDs is saving up to 95% in energy output. In a pilot project among national parks, funds from the American Recovery and Reinvestment Act and partnerships with private donors are helping defray costs. Grass-root support outside the park is bolstered by the Big Bend Astronomical Society's Dark Sky Fund to retrofit private lighting. When preparations are complete, more than 1 million acres of near-pristine sky will be preserved!

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Mastercard, Visa, Discover, American Express, PayPal. E-mail: **questions @ astronomics.com** Prices and specifications current as of 6/1/11, but subject to change.

Dennis di Cicco

The David H. Levy Comet Hunter

Don't be fooled by the name; this 6-inch Maksutov-Newtonian reflector will do a lot more than help you find comets.

David H. Levy Comet Hunter

U.S. price: $1,199
(on sale through the end of August 2011 for $999)
Explore Scientific, 621 Madison St., Springdale, AR 72762
explorescientific.com; 888-599-7597

Explore Scientific's David H. Levy Comet Hunter is sold as a complete telescope with a 8×50 illuminated finder, a 30-mm eyepiece, dew cap, tube rings, a Vixen-style dovetail mounting bar, and a high-quality storage case. ALL PHOTOGRAPHY BY THE AUTHOR

The David H. Levy Comet Hunter

from Explore Scientific is more than a run-of-the-mill telescope out of Asia rebranded with a celebrity endorsement. A lot more. For starters, the 6-inch Maksutov-Newtonian has no commercial counterpart being sold under another brand name. And the scope's f/4.8 optics bear a striking similarity to David Levy's cherished Minerva — a 6-inch f/4 Newtonian reflector that he used for many years of comet sweeping. Levy described his scope in our September 1988 issue, page 250, saying that if he had to do it over again, he'd opt for an f/5 mirror to improve off-axis star images. While the Comet Hunter is close to f/5, its really the Maksutov optics that get a bigger share of the credit for improving off-axis images, since the design has only about a third as much coma as an equivalent Newtonian reflector.

I knew there was something different about the Comet Hunter, which we borrowed from the manufacturer for this review, the moment I began unpacking the shipping box. The scope's foam-lined storage case is unusually well made, with reinforced metal trim, recessed carrying handle, and recessed heavy-duty latches. Except for the finder, which locks into its holder with a pair of thumbscrews, the scope fits in the case completely assembled with its tube rings and Vixen-style dovetail mounting bar in place. You can lift the scope from the case, place it on a mount, and attach the finder in less than a minute.

I did most of my testing with a 20-year-old Vixen Great Polaris DX German equatorial mount. It's an ideal class of mount for the Comet Hunter, which weighs 18 pounds (8 kg) as typically configured for observing.

A plastic cap unscrews to reveal collimation adjustments for the scope's secondary mirror. While the three brass thumbscrews provide standard tip-tilt motions, there are also adjustments (carefully explained in the scope's manual) for centering, rotating, and longitudinally positioning the secondary mirror in the rare case these factory-made settings ever need adjusting.

The scope is strikingly handsome, and in this case its beauty is also more than skin deep. The build quality is excellent, and there are lots of subtle features that make it clear people were paying attention to details when they designed the instrument. For example, the top bar on the tube rings is a nicely contoured carrying handle that makes easy work of maneuvering the scope on and off

What we liked:

Very good optics for observing and photography

Solid, high-quality construction

Many subtle features

What we didn't like:

A small issue with the focuser (now being corrected by the manufacturer — see the text for details)

In addition to the conventional location near the telescope's focuser, there's a mounting bracket for the finder at the bottom of the tube. While this helps balance the otherwise front-heavy telescope, as explained in the accompanying text, the author found this position unexpectedly nice to use.

a mount. But the handle is also slotted for ¼-20 screws and thus forms a solid piggyback mounting for cameras, guidescopes, and other accessories.

Another nice feature is a second finder mount at the bottom of the tube near the primary mirror, in addition to the conventional one near the focuser. The manual suggests that the rear-mounted finder helps balance the tube, which is somewhat front heavy because of the Maksutov's thick meniscus corrector. While that's true, I also found the rear-mounted finder surprisingly nice to use even though it often meant I had to kneel down to look through it. Sighting up the tube made it intuitively easy to point the finder at various targets, and much easier than when I had to lean my head sideways to look through the finder mounted in the conventional location.

Speaking of the 8×50 finder, it's a very nice straight-through design with a 6° field of view and a correct-reading image (like the view through a binocular). There are separate focus adjustments for the illuminated eyepiece reticle and the finder itself. If I had to nit-pick the finder, it would be that even at its lowest-intensity setting, the variable-brightness illuminator is a bit bright when you're observing in a truly dark sky.

The quality of the Crayford-style focuser is above average and it has a 10:1 fine-focus control. The drawtube has 43 millimeters of travel and it comes with 20- and 40-mm-long extension tubes and adapters for 1¼- and 2-inch eyepieces. I tested the scope with dozens of eyepieces from every major manufacturer and could always find a combination of extension tubes and adapters that worked. Ideally you want to reach focus with the drawtube racked out at least 25 mm, since anything less makes the bottom of the drawtube protrude into the scope's incoming light path, causing a pair of diffraction spikes on bright stars.

The dual-speed Crayford-style focuser comes with two extension tubes and adapters for 1¼- and 2-inch eyepieces. The scope's focal point falls approximately 3¾ inches (95 mm) beyond the top of the focuser's body.

This 15-second "snapshot" of the globular cluster M13 in Hercules was made with a full-frame DSLR camera on the night of June's full Moon to show the Comet Hunter's vignetting and that the scope covers all but the corners of the frame with decent star images. The field is almost 3° wide with north at right.

My only beef with the focuser involved the arrangement needed for photography with a DSLR camera fitted with a 2-inch nosepiece. This setup only reaches focus with the extension tubes removed, but screwing the 2-inch adapter directly to the focuser drawtube interferes with the adapter's compression ring because the threads on the drawtube are about a millimeter too long. This isn't a show-stopper since it's easy enough to slip out the compression ring, tighten down the adapter, and just use the adapter's thumbscrews to lock your camera in the focuser (this is the way the world worked before compression rings). Scott Roberts at Explore Scientific has since told me that he'll have the drawtube threads shortened on future scopes to prevent the issue with the compression ring. Problem, albeit small, solved.

Optics

As mentioned earlier, the Comet Hunter's Maksutov optics produce far better off-axis star images than a conventional Newtonian of similar focal ratio. Indeed, the appearance of off-axis stars in low-power, wide-field views will likely depend more on your choice of eyepiece than on the scope itself. With a 730-mm focal length, the Comet Hunter covers a field of view almost 4° across at the opening of the 2-inch focuser. Accessing this much field with an eyepiece isn't practical, however, even if you ignore the restrictions cause by an eyepiece barrel.

In order to use the maximum light-gathering power of a 6-inch telescope, you shouldn't use a magnification less that 22×, producing an exit pupil 7 mm across (the maximum most eyes can accept). In the case of the Comet Hunter, this means using an eyepiece with a focal length no greater than 33 mm. The scope comes with a 30-mm eyepiece that covers a field almost 3° across at 24×.

I prefer to do low-power sweeping with an exit pupil between 4 and 5 mm across because it offers more magnification and a darker sky background. For the Comet Hunter, this means using 20- to 25-mm eyepieces yielding a magnification range of 37× to 30×, and, depending on the eyepiece, fields of view about 2½° across. I could spend a lifetime plumbing the Milky Way with this configuration. All the major manufacturers have top-of-the-line eyepieces within this range, so take your pick. For example, Explore Scientific's 20-mm 100° eyepiece covers a 2¾° true field at 37×.

Although the Comet Hunter's emphasis is on wide-field viewing, the scope handles higher magnifications well. I would often track down deep-sky objects with a 9-mm (81×) eyepiece and then switch to a 5-mm (146×) for a detailed look. One evening when the atmosphere was unusually stable, I pushed the magnification to 365× with a 2-mm eyepiece. The view of Epsilon Lyrae, the famous Double Double, was particularly impressive with both star pairs cleanly separated and each star's Airy disk surrounded by a perfect set of diffraction rings.

The scope has fully adjustable collimation and the primary mirror is marked with a central ring that's compatible with laser collimators. I touched up the collimation when the scope first arrived (it was borderline being good enough to leave as is), and the optics never drifted out of alignment during my testing.

Photography

The Maksutov-Newtonian's good off-axis star images also extend to photography, making the Comet Hunter a respectable little astrograph. Here, too, it's the scope's subtle features that make a noteworthy difference. Foremost is the suppression of stray light inside the telescope. Light is completely blocked from entering the tube around the primary mirror and there's even a baffle ring around the front of the primary. The textured inside surface of the carbon-fiber tube is fully blackened, and the extended dew cap prevents all direct light from entering the focuser. Even the base of the focuser fits tightly against the side of the tube, preventing light leaks. The system is so well sealed from stray light that it can be effectively used as a 730-mm "telephoto" lens for daytime photography, which is rare for a telescope with a Newtonian configuration.

The scope delivers nice round star images across the frame of popular DSLR cameras with APS-size detectors. It even does a good job of filling all but the corners of a full-frame camera. I measured the scope's effective aperture as 146 mm, which is consistent for a Maksutov-Newtonian with a 6-inch primary. The secondary's optical obstruction is 52 mm.

The Comet Hunter proved to be an unexpectedly good 730-mm telephoto lens for daytime photography because of its excellent suppression of scattered light. And as this view through the author's office window on a dreary morning shows, the scope delivers apo-like images that are free of color fringes on high-contrast edges. Made with a full-frame DSLR, the image has been cropped only on the vertical edges.

All told, I found a lot to like about the David H. Levy Comet Hunter and very little to criticize. The scope offers first-class performance for observers and astrophotographers. And I'm particularly impressed with its quality of construction. ✦

Although Sky & Telescope *senior editor* ***Dennis di Cicco*** *hunts for comets only in his dreams, he still hasn't managed to discover one.*

SOUTHERN STARS

▲ **COMPACT AUTOGUIDER** SBIG announces its next-generation planetary camera and autoguider, the ST-i ($595). The camera features a 648-by-484 array of 7.4-micron-square pixels in a tiny 3½-inch-long body that weighs only 2.2 ounces, and fits into any 1¼-inch focuser or off-axis guider. The ST-i is threaded to accept standard 1¼-inch filters, and is controlled and powered by a single USB 2.0 cable. Exposures as short as 0.001 second are possible with the electronic shutter, and a built-in mechanical shutter enables automatic dark-frame capture. The ST-i produces frame rates as fast as 5.8 frames per second in full-resolution mode, or up to 21 frames per second in focus mode, in full 16-bit format that requires fewer frames to achieve sharp, detailed planetary images. It also interfaces with your telescope mount via an opto-isolated guide port. Each purchase comes with full copies of *CCDSoft* version 5, *CCDOPS* with Planet Master, and *TheSky* version 5.

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

▼ **iPHONE ADAPTER** Magnilux introduces the MX-1 ($44.95), an afocal adapter that allows you to attach your Apple iPhone or 4th-generation iPod Touch directly to your eyepiece for viewing and photography. This rugged, lightweight adapter is compatible with all iPhone models and includes 3 felt-lined attachment clamps that will adapt to almost any standard 1¼-inch eyepiece. It enables your iPhone to be used as a small, ultra-portable display for showing off your scope's view to groups at star parties. The cradle allows quick swapping out the iPhone so others can place their own phones in the MX-1 and take snapshots through your scope. The MX-1 can also be configured to attach your iPhone to a standard photo tripod for shooting landscapes, panoramas, or even family photos.

Magnilux
6953 W. NASA Blvd., #24, West Melbourne, FL 32904
321-537-4811; www.magnilux.com

MAGNILUX

FIG. 2

S&T: SEAN WALKER

CENTERING EYEPIECE ADAPTER Howie Glatter now offers an innovative 2-to-1¼-inch adapter that properly squares your eyepieces, collimation devices, and cameras to the optical axis in your 2-inch telescope focuser. The Parallizer is machined with a wide vertical recess on the inner and outer barrels to ensure perfect and repeatable squaring of all your optical accessories. Additionally, the knurled, non-marring brass thumbscrew is set at a 45° angle to eliminate cocking your 1¼-inch accessories when securing them in the adapter. The Parallizer is threaded to accept standard 2-inch filters.

Howie Glatter
3850 Sedgwick Ave., 14F, Bronx, NY 10463
www.collimator.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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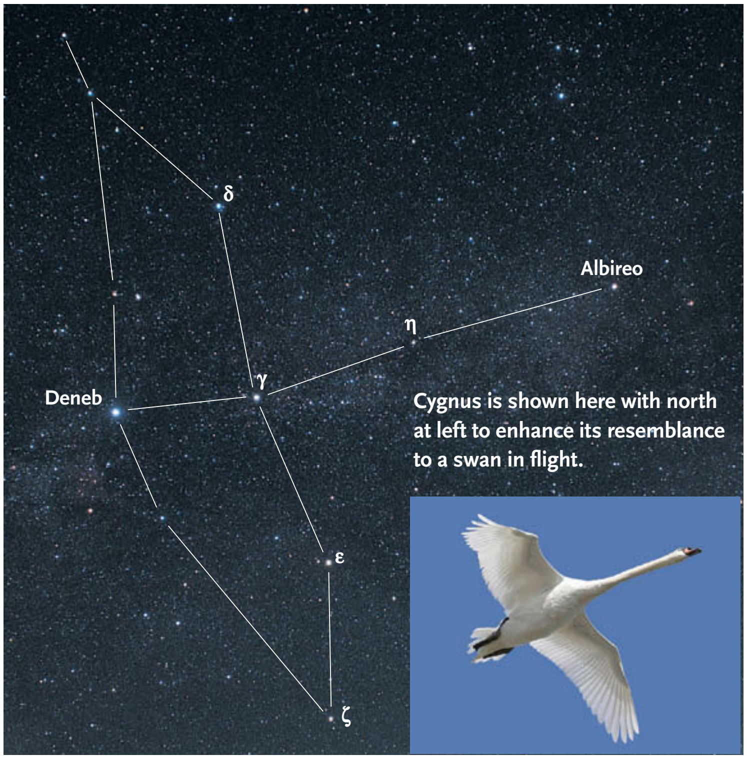
The Bird of the Starry Cross

Cygnus the Swan flies high on September evenings.

CONTRARY TO ITS NAME, the Summer Triangle of Vega, Altair, and Deneb is highest at dusk in early autumn — the sidereal time for our all-sky map on page 44. So we can call this the Summer Triangle Hour. But let's concentrate now on a smaller but still giant asterism, one that pierces into the interior of the Triangle like a sword. I'm talking about the Northern Cross.

The cross of the reversed swan. The Northern Cross is formed from the same basic pattern of stars that's officially known as Cygnus the Swan. The biggest difference is that the direction of the Swan and Cross is reversed. Deneb, the constellation;s brightest star, forms the tail of the Swan but the head (or top) of the Northern Cross.

It might seem more appropriate to have the brightest star be the Swan's head, just as it's the top of the Northern Cross. But there's a long tradition behind Deneb marking the tail. The name is from late medieval Arabic *dhanab al-dajaja*, meaning "tail of the hen" — for that's the bird that these particular stargazers associated with the pattern of Cygnus. Perhaps they had never seen a swan. Whatever the explanation may be, I'm sure that most of us today would prefer to imagine the constellation as being the more graceful and majestic bird.



Cygnus is shown here with north at left to enhance its resemblance to a swan in flight.

Most of us also find it hard to imagine the Cygnus pattern as anything other than a bird or cross. But the earlier Arabs of more than a thousand years ago saw Delta (δ), Gamma (γ), Epsilon (ε), and Zeta (ζ) Cygni — the short beam of the Northern Cross extended to the southeast by Zeta — as "the Riders." These Arabs related Deneb to those stars, calling it *al-ridf*. Modern star-name scholar Paul Kunitzsch translates this as "the One Sitting Behind the Rider (on the same animal)." The title *al-ridf* became corrupted to Arided, an alternate name for Deneb.

Wonders along the Northern Cross. Novices learn early to identify Deneb as one of the 1st-magnitude stars of the Summer Triangle. Gold-and-blue Albireo (Beta Cygni) is the most famous color-contrast double star in the heavens. And any stargazer who sees this part of the heavens in a reasonably dark sky learns to recognize the hazy patch of Milky Way glow wreathed around the Swan's breast and neck: the Cygnus Star Cloud.

But there are more elusive wonders located on or very near the stick figure of the Northern Cross.

There's the amazing long-period variable star Chi (χ) Cygni, which over a period of about 400 days ranges from around 13th magnitude to a maximum of 4th or 5th magnitude and back down. Chi is about 2½° Albireo-wards from 3.9-magnitude Eta (η) Cygni, one of the key stars of the cross's upright.

Less than ½° east-northeast of Eta is the first black-hole candidate ever identified, the powerful X-ray source Cygnus X-1, which seems to be the unseen companion of a 9th-magnitude star.

What's a black hole? Stellar-mass black holes, the most famous kind, are the collapsed corpses of massive stars. Supermassive black holes, the result of lots of feasting, are the dark hearts at the bright centers of many galaxies, including our own. One pundit has quipped that a black hole is the tunnel at the end of the light. ✦

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

Sky at a Glance

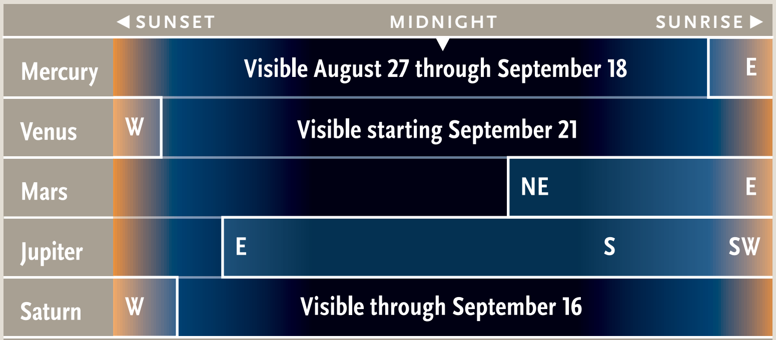
SKY & TELESCOPE

September 2011

MOON PHASES

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

PLANET VISIBILITY



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

3 **EVENING:** Binoculars and telescopes show 2.3-magnitude Delta Scorpii very close to the Moon. The Moon covers the star in parts of the southern and eastern U.S. — though in the eastern end of this zone the event will take place very low in the sky. For details, see SkyandTelescope.com/sep2011occult.

4 **FIRST-QUARTER MOON** (1:39 p.m. EDT).

9 **DAWN:** Look for faint Regulus less than 1° right of Mercury low in the east 45 to 30 minutes before sunrise, as shown on page 48. Binoculars help.

12 **FULL MOON** (5:27 a.m. EDT).

16 **NIGHT:** Jupiter is to the right of the Moon after they rise this evening. Ceres, the largest asteroid, is at opposition; see page 53 of the August issue for a finder chart.

20 **LAST-QUARTER MOON** (9:39 a.m. EDT).

23 **DAWN:** Mars is upper left of the thick waning crescent Moon.

AUTUMN BEGINS in the Northern Hemisphere at the equinox, 5:05 a.m. EDT.

25–26 **ALL NIGHT:** Uranus is at opposition tonight, rising around sunset, highest around midnight, and setting around sunrise. See page 53 for a finder chart.

Sept. 25 – Oct. 10 **PREDAWN:** The zodiacal light, or "false dawn," is visible in the east 120 to 80 minutes before sunrise from dark locations at mid-northern latitudes.

26 **DAWN:** North Americans have a great opportunity to see an extremely thin crescent Moon a few degrees above the eastern horizon a half hour before sunrise. Bring binoculars.

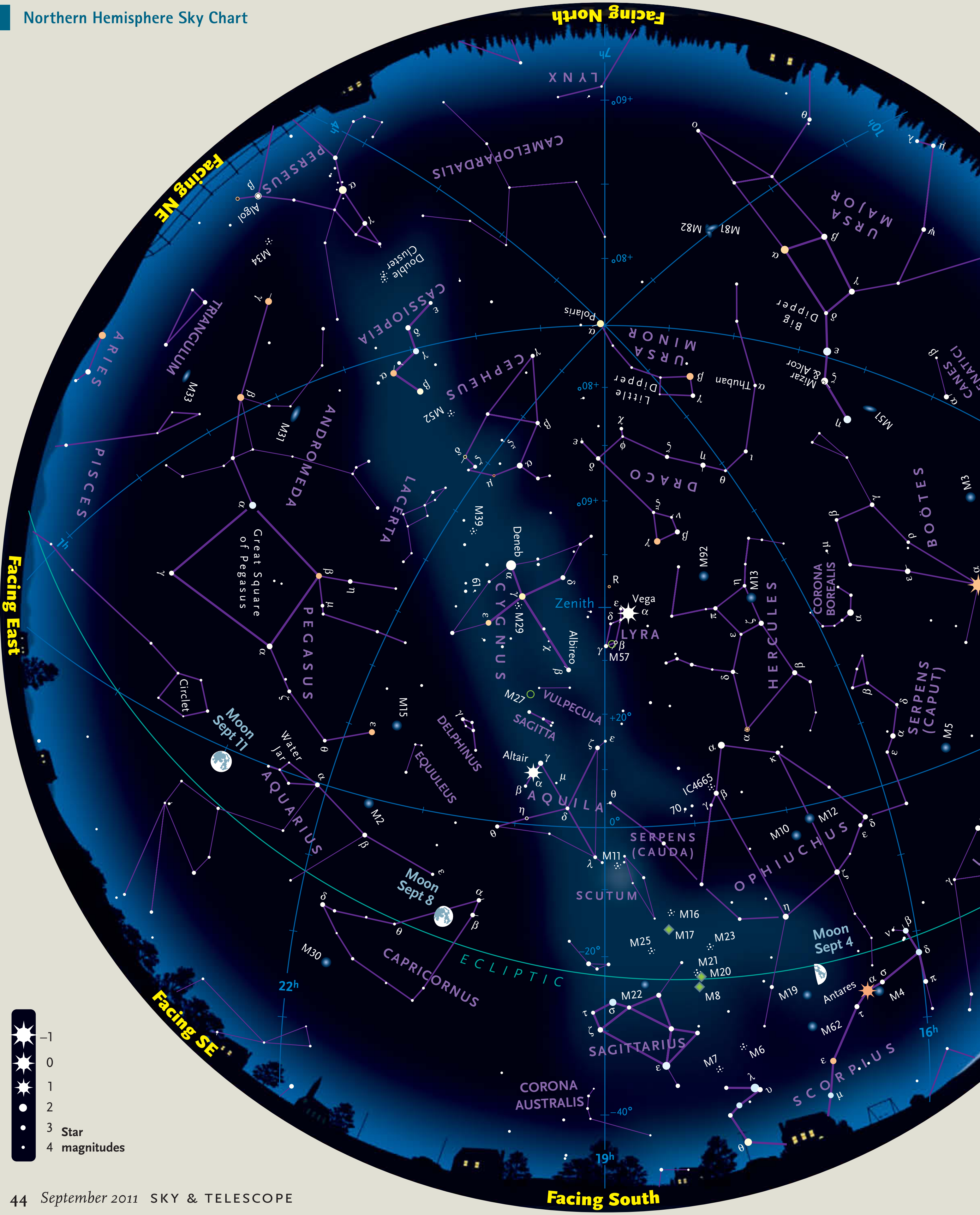
27 **NEW MOON** (7:09 a.m. EDT).

28 **DUSK:** A telescope may show Saturn less than 2° above Venus extremely low in the west 15 minutes after sunset, with a very thin crescent Moon setting 12° to their left.

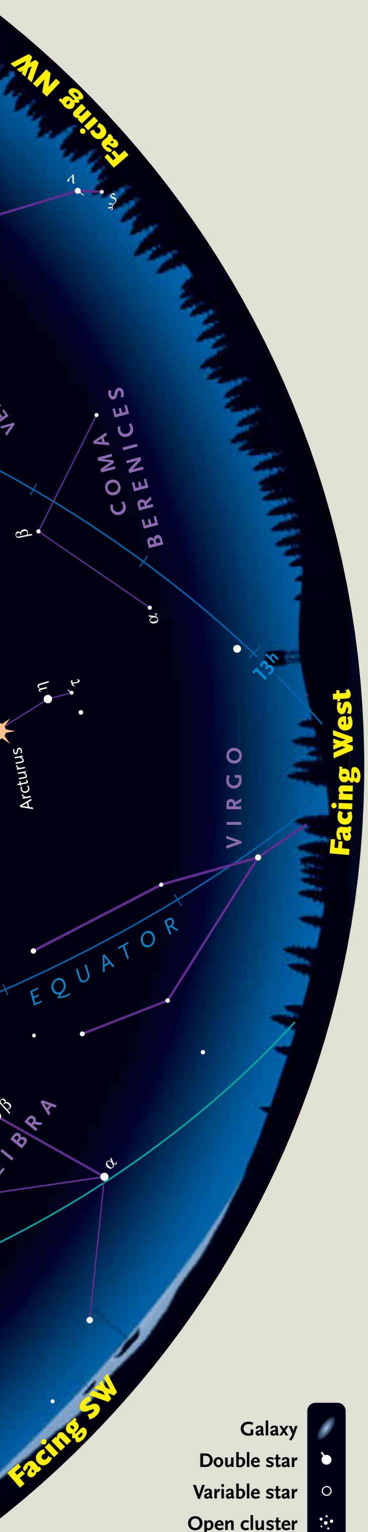
See SkyandTelescope.com/ataglance for details on each week's celestial events.

IMAGE BY TAMAS LADANYI

THE EQUINOX SUN sets due west. It's shown here over Hungary's Lake Balaton.



Facing North
Facing NE
Facing East
Facing SE
Facing South
LYNX
CAMELOPARDALIS
PERSEUS
Algol
M34
Double Cluster
CASSIOPEIA
CEPHEUS
M52
URSA MINOR
Polaris
Little Dipper
Thuban
URSA MAJOR
Big Dipper
Mizar & Alcor
M81
M82
M51
CANES VENATICI
TRIANGULUM
M33
ARIES
ANDROMEDA
M31
PISCES
LACERTA
DRACO
M39
Deneb
61
CYGNUS
M29
Albireo
Zenith
Vega
LYRA
M57
R
M92
M13
HERCULES
CORONA BOREALIS
BOÖTES
M3
Great Square of Pegasus
PEGASUS
Circlet
Moon Sept 11
Water Jar
M15
DELPHINUS
EQUULEUS
M27
VULPECULA
SAGITTA
Altair
AQUILA
IC4665
70
SERPENS (CAUDA)
SERPENS (CAPUT)
M5
OPHIUCHUS
M10
M12
AQUARIUS
M2
Moon Sept 8
CAPRICORNUS
M30
ECLIPTIC
M11
SCUTUM
M16
M17
M23
M25
M21
M20
M8
M22
Moon Sept 4
M19
Antares
M4
M62
SAGITTARIUS
M7
M6
CORONA AUSTRALIS
SCORPIUS
+60°
+80°
+60°
+40°
+20°
0°
–20°
–40°
7h
10h
4h
1h
22h
19h
16h
–1
0
1
2
3
4
Star magnitudes



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

Using the Map

WHEN

Late July	Midnight*
Early August	11 p.m.*
Late August	10 p.m.*
Early September	9 p.m.*
Late September	Dusk

* Daylight-saving time..

HOW

Go outside within an hour or so of a time listed above. Hold the map out in front of you and turn it around so the yellow label for the direction you're facing (such as west or northeast) is at the bottom, right-side up. The curved edge is the horizon, and the stars above it on the map now match the stars in front of you in the sky. The map's center is the zenith, the point overhead. Ignore all parts of the map over horizons that you're not facing.

Example: Rotate the map so that "Facing West" is at the bottom. A third of the way from there to the map's center is the bright yellow-orange star Arcturus. Go out, face west, and look a third of the way up the sky. There's Arcturus!

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

Watch a SPECIAL VIDEO

To watch a video tutorial on how to use this sky map, hosted by *S&T* senior editor Alan MacRobert, visit SkyandTelescope.com/maptutorial.

Binocular Highlight: Sagittarius Globulars

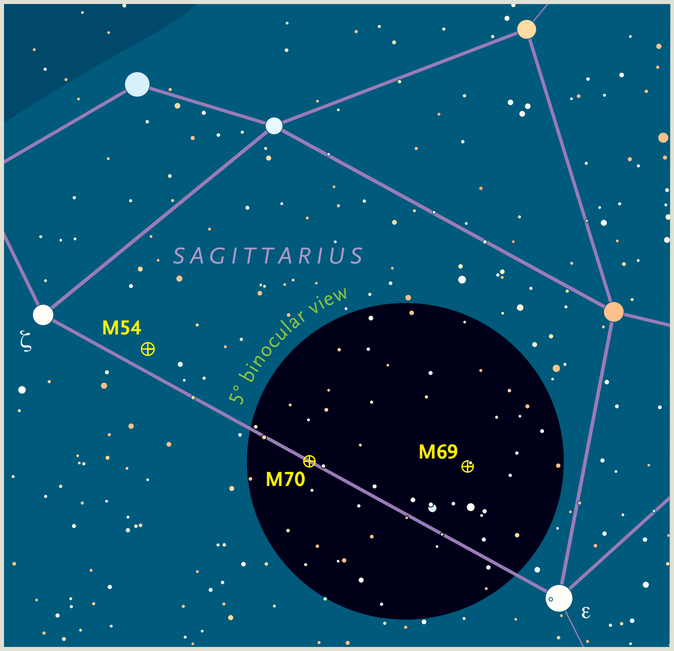
Sagittarius is home to seven Messier globular clusters, but most are small, and tricky to identify with binoculars. Three of the smallest are made even more difficult by their southern declinations, which means they never rise very high for many readers. But if you're up for a challenge, try for the trio of M54, M69, and M70, situated between the stars Zeta (ζ) and Epsilon (ε) Sagittarii at the base of the Teapot.

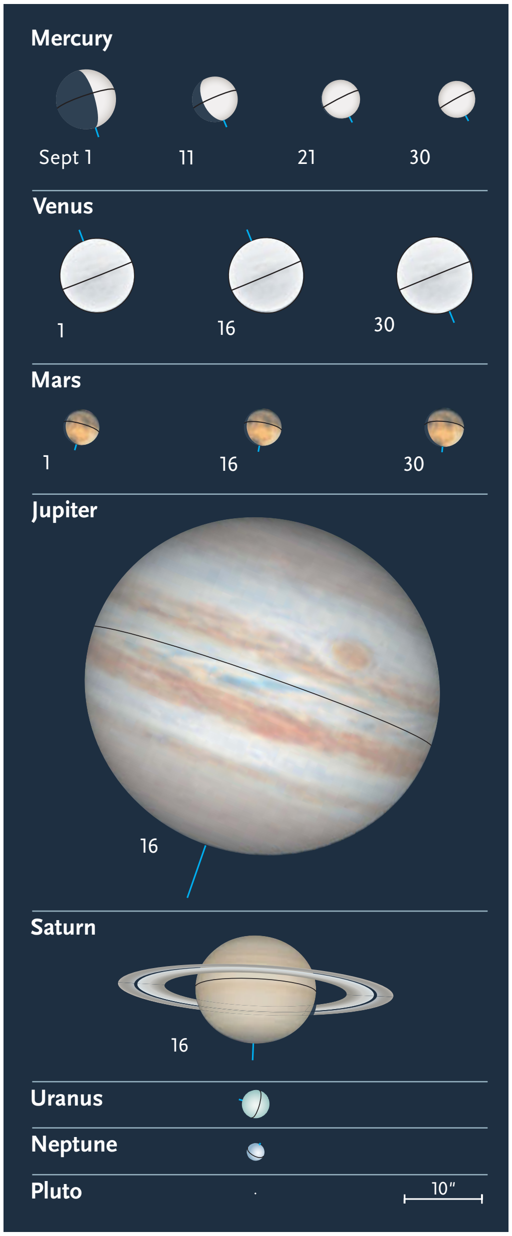
Lying in the same field as Zeta is 7.6-magnitude **M54**. Although it's the brightest of the three, it's also the most star-like, which makes it tough to distinguish from nearby field stars. With 10×50s and averted vision, though, some of M54's globular "fuzz" becomes visible, giving away its identity.

Jumping off from Epsilon, you'll find **M69** north of a ragged line of five equally spaced 5th- and 7th-magnitude stars, and just southeast of a solitary 8th-magnitude star. Indeed, the challenge with M69 is to separate it from its close stellar companion. My mounted 10×50s do so with only a little difficulty, and the extra magnification of my 15×45 image-stabilized binos makes the task quite easy. Although some sources list M69 as having the same magnitude as M54, to my eye the former is clearly fainter. Indeed, M69 appears about the same brightness as its 8th-magnitude neighbor. But M69 looks fuzzier than M54, so it isn't much more difficult to pick out.

Finally, midway between Epsilon and Zeta is **M70**. Listed at magnitude 8.0, it's the most difficult of the threesome. In my 10×50s, it simply looks like a dim point of light. Mounted 15×70s make the task substantially easier, bringing out more of the cluster's outer haze of unresolved stars. ✦

— *Gary Seronik*



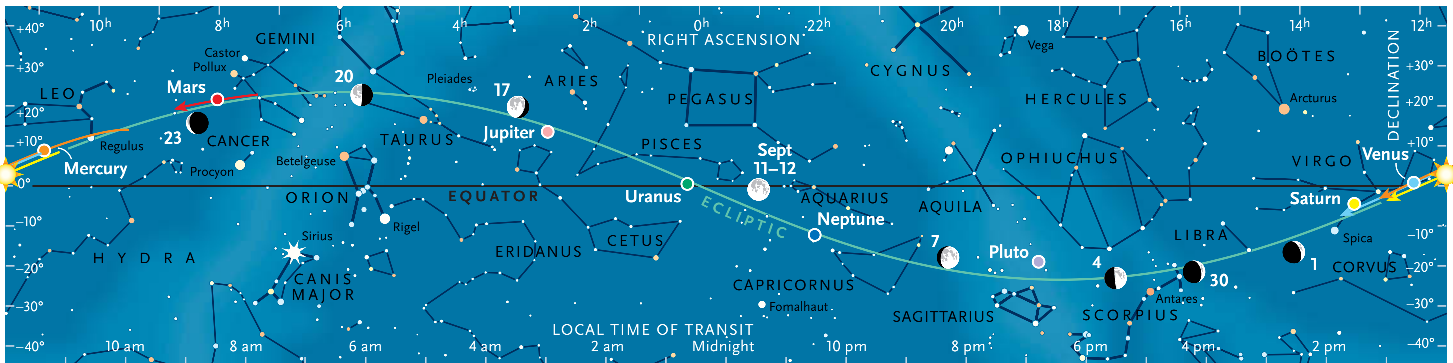


Sun and Planets, September 2011

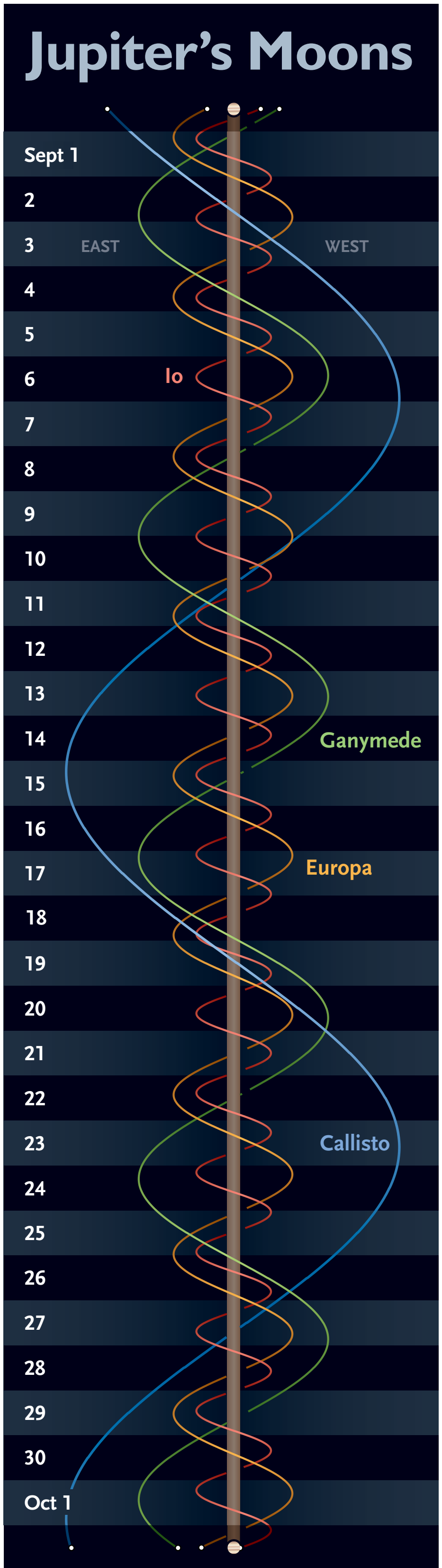
	Sept.	Right Ascension	Declination	Elongation	Magnitude	Diameter	Illumination	Distance
Sun	1	$10^h\ 38.9^m$	+8° 33′	—	–26.8	31′ 41″	—	1.009
	30	$12^h\ 23.2^m$	–2° 31′	—	–26.8	31′ 56″	—	1.002
Mercury	1	$9^h\ 29.8^m$	+14° 04′	18° Mo	+0.1	7.8″	35%	0.865
	11	$10^h\ 20.5^m$	+11° 49′	15° Mo	–1.0	5.9″	76%	1.135
	21	$11^h\ 29.0^m$	+5° 18′	7° Mo	–1.4	5.1″	97%	1.325
	30	$12^h\ 28.6^m$	–1° 43′	2° Ev	–1.7	4.8″	100%	1.402
Venus	1	$10^h\ 57.0^m$	+8° 15′	4° Ev	–3.9	9.7″	100%	1.721
	11	$11^h\ 42.8^m$	+3° 21′	7° Ev	–3.9	9.8″	99%	1.709
	21	$12^h\ 28.2^m$	–1° 44′	10° Ev	–3.9	9.9″	99%	1.691
	30	$13^h\ 09.2^m$	–6° 17′	12° Ev	–3.9	10.0″	98%	1.671
Mars	1	$7^h\ 20.7^m$	+22° 51′	50° Mo	+1.4	4.7″	93%	1.992
	16	$8^h\ 00.9^m$	+21° 27′	55° Mo	+1.4	4.9″	93%	1.909
	30	$8^h\ 36.5^m$	+19° 44′	60° Mo	+1.3	5.1″	92%	1.820
Jupiter	1	$2^h\ 32.9^m$	+13° 33′	118° Mo	–2.7	44.8″	99%	4.404
	30	$2^h\ 27.1^m$	+13° 00′	148° Mo	–2.8	48.3″	100%	4.085
Saturn	1	$12^h\ 58.9^m$	–3° 48′	37° Ev	+0.9	15.9″	100%	10.444
	30	$13^h\ 11.1^m$	–5° 06′	12° Ev	+0.8	15.6″	100%	10.642
Uranus	16	$0^h\ 11.5^m$	+0° 24′	170° Mo	+5.7	3.7″	100%	19.090
Neptune	16	$22^h\ 04.2^m$	–12° 27′	156° Ev	+7.8	2.3″	100%	29.084
Pluto	16	$18^h\ 19.9^m$	–19° 07′	102° Ev	+14.0	0.1″	100%	31.870

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-September; 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). All Moon dates are in September. "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.



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.

Welcome Jupiter

The giant planet blazes in the evening sky.

With each evening in September, Saturn sinks lower to the western horizon in twilight, and Jupiter rises earlier after nightfall. Mars comes up near Castor and Pollux around 2 a.m. (daylight-saving time). And early in September, Mercury puts in a fine appearance low in the east during dawn.

DUSK

Saturn on September 1st glimmers low in the west during twilight, with Spica 10° to its left. Both shine at about magnitude 1.0. They sink even lower on subsequent dates and become invisible to the unaided eye around mid-month.

Venus passed through superior conjunction with the Sun on August 16th. It is therefore setting too soon after the Sun to sight until late September — and even then only with difficulty. On September 29th Venus shines less than 2° below Saturn, but only in the Southern Hemisphere will the two planets be high enough in bright twilight to detect easily.

EVENING AND NIGHT

Jupiter is a resplendent lamp in Aries, just above the head of Cetus the Whale. It doesn't rise until roughly 10 p.m. (daylight-saving time) on September 1st. But by month's end the brilliant planet comes up around the end of twilight, and it's high enough for good telescopic views by 11 p.m. or midnight. During September Jupiter brightens slightly from magnitude –2.7 to –2.8, and its apparent diameter swells from 45″ to 48″. Jupiter will reach a particularly close, bright opposition on October 29th.

Uranus comes to opposition on the American evening of September 25th. Last year the distant planet had the company of Jupiter. This year you'll need the finder chart on page 53 to locate Uranus in a star-poor area of Pisces.

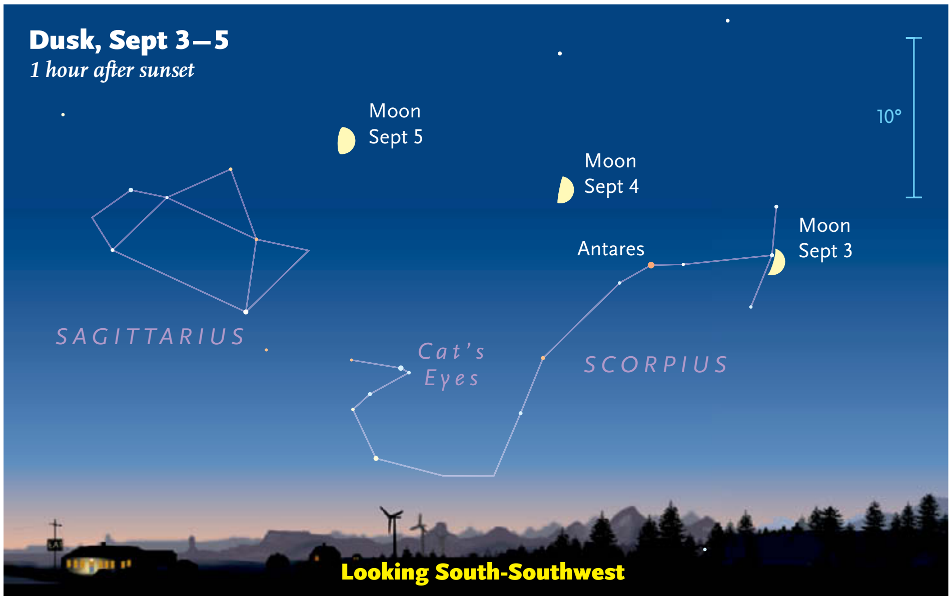
Uranus is visible virtually all night long this month, but it's highest and best observed in the middle of the night. At magnitude 5.7 it's bright enough to see with the naked eye in a really dark sky. Telescopes reveal its pale bluish or greenish disk, just 3.7″ wide.

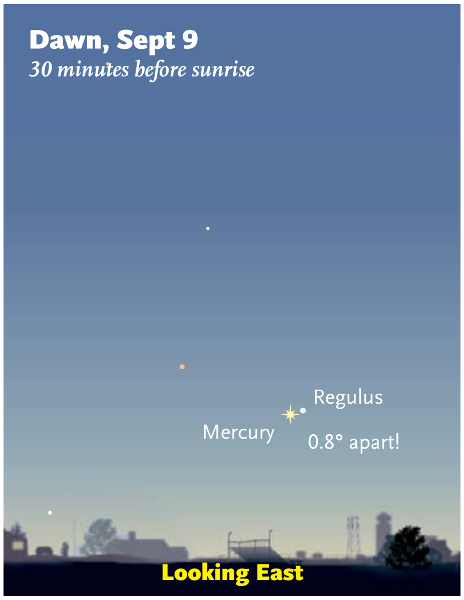
Neptune, in Aquarius, is well placed for telescopic observing by mid-evening. It shines at magnitude 7.8 and appears 2.3″ wide. Again, see page 53 for a finder chart.

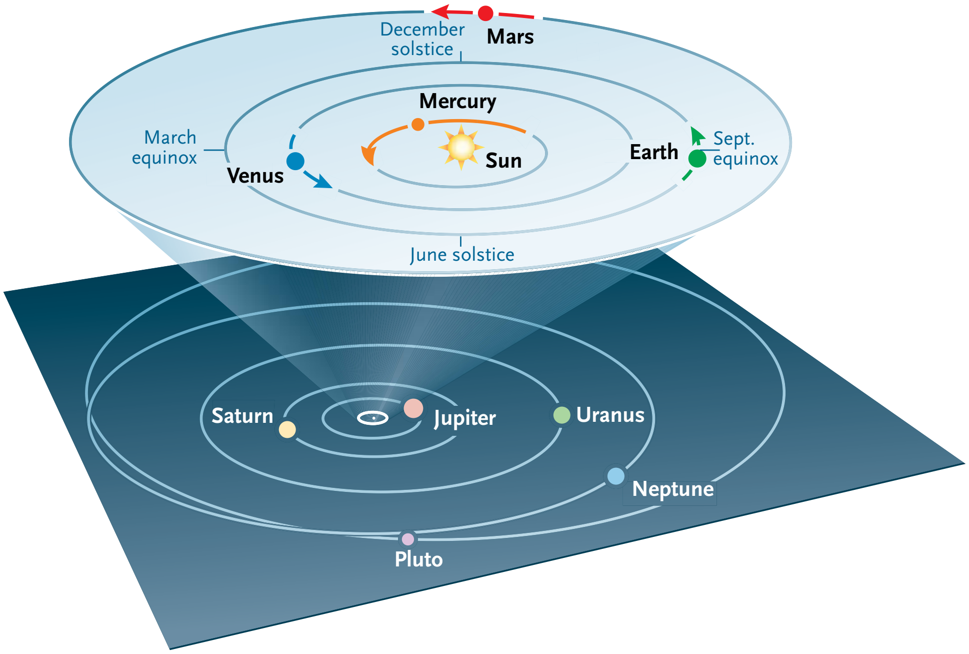
Pluto glows feebly at 14th magnitude in northern Sagittarius. It's still high enough to locate with a large telescope immediately after dark, using the chart on page 64 of the July issue.

PREDAWN

Mars rises in the east-northeast around 2 a.m. (daylight-saving time) throughout September. Earth is slowly catching up with Mars in its orbit around the Sun, so the "red planet" brightens slightly, from







ORBITS OF THE PLANETS

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

magnitude +1.4 to +1.3, and its disk grows from 4.7″ to 5.1″ — still disappointingly small for telescopic observation.

What's really interesting about Mars is the stellar scene that it's passing through. It's less than 6° south of Pollux from September 7th to 10th. The planet forms a straight line with Gemini's two brightest stars — Mars-Pollux-Castor, southeast to northwest — on September 15th. Mars is then almost exactly midway in brightness (not in position) between Pollux (magnitude 1.2) and Castor (magnitude 1.6). Compare its orange tint to that of Pollux — which is deeper? — and note that Mars doesn't twinkle as much.

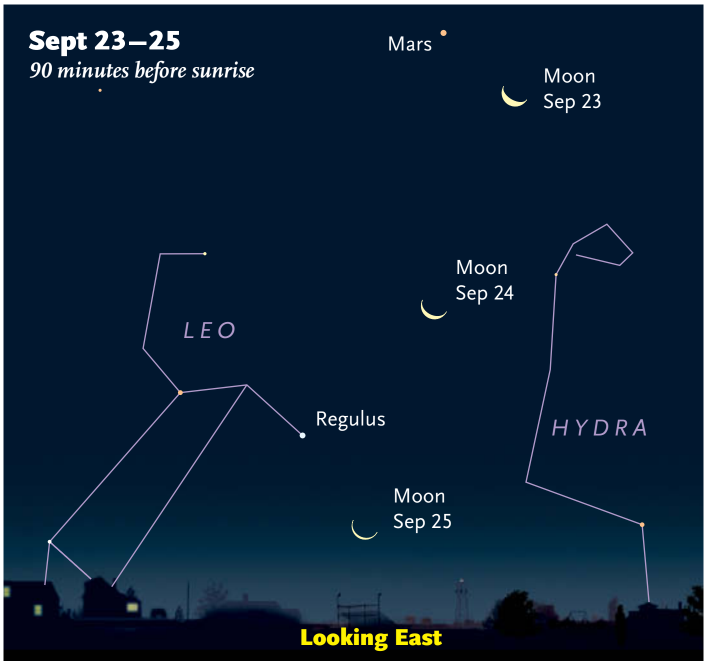
Mars then glides into Cancer, and on the final morning of September it's on the verge of entering M44, the Beehive Star Cluster (use binoculars or a telescope to see the planet at the cluster's edge). It's deep inside the cluster on the morning of October 1st. Mars's rapid motion eastward against the stars is the reason why it rises only ½ hour earlier on September 30th than on the 1st.

DAWN

Mercury is near the peak of a brief but relatively high leap into the dawn sky in early September. Look for it low in the east. The little planet continues to brighten rapidly, going from magnitude +0.1 to –1.0 in the first 10 days of the month, but by then it's sinking back down. Greatest elongation from the Sun comes on September 3rd, with Mercury rising about 1½ hours before the Sun and its 7.2″-wide disk appearing 45% illuminated in telescopes.

On September 8th Mercury stands almost 10° above the eastern horizon a half hour before sunup. That's good, because that morning Mercury is only about 1.3° above fainter Regulus. It's a mere 0.8° left of Regulus at dawn on September 9th. Binoculars will probably be needed to see the 1.4-magnitude star that low in bright twilight.

Mercury appears markedly lower each morning after that, disappearing from view in the third week of the month and reaching superior conjunction with the Sun on September 28th.



These scenes are drawn for near the middle of North America (latitude 40° north, longitude 90° west); European observers should move each Moon symbol a quarter of the way toward the one for the previous date. In the Far East, move the Moon halfway. The blue 10° scale bar is about the width of your fist at arm's length. For clarity, the Moon is shown three times its actual apparent size.

MOON AND SUN

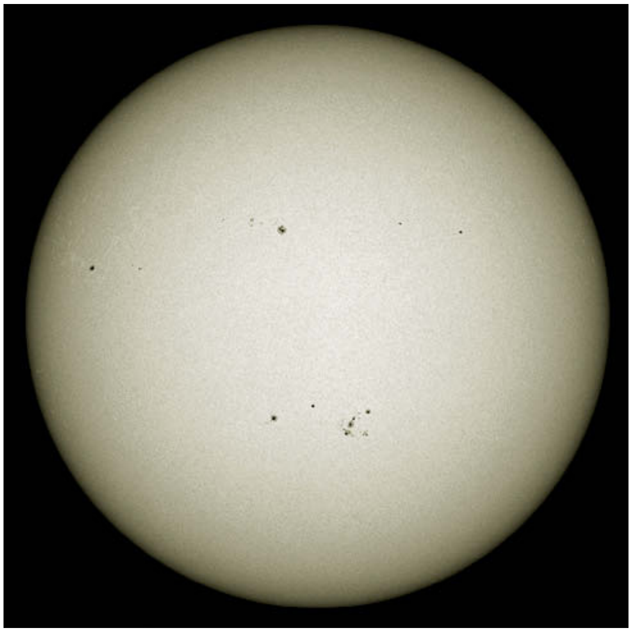
The waxing crescent **Moon** is very close to 2nd-magnitude Delta Scorpii on the evening of September 3rd and occults (covers) the star for parts of the U.S. (see the timetables at **SkyandTelescope.com/sep2011occult**). The next evening the first-quarter Moon is upper left of Antares. The waning gibbous Moon is fairly near Jupiter on the evenings of September 15th and 16th. The waning lunar crescent hangs to the lower right of Mars at dawn on September 23rd, and a very thin crescent is lower right of Regulus on the 25th.

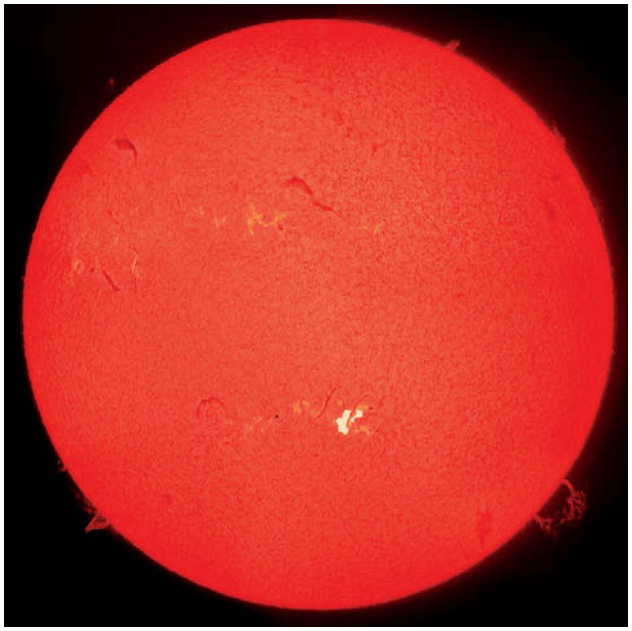
The **Sun** arrives at the September equinox at 5:05 a.m. EDT on September 23rd. This event marks the beginning of autumn in the Northern Hemisphere and spring in the Southern Hemisphere. ✦

Stephen W. Ramsden

Probing the Nearest Star

With the next solar maximum approaching, gear up to view the Sun.





LEFT: NASA / SDO; *RIGHT:* S&T: SEAN WALKER

The Sun offers endless daytime observing opportunities for amateurs. *Left:* Telescopes of any size equipped with safe solar filters can reveal dark sunspots across the photosphere, as seen here. *Right:* This image, taken at about the same time through a solar hydrogen-alpha filter, shows several giant prominences towering above the solar limb, and a bright flare erupting near the central meridian.

VISIBLE ON EVERY CLEAR DAY from nearly every location on Earth, the Sun is perhaps the easiest target to observe in the solar system. Now reawakening from an unusually long solar minimum, our Sun offers intriguing details to the careful observer using small telescopes and the proper techniques.

Observers today have more choices than ever to adapt their scopes to solar viewing. The easiest way to begin is to purchase a white-light solar filter. These devices block 99.999% of the Sun's light, revealing complex sunspot groups that churn across the photosphere. Sunspots are cooler regions of the photosphere that consist of oppositely charged magnetic polarity. As they form and decay and produce ever-changing groups, sunspots display a rhythmic dance of magnetic ferocity. A sunspot's black core is known as an *umbra*, which is often surrounded by a grayish *penumbra*. These features appear in stark contrast to the granulated photosphere even in small refractors, giving the observer a real-time view of the surface magnetic-force lines as they circulate in hotter material to fill the cooler regions in the sunspot's recessed umbra.

Regions of intense brightening known as *faculae* surround sunspots. Astronomers think faculae are electromagnetically related to sunspot groups. These fields of superheated photospheric plasma come and go in a ghostly partnership with meandering sunspot groups

Lucky observers may glimpse a rare white-light flare in the coming years. Richard Carrington viewed a particularly bright flare in 1859 (February issue, page 28), which touched off a geomagnetic storm that affected telegraph communications and produced auroras near the equator.

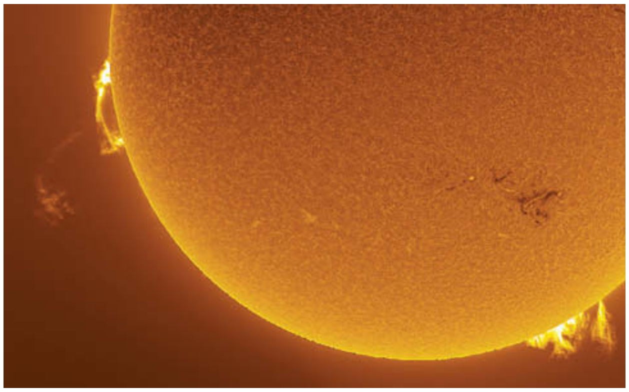
Beyond sunspots, the entire photosphere is riddled with granulation, a patchwork of bright areas bounded by darker lines. Granules are small cells of magnetically charged plasma bubbling up from the Sun's convective zone into the photosphere. They appear as dome-like structures, typically ranging from 500 to 1,000 miles (800 to 1,600 km) in diameter. Granules resemble the complicated cellular structures seen in plant life or the grouped skin cells of our epidermis seen through a microscope.

These visible-light structures last for 4 to 6 minutes before falling back into the interior, only to be replaced by the next energy-releasing granules. Granulation and, for that matter, all of these features revealed in white light, remain mostly a mystery as astronomers continue to study data provided by space-based observatories and data recorded by professional and amateur astronomers using ground-based telescopes.

Beyond the broadband views, rapidly changing solar phenomena await observers willing to invest a bit more capital in their solar-observing arsenal. Solar observers have long been staring at narrowband views of the Sun through various filtration mechanisms and devices. The hydrogen-alpha wavelength (656.28 nanometers) reveals dramatic fluid motions and complex structures within the solar chromosphere, just above the photosphere, the region where white-light features are visible.

When observing through a telescope equipped with a specialized solar hydrogen-alpha filter, the features that initially catch your eye are delicate prominences dancing along the edge of the Sun. These are protuberances of relatively cool hydrogen plasma held aloft by powerful magnetic fields extending out to the solar corona. Appearing similar to licks of fire or massive loops, prominences can commonly span the length of 30 or more Earths. When a prominence is seen in front of the solar disk, it appears darker than the solar surface and is known as a *filament*. A prominence's brightness is directly proportional to the temperature of the plasma contained within these magnetic fields; prominences with hotter plasma appear brighter than those containing cooler gas.

Prominences can last anywhere from minutes to months and can change appearance rapidly, depending on the stability of the magnetic fields holding them aloft. When the magnetic field containing a prominence or filament becomes unstable, the plasma either falls back into the Sun, or in some cases, the prominence can erupt off the limb into space. An erupting prominence can sometimes develop into a full-blown coronal mass ejection,



STEPHEN W. RAMSDEN

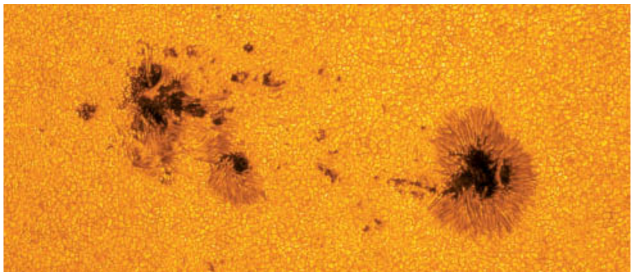
Huge prominences, such as these exquisite examples recorded on June 5th, can change appearance within minutes. These prominences lasted for days, while the fainter arc at left was pulled back into the Sun within hours of this photo being taken.

launching billions of tons of superheated plasma at velocities approaching 1% of the speed of light.

Besides prominences, *spiculae* are visible along the solar limb, appearing as tiny "hair" prominences particularly around the Sun's polar regions. Bright areas within the chromosphere often surrounding sunspots are called *plages*. Solar flares can suddenly erupt from plage regions without warning. These powerful flares can outshine the entire Sun for a brief time and result in terrestrial radio interference, auroras, and satellite outages. In recent months, active regions have been crackling with dozens of C- and X-class flares. Astronomers have not yet been able to reliably predict flares, but if you spend a lot of time behind an H-alpha scope in the next few years, you'll surely catch several in action.

White-light and hydrogen-alpha solar observing are the most popular methods for amateurs to study the Sun. But other spectral bands reveal interesting solar phenomena. A calcium-K filter shows ionized calcium in the chromosphere as it emits and absorbs energy in the violet region of the spectrum. Some observers have little or no visual acuity at these wavelengths, so calcium-K observations are more useful when combined with imaging.

The introduction of affordable technologies in narrowband filters and specialized telescopes has generated a global boom in solar astronomy. Those of you who already own a narrowband solar scope already know how beautiful the Sun's fiery ballet of plasma can be. I invite the rest of you star lovers to come join the hottest thing in astronomy by taking the plunge into safe solar astronomy. As the Sun approaches solar maximum in the next two years, now is the best time to get acquainted with our stellar neighbor. ✦



EMIL KRAAIKAMP

Large telescopes using white-light solar filters offer breathtaking views of sunspots at high magnification, as well as tiny granules that form and decay within minutes.

Stephen W. Ramsden *operates the Charlie Bates Solar Astronomy Project (www.charliebates.org), a nonprofit public outreach program sharing views of the Sun worldwide.*

Visit Uranus and Neptune

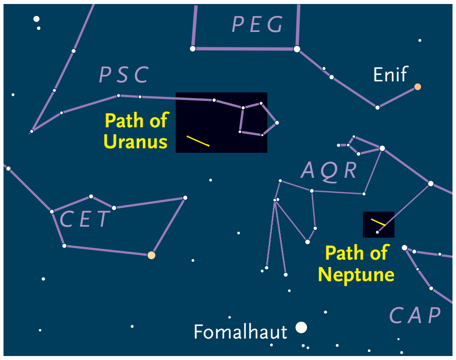
These dim lurkers turn out to be an abundant type of planet cosmos-wide.

The solar system's twin "ice giants," far and faint, may seem like afterthoughts as the planets go. But by the standards of the wider universe, Uranus and Neptune — with 4.0 and 3.9 Earth diameters, respectively — are right in the mainstream. NASA's Kepler transit-hunting spacecraft is finding more planets of this size than any other, at least among the easy-to-find hot worlds very close to their stars. But "hot Neptunes" will probably remain on top of the exoplanet heap only briefly. Astronomers expect that smaller planets are even more abundant, though these are harder to tease out of Kepler's data.

In our solar system Uranus and Neptune are extremely cold: about 50 to 70 Kelvins at their visible "surfaces." The layer we see visually is mostly clear blue hydrogen-helium sky with some hydrocarbon haze, overlying a deeper cloud deck that shows through dimly. Occasional white methane clouds appear at high altitudes.

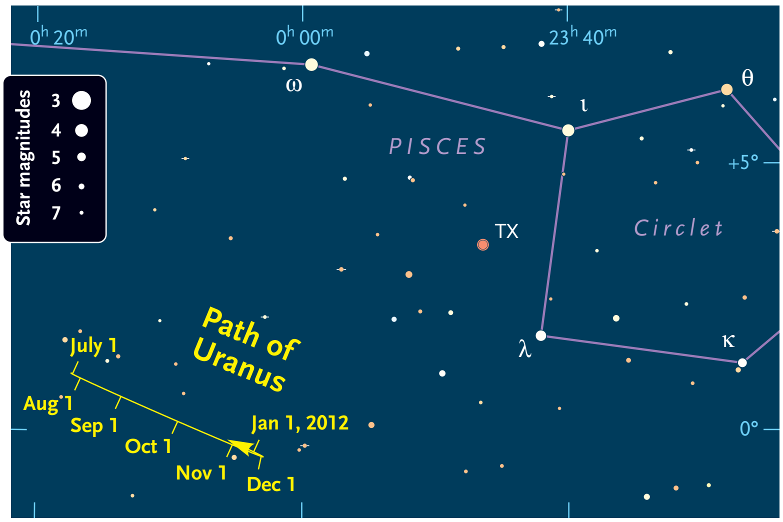
Unlike Jupiter and Saturn, which are mostly hydrogen and helium by mass, Uranus and Neptune are thought to be mostly water (H_2O), ammonia (NH_3), and methane (CH_4) below a thick hydrogen-helium layer. Planetary scientists call these compounds "ices," even though they must be fluids at the great heat and pressure deep inside.

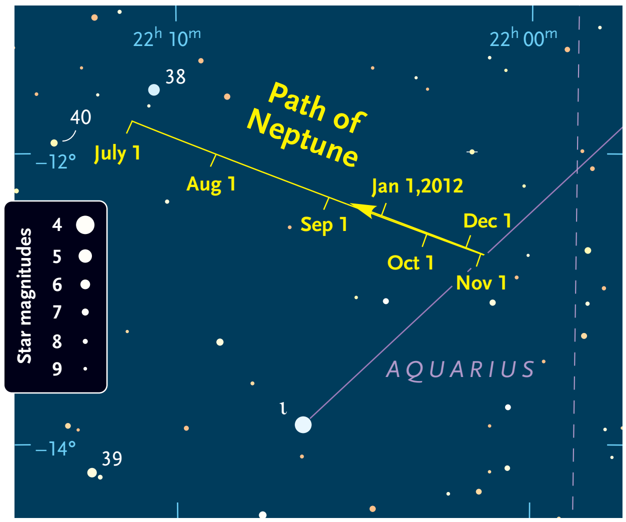
Uranus is easy to spot in binoculars at 6th magnitude. Neptune is a little harder at 8th. Use the charts below to find them along their apparent paths for the rest of this observing season. In most telescopes, the 3.7″ disk of Uranus shows distinctly as a nonstellar blob or even a fuzzy little disk at high power in excellent seeing. Neptune's 2.3″ disk is harder to distinguish from a star, but a 4-inch scope at 120× on a good night should do it.



The twin outermost planets creep westward for the next few months, then double back on themselves. The black boxes above show the areas covered by the finder charts below.

South of Uranus and southwest of Neptune, by roughly 15° for each, you can also check on the two brightest asteroids: 1 Ceres and 4 Vesta, respectively. They're magnitudes 8 and 6½ during September. Use the charts for them in last month's issue, page 53, or at **SkyandTelescope.com/asteroids**.





Action at Jupiter

In September Jupiter is up in good view in the east before midnight, though it's highest in the south and sharpest in a telescope between about 2 and 5 a.m.

Any telescope will show Jupiter's four big Galilean moons. Identify them with the diagram on page 46. Listed below are all their interactions with Jupiter's disk and shadow during September.

On Jupiter itself, the most prominent marking remains the dark red-brown North Equatorial Belt. The South Equatorial Belt (SEB) has returned, broad and double, after its disappearance for most of 2010. The Great Red Spot, sitting within the SEB, has lately been bordered with dark material rather than the usual white Red Spot Hollow.

Here are the times, in Universal Time, when the Great Red Spot should cross Jupiter's central meridian. The dates (also in UT) are in bold. Eastern Daylight Time is UT minus 4 hours:

September 1, 6:17, 16:13; **2**, 2:08, 12:04, 21:59; **3**, 7:55, 17:51; **4**, 3:46, 13:42, 23:38; **5**, 9:33, 19:29; **6**, 5:24, 15:20; **7**, 1:16, 11:11, 21:07; **8**, 7:03, 16:58; **9**, 2:54, 12:49, 22:45; **10**, 8:41, 18:36; **11**, 4:32, 14:27; **12**, 0:23, 10:19, 20:14; **13**, 6:10, 16:05; **14**, 2:01, 11:57, 21:52; **15**, 7:48, 17:43; **16**, 3:39, 13:35, 23:30; **17**, 9:26, 19:21; **18**, 5:17, 15:13; **19**, 1:08, 11:04, 20:59; **20**, 6:55, 16:51; **21**, 2:46, 12:42, 22:37; **22**, 8:33, 18:29; **23**, 4:24, 14:20; **24**, 0:15, 10:11, 20:07; **25**, 6:02, 15:58; **26**, 1:53, 11:49, 21:44; **27**, 7:40, 17:36; **28**, 3:31, 13:27, 23:22; **29**, 9:18, 19:14; **30**, 5:09, 15:05.

These times assume that the spot is centered at System II longitude 173°. If it has moved a bit, it will transit 1⅔ minutes late for every 1° of longitude greater than 173°, or 1⅔ minutes early for every 1° less than 173°. Markings on Jupiter appear a little more contrasty through a blue or green eyepiece filter. ✦

Jupiter was still fairly low before sunrise when Christopher Go took this stacked-video image on May 29th. South is up.

Phenomena of Jupiter's Moons, September 2011

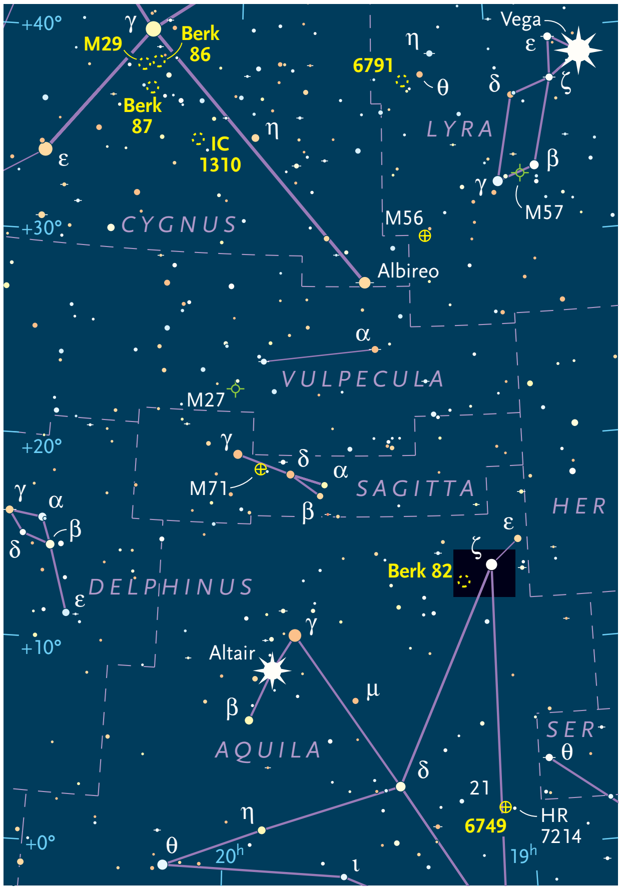
Sept. 1	0:46	III.Oc.D
	2:07	III.Oc.R
	12:05	I.Sh.I
	13:18	I.Tr.I
	14:15	I.Sh.E
	15:25	I.Tr.E
	20:56	II.Sh.I
	23:25	II.Sh.E
	23:26	II.Tr.I
Sept. 2	1:46	II.Tr.E
	9:24	I.Ec.D
	12:47	I.Oc.R
Sept. 3	6:34	I.Sh.I
	7:45	I.Tr.I
	8:43	I.Sh.E
	9:53	I.Tr.E
	15:03	II.Ec.D
	19:52	II.Oc.R
Sept. 4	3:53	I.Ec.D
	7:14	I.Oc.R
	9:37	III.Sh.I
	11:41	III.Sh.E
	14:46	III.Tr.I
	16:03	III.Tr.E
Sept. 5	1:02	I.Sh.I
	2:13	I.Tr.I
	3:11	I.Sh.E
	4:20	I.Tr.E
	10:14	II.Sh.I
	12:38	II.Tr.I
	12:43	II.Sh.E
	14:58	II.Tr.E
	22:22	I.Ec.D
Sept. 6	1:41	I.Oc.R
	19:31	I.Sh.I
	20:40	I.Tr.I
	21:40	I.Sh.E
	22:47	I.Tr.E
Sept. 7	4:21	II.Ec.D
	9:04	II.Oc.R
	16:50	I.Ec.D
	20:08	I.Oc.R
	23:27	III.Ec.D
Sept. 8	1:33	III.Ec.R
	4:26	III.Oc.D
	5:44	III.Oc.R
	13:59	I.Sh.I
	15:07	I.Tr.I
	16:08	I.Sh.E
	17:14	I.Tr.E
	23:32	II.Sh.I
Sept. 9	1:51	II.Tr.I
	2:01	II.Sh.E
	4:10	II.Tr.E
	11:19	I.Ec.D
	14:35	I.Oc.R
Sept. 10	8:28	I.Sh.I
	9:34	I.Tr.I
	10:37	I.Sh.E
	11:41	I.Tr.E
	17:39	II.Ec.D
	22:16	II.Oc.R
Sept. 11	5:47	I.Ec.D
	9:02	I.Oc.R
	13:38	III.Sh.I
	15:41	III.Sh.E
	18:23	III.Tr.I
	19:37	III.Tr.E
Sept. 12	2:56	I.Sh.I
	4:01	I.Tr.I
	5:06	I.Sh.E
	6:08	I.Tr.E
	12:50	II.Sh.I
	15:02	II.Tr.I
	15:19	II.Sh.E
	17:22	II.Tr.E
Sept. 13	0:16	I.Ec.D
	3:29	I.Oc.R
	21:24	I.Sh.I
	22:27	I.Tr.I
	23:34	I.Sh.E
Sept. 14	0:35	I.Tr.E
	6:57	II.Ec.D
	11:27	II.Oc.R
	18:44	I.Ec.D
	21:55	I.Oc.R
Sept. 15	3:29	III.Ec.D
	5:33	III.Ec.R
	8:01	III.Oc.D
	9:16	III.Oc.R
	15:53	I.Sh.I
	16:54	I.Tr.I
	18:03	I.Sh.E
	19:01	I.Tr.E
Sept. 16	2:08	II.Sh.I
	4:13	II.Tr.I
	4:37	II.Sh.E
	6:33	II.Tr.E
	13:13	I.Ec.D
	16:22	I.Oc.R
Sept. 17	10:21	I.Sh.I
	11:21	I.Tr.I
	12:31	I.Sh.E
	13:28	I.Tr.E
	20:15	II.Ec.D
Sept. 18	0:37	II.Oc.R
	7:41	I.Ec.D
	10:49	I.Oc.R
	17:38	III.Sh.I
	19:40	III.Sh.E
	21:55	III.Tr.I
	23:07	III.Tr.E
Sept. 19	4:50	I.Sh.I
	5:47	I.Tr.I
	7:00	I.Sh.E
	7:55	I.Tr.E
	15:26	II.Sh.I
	17:23	II.Tr.I
	17:55	II.Sh.E
	19:43	II.Tr.E
Sept. 20	2:10	I.Ec.D
	5:15	I.Oc.R
	23:18	I.Sh.I
Sept. 21	0:14	I.Tr.I
	1:28	I.Sh.E
	2:21	I.Tr.E
	9:33	II.Ec.D
	13:48	II.Oc.R
	20:38	I.Ec.D
	23:42	I.Oc.R
Sept. 22	7:30	III.Ec.D
	9:34	III.Ec.R
	11:32	III.Oc.D
	12:45	III.Oc.R
	17:47	I.Sh.I
	18:41	I.Tr.I
	19:57	I.Sh.E
	20:48	I.Tr.E
Sept. 23	4:44	II.Sh.I
	6:33	II.Tr.I
	7:13	II.Sh.E
	8:53	II.Tr.E
	15:07	I.Ec.D
	18:08	I.Oc.R
Sept. 24	12:16	I.Sh.I
	13:07	I.Tr.I
	14:25	I.Sh.E
	15:14	I.Tr.E
	22:51	II.Ec.D
Sept. 25	2:57	II.Oc.R
	9:36	I.Ec.D
	12:35	I.Oc.R
	21:39	III.Sh.I
	23:40	III.Sh.E
Sept. 26	1:22	III.Tr.I
	2:33	III.Tr.E
	6:44	I.Sh.I
	7:33	I.Tr.I
	8:54	I.Sh.E
	9:41	I.Tr.E
	18:02	II.Sh.I
	19:42	II.Tr.I
	20:31	II.Sh.E
	22:02	II.Tr.E
Sept. 27	4:04	I.Ec.D
	7:01	I.Oc.R
Sept. 28	1:13	I.Sh.I
	2:00	I.Tr.I
	3:22	I.Sh.E
	4:07	I.Tr.E
	12:09	II.Ec.D
	16:06	II.Oc.R
	22:33	I.Ec.D
Sept. 29	1:27	I.Oc.R
	11:32	III.Ec.D
	13:34	III.Ec.R
	14:56	III.Oc.D
	16:09	III.Oc.R
	19:41	I.Sh.I
	20:26	I.Tr.I
	21:51	I.Sh.E
	22:34	I.Tr.E
Sept. 30	7:20	II.Sh.I
	8:51	II.Tr.I
	9:49	II.Sh.E
	11:11	II.Tr.E
	17:01	I.Ec.D
	19:54	I.Oc.R

Every day, interesting events happen between Jupiter's satellites and the planet's disk or shadow. The first columns give the date and mid-time of the event, in Universal Time (which is 4 hours ahead of Eastern Daylight Time). Next is the satellite involved: **I** for Io, **II** Europa, **III** Ganymede, or **IV** Callisto. Next is the type of event: **Oc** for an occultation of the satellite behind Jupiter's limb, **Ec** for an eclipse by Jupiter's shadow, **Tr** for a transit across the planet's face, or **Sh** for the satellite casting its own shadow onto Jupiter. An occultation or eclipse begins when the satellite disappears **(D)** and ends when it reappears **(R)**. A transit or shadow passage begins at ingress **(I)** and ends at egress **(E)**. Each event is gradual, taking up to several minutes. Predictions courtesy IMCCE / Paris Observatory.

The Berkeley Clusters

These groupings are rarely observed but often rewarding.

In 1962 two astronomers at the University of California, Berkeley, Arthur F. Setteducati and Harold F. Weaver, published a two-part paper titled *Newly Found Star Clusters*. It contains the list of 104 objects that now bear the designation Berkeley. The paper is rather rare, and I was quite pleased when the Canadian amateur Pierre Paquette sent me a scanned copy from the Gerstein Science Information Centre in Toronto. This inspired me to observe Berkeley clusters that are well placed at this time of the year, and I've selected some noteworthy examples for this month's sky tour.



The objects discussed here are scattered over a wide swath of sky. The main chart shows stars to magnitude 6.5, and the close-up for Berkeley 82 shows stars to magnitude 9.5.

Let's start in Aquila with Berkeley 42, the only globular cluster among the Berkeleys. It's more commonly known as **NGC 6749**. The Setteducati and Weaver paper includes some objects with NGC (*New General Catalogue*) designations that had been "overlooked in the recent literature." Despite the more common NGC designation, this is not an easy Berkeley cluster. In fact, it might be the most difficult one we'll visit, because it's camouflaged in a rich Milky Way star field.

NGC 6749 lies one-sixth of the way (26′) from the 5.8-magnitude star HR 7214 to 5.1-magnitude 21 Aquilae, as shown in the chart at left and the photograph on the facing page. Through my 130-mm refractor at 63×, it's fairly apparent as a low-surface-brightness puff flanked by two 11th-magnitude stars. The stars are 5.8′ apart and aligned almost east-west, with the globular cluster nearly nudging the eastern star. At 102×, the 3′ ghostly ball of light rests on a 2′ trapezium of 12th- and 13th-magnitude stars, the star at its northwest corner closely guarding the fringe of the cluster. NGC 6749 is slightly brighter in the center, and there's a very faint star superposed near its northeast edge.

None of the stars I saw belong to the cluster, whose brightest members shine at magnitude 16.5. Their feeble light is not due to distance. NGC 6749 lies about 26,000 light-years away — only a little farther than the Great Cluster in Hercules (Messier 13), which is much easier to resolve. But while our window to M13 is relatively clear, the stars of NGC 6749 suffer 4.7 magnitudes of extinction from intervening dust clouds. Setteducati and Weaver comment: "Although it is described as a cluster in the NGC, later attempts to identify it photographically were unsuccessful, presumably because of the very heavy obscuration."

Let's leap northward to Lyra, where we'll find the open cluster **NGC 6791** (Berkeley 46) sitting 58′ east-southeast of golden Theta (θ) Lyrae and 29′ northeast of a pair of 6th-magnitude stars. (See the photograph on page 58.) My 130-mm refractor at 37× shows a pretty gathering of several faint to very faint stars awash with haze. At 102×, 14 stars fleck a subtly textured glow 10′ across. Some must

Left: The heavily obscured globular cluster NGC 6749 (far left) lies 26′ east and a little north of the star HR 7214 (far right). *Right*: IC 1310, the tight knot of stars near the center, is shown here 6′ almost due south of an 8.9-magnitude star and 10′ northwest of an 8.3-magnitude star, both of which are plotted on the star chart on page 58. The 8.3-magnitude star is a double with components 4″ apart. All of the photographs in this article are synthesized from red and blue plates of the Palomar Sky Survey, courtesy of Caltech and Palomar Observatory.

be foreground stars, since only a few of the cluster's probable members shine brighter than 14th magnitude. In my 10-inch reflector at 170×, the haze glitters with many barely visible motes of light, while my 14.5-inch scope unveils a grand flurry of faint suns.

NGC 6791 is an exceptionally ancient and populous open cluster, roughly 8 billion years old with 3,000 stars. It lies about 13,000 light-years away — half the distance of NGC 6749.

The Berkeley list contains one object that bears an IC (*Index Catalogue*) designation, **IC 1310** (Berkeley 50). Setteducati and Weaver note that IC 1310 inhabits a nebulous region of the sky and had been previously listed as a diffuse nebula.

Although a sweep 2.8° east from golden Eta (η) Cygni will take you straight to IC 1310, this region of Cygnus is so crowded with stars, clusters, and nebulae that a careful star-hop may be necessary to pinpoint the cluster's location. It lies 10′ northwest of an 8.3-magnitude star and 6′ south of an 8.9-magnitude star, as shown in the photo at upper right and the star chart on page 58.

My 130-mm scope at 102× displays three faint stars arrayed in an equilateral triangle. A patch of haze is centered on the southern star and reaches as far as the northeastern one. Two additional stars dot the haze. At 164× the star tally reaches eight, and the cluster appears to span 2½′.

When I view the cluster through my 10-inch scope at 213×, each star of the triangle has a companion, and a wider star pair to the southeast gives the group the shape of a lower-case y. In total I count 20 faint to extremely faint stars within a 3½′ circle. Most of the stars crowd the joint of the y, where a touch of mist remains.

IC 1310 is about 6,800 light-years away, with an age of 250 million years — half as distant and only 3% as old as NGC 6791.

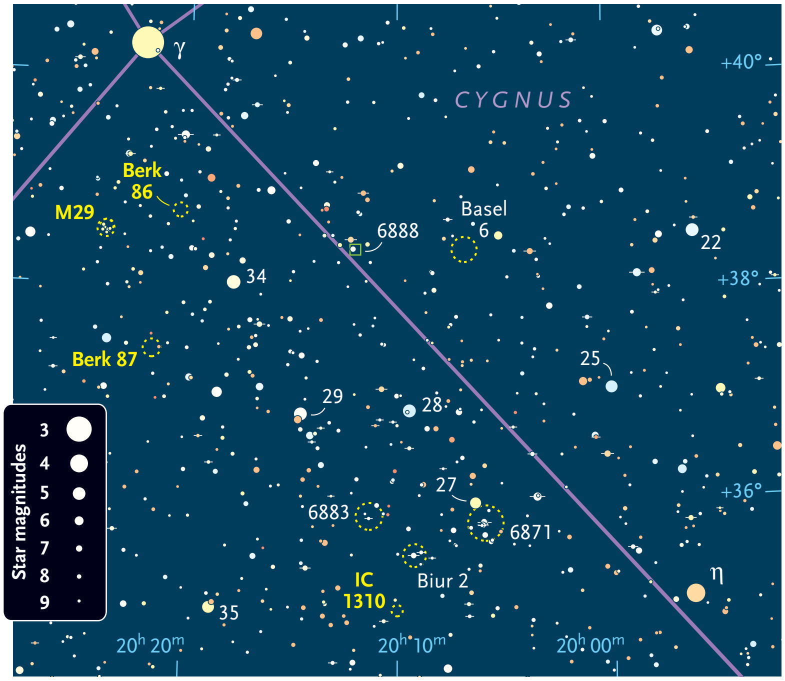
The three Berkeley clusters above are from Setteducati and Weaver's list of 59 "obvious clusters." The next three are from their list of 45 "probable clusters" and are original discoveries by the Berkeley team.

The first is **Berkeley 82**, located 1.6° east-southeast of Zeta (ζ) Aquilae. A curvy line of 7th- to 9th-magnitude

An Assortment of Berkeley Clusters

Object	Mag(v)	Size	RA	Dec.
NGC 6749	12.4	4′	19^h 05.3^m	+01° 54′
NGC 6791	9.5	10′	19^h 20.9^m	+37° 46′
IC 1310	~10	4′	20^h 10.0^m	+34° 58′
Berk 82	~9	4′	19^h 11.3^m	+13° 07′
Messier 29	6.6	10′	20^h 24.1^m	+38° 30′
Berk 86	7.9	7′	20^h 20.2^m	+38° 41′
Berk 87	~7	10′	20^h 21.6^m	+37° 24′

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.



NGC 6791, shown above, is an extraordinarily dense open cluster. It's easily located 29′ northeast of a pair of 6th-magnitude stars, both of which are plotted on the chart on page 56, where this cluster is discussed.

stars leads you most of the way from Zeta to the cluster, which appears as a little arc of three dim stars when viewed through my 130-mm scope at 37×. The stars are prominent at 102× and line the northwest rim of a 2′ cloudy patch that's dotted with four very faint stars. The southernmost star seems elongated, and a magnification of 164× shows it to be double while adding several faint stars to the scene.

Berkeley 82 is a nearby cluster at 2,800 light-years, and it has a youthful age of 30 million years. It seems to have formed at the shock front of an expanding supershell of compressed hydrogen driven by stellar winds and supernova explosions.

To find our next Berkeley cluster, let's start at the bright open cluster **Messier 29**, which is fairly easy to sweep up in 7×42 binoculars as a small, granular glow. My 6-inch reflector at 68× shows back-to-back arcs of three bright stars each, and an entourage of dimmer stars plumps the cluster to about 7½′.

From Messier 29, it's a short hop 46′ west-northwest to **Berkeley 86**. With my 6-inch scope at 44×, I see a dozen moderately bright to faint stars, most of which lie along a skinny V about 5′ tall. The eastern arm of the V is longer, and a 5′ line of three stars proceeds east-northeast from its top. Two of the group's brightest stars appear yellow to my eye. My 10-inch scope at 187× exposes 25 stars in an area 7′ across. The star at the point of the V is not generally considered part of the cluster.

Messier 29 is also a good guide to our final cluster, **Berkeley 87**. Dropping 1° due south from M29 will take you to a 6th-magnitude star, the brightest in the area. Berkeley 87 is centered 26′ west-southwest of this star and is a fairly obvious knot of stars through my 105-mm refractor at 28×. The brightest star rests at the cluster's west-northwestern edge and glows orange.

A dozen stars are visible at 87×, most forming a lowercase Greek letter chi (χ), although it's mirror-reversed in the refractor's field of view. Another orange spark ornaments the center of the χ. My scope at 118× shows about 25 stars, 9th magnitude and fainter, assembled in an area 10′ across.

Messier 29, Berkeley 86, and Berkeley 87 are generally thought to be concentrations within the Cygnus OB1 association, a loose stellar grouping that extends across 4° × 3½° of sky and is dominated by massive young stars. The association is centered approximately 5,000 light-years away, and its stars range from about 2 to 10 million years old. ✦

Long-time Sky & Telescope *contributor* ***Sue French*** *observes deep-sky objects from her home in upstate New York. She welcomes observing reports, questions, and comments at scfrench@nycap.rr.com. Her new book,* Deep-Sky Wonders, *will be available this fall.*

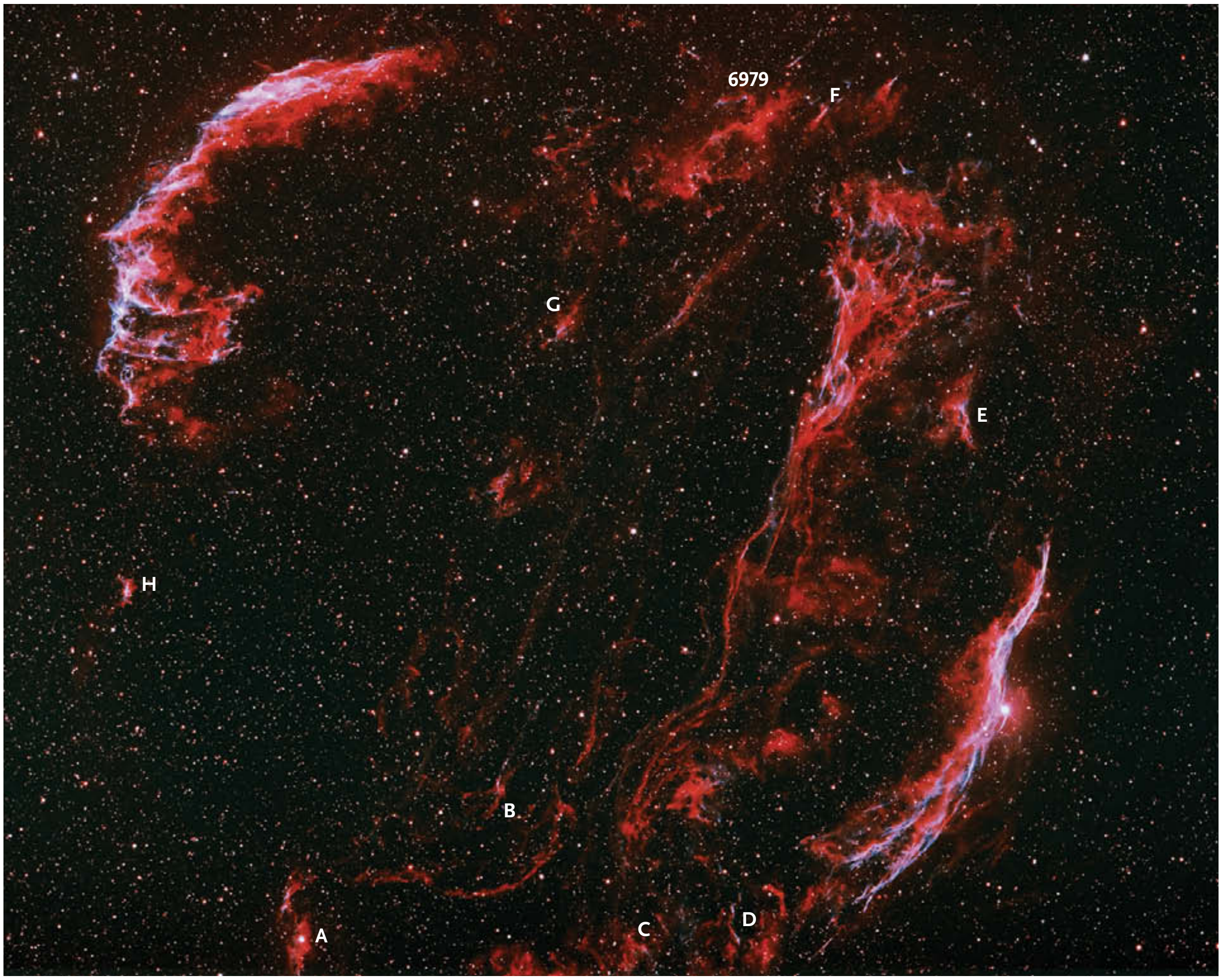
Beyond the Familiar Veil

There's more to this nebula than the bright arcs and Pickering's Wisp.

I CONSIDER THE intricate Veil Nebula in Cygnus to be the most striking nebula of all, surpassing the much brighter Carina, Orion, and Tarantula nebulae when viewed through a 6-inch or larger telescope. William Herschel discovered the Veil in 1784. This complex, 3°-wide supernova remnant was once considered a challenge object even though its easternmost and brightest arc (NGC 6992/5) is obvious in 7×50 binoculars.

The view through an O III filter of the Veil Nebula's two main arcs, NGC 6960 and NGC 6992/5, is what made that filter famous about 30 years ago, and all of the observations described in this article were made using an O III filter unless stated otherwise.

With an O III filter on my 16-inch f/4.5 Newtonian, **NGC 6992/5** exhibits diagonal streaks. It also has "bays" and "headlands," as depicted on *Millennium Star Atlas*



MICHAEL MAYDA

This is a composite of exposures shot through Hα and O III filters. Hα, which is invisible to the human eye at low levels, is shown as red. The O III areas, which to a great extent coincide with the ones observed by the author, are shown as bluish white. North is skewed slightly clockwise from straight up, so area D is partially cropped off.

(*MSA*) chart 1169, which is reproduced at right. And I can see some of the lacework detail that's shown on the image on the facing page. The two "fangs" of **IC 1340** that project westward from NGC 6995's southern end are my favorite part of the entire complex.

Without a filter, I can see only the northern spike of **NGC 6960**, running north from 52 Cygni, a yellow-and-orange double star. The O III filter shows that this northern spike has bright edges. It also reveals the arc south of 52 Cygni, where NGC 6960 is fainter and eventually becomes bifurcated.

An O III filter used under dark skies shows Simeis 3-188, better known as **Pickering's Triangular Wisp**, northeast of NGC 6960. My 80-mm refractor at 14× fits both arcs plus Pickering's Wisp in a single wide field of view. Larger scopes can trace the Wisp's long, winding tail as well. This marvelous complex can be followed for almost 2°, much longer than either of the bright arcs.

On three nights last summer I used my 16-inch reflector to star-hop to all 19 of the smaller splatters of nebulosity that are plotted on *MSA* chart 1169. Here are descriptions of eight of these splatters as seen with an O III filter and a 16-mm Nagler eyepiece yielding 114×. The sections that I saw are labeled and sketched in red superposed on the *Millennium* chart.

A is a narrow band of haze centered on the 6.3-magnitude star HR 7999. I could not follow the nebulosity, which is obvious to the north of the star, past the bright star, but it reappeared immediately to the south of it. The streak bends southwestward and then disappears at the Vulpecula border, 12′ from the star.

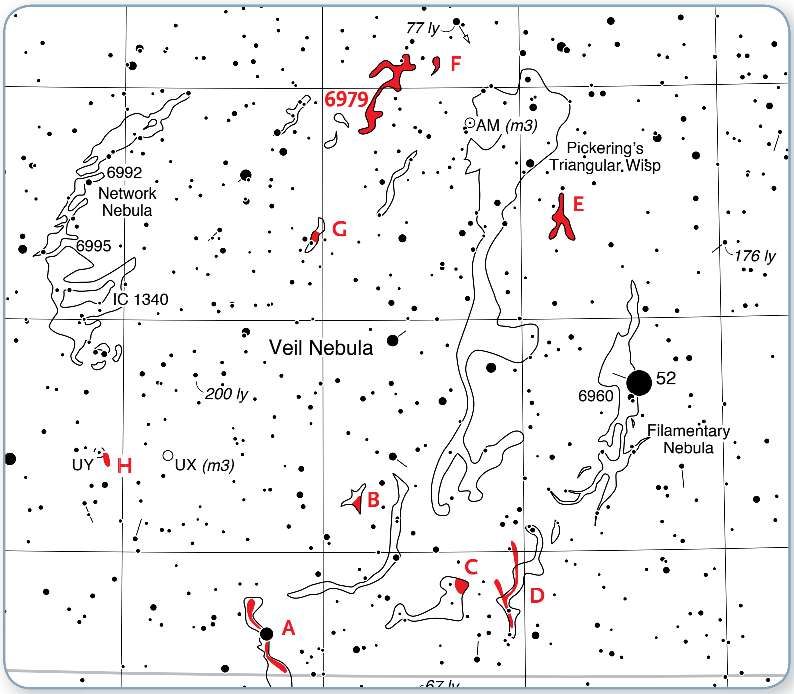
At **B** just a very small patch at the southwestern tip of the charted nebulosity was visible. **C** is a triangular patch, brightest at its western tip.

D was interesting and challenging. Starting near the southern end of the area on the chart, it ran northward and split into two streaks, as sketched, which continued outside the boundaries of the charted nebulosity. Observing D was educational. On the third night of observing I shortened the northeastern arm on my sketch, having realized that on the first two nights my mind had been fooled by clumps of very faint stars into extending the streak past the end of the nebulosity.

E, a 12′-long, Y-shaped patch just southwest of Pickering's Triangular Wisp, is quite obvious with the O III filter, and my view essentially matches the *MSA* chart. Because it was so easy with the filter, I was surprised to find that it was invisible when I later attempted it without a filter.

F is small, but surprisingly obvious. It's elongated 4:1, north to south.

On the best of the three nights, subtle **NGC 6979** appeared much as plotted, including the arm extending toward the number 6979 on the *MSA* chart. But on the first evening I could only detect the thin section



The areas observed by the author (aside from the two bright arcs and Pickering's Wisp) are sketched and labeled in red.

immediately south of declination +32. Even without a filter, I logged this section, labeled NGC 6974 on some charts, as "suspected."

Only the central quarter of the very faint patch labeled **G** was visible — the part within the flat triangle of stars that is plotted on the *MSA* chart.

To avoid the power of suggestion, I looked at an image of the Veil Nebula only after my first night of observing. The image confirmed the nebulous patches described above and also guided me to a patch of nebulosity about ½° south of NGC 6995 that, surprisingly, is not plotted on the *MSA*. Labeled **H** on the chart, this patch was bright enough to be obvious even during my star-hop to the field at 76× without a filter. With the O III filter at 114× it was a 2.3′-long, oval patch elongated 2:1, lying north-northeast to south-southwest. How can something this bright not have an NGC or IC number?

Other than NGC 6979, I have not read any other accounts of these small streaks and blobs being seen at the eyepiece, except for a pioneering observation of streak A that Atlanta stargazer Dave Riddle made a decade ago with his 18-inch during a Florida observing run.

This detailed survey of the Veil Nebula was not done on some remote mountaintop. My valley-bottom observatory is located in the well-populated Okanagan Valley of southern British Columbia. But I carefully chose a yard that's south of the valley's three cities and in a subdivision that decades ago voted to be streetlight-free in a referendum because the residents recognized that the night sky is part of nature! The result is that the gegenschein is occasionally visible from my backyard in October. ✦

__Alan Whitman__ is a fan of supernova remnants. He has observed seven, most recently the supposedly invisible Cas A.

Australian Eclipse 2012

E. AUSTRALIA · NOVEMBER 8TH – NOVEMBER 15TH, 2012

Let *Sky & Telescope* help you get the most out of the eclipse and the glories of Down Under. Join us November 8–15, 2012 for a swing through Australia, astronomy-style.

Join Greg Bryant, Editor of *Australian Sky & Telescope*, who will bring you eclipse expertise, the latest on Australian astronomy, and a behind-the-scenes look at the innovative instrumentation and research found in Oz.

S&T visits "The Dish" at Parkes and the Siding Spring Observatory at Coonabarabran, and we'll get the latest on Australian astronomy research from University of Sydney astrophysicist Julia Bryant, Ph.D.

Then we head north to Cairns, with suspense building. We'll relax before the eclipse with a visit to the Great Barrier Reef. Eclipse day finds us with three site choices for eclipse viewing: the beach, on the ground in the Outback, or in a hot-air balloon out of Mareeba.

Map out a robust intellectual adventure. Reserve now, and join *Sky & Telescope* and kindred spirits in a timeless moment. Visit http://www.insightcruises.com/SolarEclipse

DAY 1: Nov. 8

Arrive Sydney

Upon arrival at Sydney Airport, you'll be met by a guide for a City Tour of Sydney, including visits to the Sydney Opera House, refreshing Bondi Beach, and the historic Rocks area. Early afternoon, relax on a luncheon cruise of Sydney Harbor, then check in to The Four Seasons Hotel.

Four Seasons
Hotels and Resorts

Lunch provided.

DAY 2: Nov. 9

Free day in Sydney

Enjoy a day at leisure on your own. We highly recommend the Royal Botanic Garden (with its famous flying foxes) and The Art Gallery of New South Wales, both within easy walking distance from our hotel. The Taronga Zoo is renowned for its Australian wildlife.

Breakfast provided.

DAY 3: Nov. 10

Travel to Parkes

Today we head out to Australia's astronomy corridor. We'll traverse the UNESCO World Heritage Blue Mountains, pausing in Katoomba for the view. We'll head into central New South Wales for lunch in a country town. On through picturesque farmland, arriving at Parkes in late afternoon. We'll have dinner and take an informal first look at Southern Hemisphere skies.

Breakfast, lunch, and dinner provided.

DAY 4: Nov. 11

Parkes Observatory

Up the Newell Highway lies the Australia Telescope National Facility, Parkes Observatory: The Dish. We'll receive exclusive briefings on the work with the 64-meter parabolic dish, and hear about Parkes' central role in the Apollo 11 Moon landing.

Breakfast, lunch, and dinner provided.

DAY 5: Nov. 12

Siding Spring Observatory

Wake up in Coonabarabran to birdsong. After breakfast we head to Siding Spring Observatory, Australia's optical astronomy center. Get the scoop on cutting-edge tools and exploration at the Australian Astronomical Observatory with an exclusive briefing, and visit some of the dozen other telescopes on site.

Breakfast, lunch, and dinner provided.

DAY 6: Nov. 13

The Great Barrier Reef

All aboard Green Island Reef Cruise to the Great Barrier Reef, among the Seven Natural Wonders of the World. Green Island National Park's tropical vine forest is home to 60 species of birds. Offshore in the surrounding reef live green and hawksbill turtles, clams, fish, stingrays, and a diversity of creatures.

Breakfast and lunch provided.

PRICING: $8,999 per person (pp) based on double occupancy. There is a $500pp early-bird discount if booked by July 31, 2011. For full terms and conditions please visit: http://InSightCruises.com/Sky-4

For more info call 650-787-5665 or concierge@InSightCruises.com

DAY 7: Nov. 14

ECLIPSE DAY... at Dawn

Option One: On the Beach
We selected this beach for weather and viewing prospects, positioned at a spot which is above the high-tide line for the entire eclipse. We'll have a breakfast buffet going before, during, and after the eclipse, and a comfortable, safe place to store your equipment or recharge your batteries.

Options Two and Three: In The Outback
You can head to the statistically sunniest spot in the Outback, on the dry side of the Great Dividing Range. Once there, choose to:

- observe on the ground in the Outback
- hop into a hot-air balloon in Mareeba

Breakfast and celebration dinner provided.

DAY 8: Nov. 15

Fly Home

CST# 2065380-40

Experience the 2012 Transit of Venus in an Otherworldly Setting. Join *Sky and Telescope's* Editor in Chief Robert Naeye on the Aloha State's astronomy-oriented Big Island for a memorable transit expedition. We'll stay at the four-star Waikoloa Beach Marriott Resort & Spa, home to gracious Hawaiian hospitality, exotic scenery, and classic sunsets. Naeye sets the scene with presentations on transits of Venus and the latest in planetary science. Transit day you'll head up Mauna Kea above the clouds (with excellent prospects for perfect weather) to 9,300 feet, based near the Onizuka Visitor's Center and the viewing sites of Hawaii's astronomy clubs. You can opt to ascend to Mauna Kea's observatory-clustered peak at nearly 14,000 feet, visit the Keck Observatory's giant telescopes, and take in an unforgettable view of the transit's progress. To ice the cake, June 6 we'll visit Keck Observatory headquarters in Waimea and learn about Keck's current endeavors, plus get a privileged behind-the-scenes look at Keck's command-and-control center.

When it's time for transit viewing, go where the pros go — Mauna Kea, with *Sky & Telescope.* Reserve your adventure now by visiting http://InSightCruises.com/Transit or call InSight Cruises at 650-787-5665. Aloha!

DAY 1: June 3

Arrive Kona

Upon your arrival at Kona, you'll grab a taxi to our hotel and conference center, the luxurious Waikoloa Beach Marriott Resort & Spa. This evening there will be a welcome reception (7pm) where you will enjoy cocktails and light hors d'oeuvres.

DAY 2: June 4

Full Day of Classes Waikoloa Beach Marriott

Learn all about Transits of Venus, past and present, from *Sky & Telescope* Editor Robert Naeye. He and other famous astronomy speakers will be delivering several talks over the next couple of days. In addition to the talk described below, other scheduled talks include:

- The Hubble Space Telescope's Greatest Scientific Achievements
- The Asteroid Impact Threat
- Cassini at Saturn, Part 1: The Planet & Rings
- Cassini at Saturn, Part 2: The Moons

DAY 3: June 5

Transit Day — Welcome to the Keck Observatory

Today we climb Mauna Kea to the summit, to the Keck Observatory (pictured above), at nearly 14,000 feet of elevation, to observe the transit. Above the cloud ceiling we're practically guaranteed to have clear skies and a perfect view. For those sensitive to very high altitude, we will also be observing from the Mauna Kea VIS (aka Onizuka Visitor's Center) at 9,300 feet.

The day's itinerary:
- 10:00am: Depart Waikoloa Beach Marriott
- Noon: Arrive VIS, picnic lunch served
- 12:10pm: Venus first touches the Sun
- 1:00pm: Group departs VIS for the Observatory on Mauna Kea
- 4:00pm: Afternoon snack
- 6:45pm: Transit ends, group departs VIS
- 8:15pm: Return to Marriott
- 8:30pm: Celebration reception and dinner

DAY 4: June 6

Keck Headquarters

This morning we take a 30-minute bus drive to the Keck Observatory headquarters in Waimea. We'll hear two lectures by prominent astronomers, "scope out" the Keck telescopes on the Mauna Kea summit (through a telescope in the lobby of the headquarters), and spend some quality time in the unique gift shop.

The day's itinerary:
- 8:30am: Depart Waikoloa Beach Marriott Resort
- 9:00am: Arrive at Keck Observatory HQ for two 90-minute presentations and tour
- 12:30pm: Depart Keck Observatory HQ
- 1:00pm: Arrive at Waikoloa Beach Marriott Resort
- Relaxed afternoon on the Resort property

DAY 5: June 7

Fly Home

Depart from KOA Airport

Optional Tour to the 'Imiloa Astronomy Center

'Imiloa Astronomy Center of Hawai'i is an astronomy and culture education center located in Hilo, Hawaii. It features exhibits and shows dealing with Hawaiian culture and history, astronomy (particularly at the Mauna Kea Observatories), and the overlap between the two. (June 8)

Itinerary for The 'Imiloa Astronomy Center:
- 8:30am: Depart Waikoloa Beach Marriott Resort
- 10:00am: Arrive at 'Imiloa Astronomy Center for a private "insiders" presentation, a planetarium show, and time to roam the exhibits
- 12:30pm: Lunch in Hilo
- 3:00pm: Depart the 'Imiloa Astronomy Center
- 4:30pm: Arrive at Waikoloa Beach Marriott Resort
- Farewell cocktail party

PRICING: Garden/Mountain View: $1,999 pp; Pool View: $2,199; Ocean View: $2,499; please inquire for Suite pricing. All pricing is per-person based on double occupancy. Single supplement: $700 for Garden/Mountain view; $750 for Pool or Ocean View rooms. Single rates are capacity controlled and subject to change or withdrawal (prior to a confirmed booking) at any time. A $600-per-person advance payment along with a completed reservation form confirms your space. For full terms and conditions please visit: http://InSightCruises.com/top_g/st03_top.html#tabs-8 . For more info, contact us at 650-787-5665 or Concierge@InSightCruises.com .

What's included: ▪ Four hotel nights (including all taxes) ▪ Six educational classes ▪ Round-trip transportation to the summit of Mauna Kea ▪ Round-trip transportation to the Keck Observatory headquarters in Waimea ▪ Lunch and snack on Mauna Kea on June 5 ▪ Arrival cocktail party on June 3 ▪ Celebration cocktail reception and dinner at the Marriott on June 5.

Insight Cruises THE JOURNEY WITHIN

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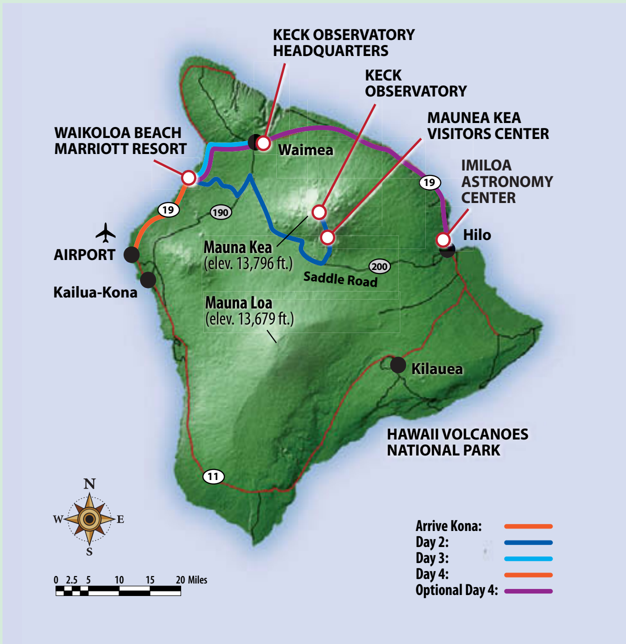

Jerry's Big Astroscan

More than a mere novelty project, this instrument amplifies the virtues of the venerable Edmund telescope.

YOU CAN'T HELP BUT SMILE when looking at the picture below. Readers familiar with the iconic Astroscan telescope introduced by Edmund Scientific in the 1970s might think that the image is one of those clever Photoshop fakes that show up on the internet. But no, the giant Astroscan is as real as its creator, science-fiction writer and avid telescope maker Jerry Oltion.

ALL PHOTOGRAPHS BY THE AUTHOR

Telescope maker and noted science-fiction writer Jerry Oltion poses with his 8-inch Astroscan while holding the 4-inch Edmund Scientific version in his lap. With several refinements not found on the original, Oltion's scope is much more than a scaled-up replica.

Although Jerry's giant Astroscan lacks the compact size and portability of the original 4⅛-inch Edmund scope, it delivers nearly four times the light-gathering power thanks to its 8-inch f/4.2 primary mirror. Most of us would consider that a worthwhile trade-off. And while the scope's resemblance to its predecessor is obvious, it actually owes much of its DNA to Jerry's trackball telescope, featured in this magazine's August 2006 issue, page 100. "When I showed my trackball scope at various star parties, people would look at the spherical base and ask if I'd modeled it after the Astroscan," Jerry recalls. "I hadn't, but those comments planted the idea."

So he ground and figured the 8-inch primary mirror and set to work making the spherical back end of the scope. Retracing some of the same steps he took while building the trackball telescope, Jerry found a supplier of large, acrylic lighting globes and ordered a 20-inch sphere. Unfortunately, it proved to be much too flimsy to work without reinforcement. "The spherical section of my previous trackball scopes was made of fiberglass that I had molded over a child's rubber ball," Jerry recounts. "So it was simple enough to add a reinforcing layer of fiberglass to the acrylic ball — but this time on the inside." This approach meant the ball would have a nice, exterior finish without laborious sanding. As a bonus, it also yielded a rough-textured interior, which helps suppress scattered light when painted black.

To keep the big Astroscan portable, Jerry equipped his scope with a removable upper section. The 11-inch-diameter tube was made from a plastic trash can fitted with a series of reinforcing rings that do double duty as light baffles. The ring at the bottom of the tube has four keyhole slots that engage the heads of bolts mounted on the top of the ball, as shown in the photograph at top left on the facing page. Separating the two parts is easy. "You don't have to unscrew anything to remove the upper tube section," Jerry reports. "Just hold the ball with your knees and give the upper tube a little twist while lifting it upward."

Central to the look of the Edmund Astroscan is the

Left: **To allow access to the primary mirror, Oltion made his Astroscan with a two-piece tube assembly. Keyed slots in the rearmost reinforcement ring of the upper tube mate with the screw heads located on the top of the ball section. By simply rotating one against the other, the two parts are securely joined. *Right*: One of the most novel features of Oltion's scope is its tracking mount, which utilizes the same design found in his trackball scope. The ball of the telescope rides on three rollers, one of which is motor driven.**

integrated rubber-roller focuser — an aftermarket focuser for the bigger version simply wouldn't do. The focuser Jerry built consists of two pieces of 1/8-inch-thick PVC sheet. He heated the parts with a candle and bent one of them into a U shape, and the other into an L. He glued them together and sanded them until the joints were invisible. As Jerry explains, "The focuser was the make-or-break component — it would either make the scope look fabulous, or funky."

While doing everything possible to keep his scope true to the original, Jerry's 8-inch contains several notable upgrades. One of the most important is that the primary mirror can be collimated. This is accomplished by using a special long tool he built to reach down the front of the scope to turn spring-loaded adjustment knobs on the primary mirror's cell.

Oltion's scope is a clever copy of the venerable original, right down to the style of the dust covers.

Another improvement on Jerry's scope is the curved-vane spider for the secondary mirror used in place of the Astroscan's optical window. "I wanted to use an optical window, but I couldn't find anything optically flat enough at a price I could afford," Jerry notes. "So I did the next best thing to give the scope the same spike-free views — I made a curved spider out of steel cargo strap." As an added bonus, this secondary support won't dew up.

So what's it like to use an 8-inch Astroscan? As one would expect, the views are just like those provided by any other fast Newtonian reflector of the same aperture. But it's the big Astroscan's utility that makes it a winner. "It has very smooth motions and I'm happy to say that the ball doesn't get in the way of my knees as I originally thought it might," says Jerry. "It's a fun scope to use — it's such a silly thing, it's hard not to smile while enjoying the views."

Readers wishing to know more about Jerry's scopes can do so by visiting his website: **www.sff.net/people/j.oltion/**. ✦

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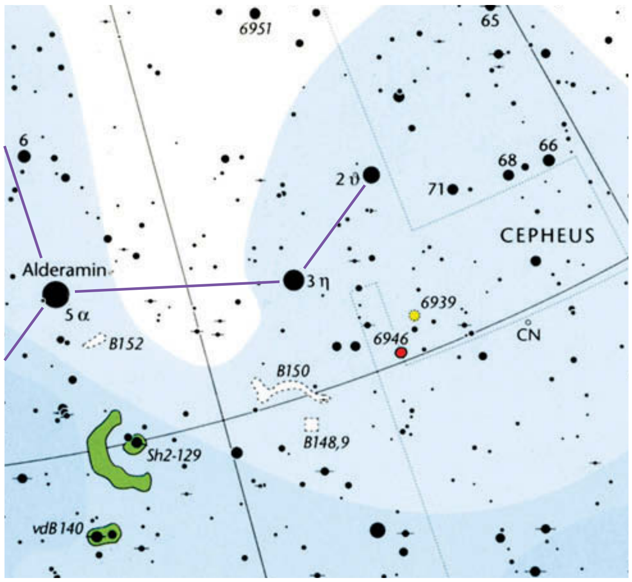
*Contributing editor **Gary Seronik** has built numerous telescopes and can be contacted through his website, www.garyseronik.com.*

DAVIDE BARDINI

In Praise of the Great Dark North

DAVID A. RODGER

If you dismiss your northward view as the sky's dullest quarter, you're missing out.



S&T: SKY ATLAS 2000.0

TRANSPARENCY TEST Despite how they look in photos *(left)*, the star cluster NGC 6939 in Cepheus is easier to see in the eyepiece than the face-on, low-surface-brightness galaxy NGC 6946. Starting from 2nd-magnitude Alpha (α) Cephei, star-hop your way 6° west-southwestward to the cluster using the piece of *Sky Atlas 2000.0* above. Stars are plotted to magnitude 8.5; constellation lines are added. Once you find the cluster, look 0.6° southeast of it to see if you can detect the galaxy. North is up in all images.

From the patio of my urban townhouse I have a marvelous sky panorama almost from east to west. But there's a problem. The panorama is centered on north. I can't see anything between the zenith and the southern horizon, because my townhouse is in the way.

But spare me your sympathy. Making a virtue of necessity, I have come to love the supposedly dull northern sky.

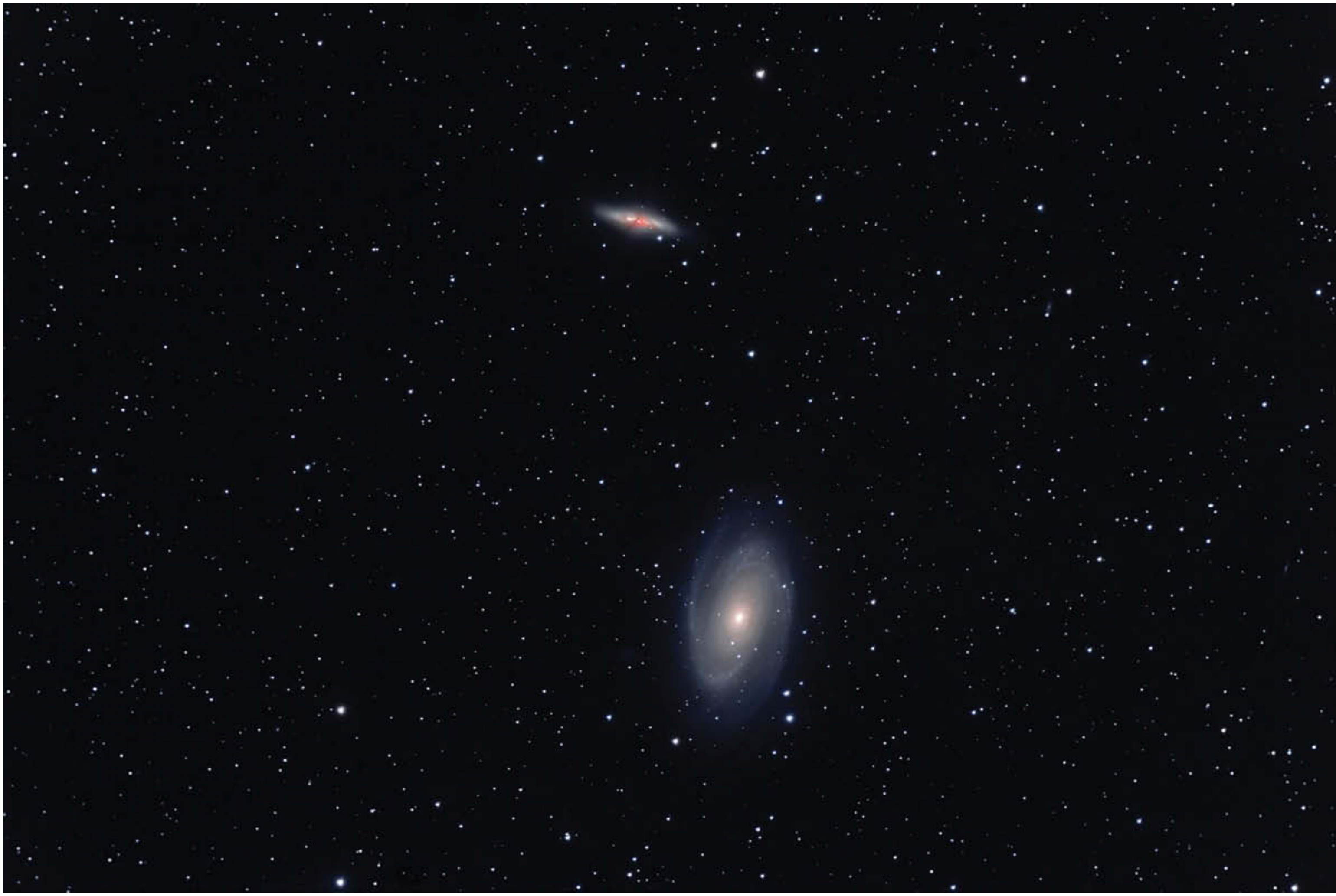
First of all, despite its overall dimness, the north has several easily spotted circumpolar star patterns that are *always there* for easy guidance. The W of Cassiopeia, the Big Dipper of Ursa Major, the upside-down Y of Perseus, and Polaris in the middle make great celestial guideposts, especially in my light-polluted city of North Vancouver, British Columbia.

Granted, other northern constellations are pretty dim to the naked eye. But among them are hundreds of star clusters, double stars, planetary nebulae, and galaxies. Of course there are similar objects in the other three sky quarters. But those aren't accessible every night of the year.

Another bonus: When you aim an undriven telescope east, south, or west, objects cross your field of view quickly due to the Earth's rotation. Objects in the north, on the other hand, remain in your field longer. It's nice not having to nudge the scope every few seconds. Think of the northern sky as taking you partway to a free drive motor.

Of course planets and the Moon are rare visitors to my sky. I haven't seen Jupiter rising or setting from my patio for almost a decade, and I won't see Saturn again until 2026.

And there's another north-related challenge. Many of us use go-to mounts that need to be initialized by aiming at two or three bright alignment stars. The shortage of bright stars in the north means you'll have to choose your own alignment stars rather than let the telescope choose. (And as always, avoid aligning on two stars near the meridian.)


ALAN DYER

ODD COUPLE M81 (bottom) and M82 in Ursa Major are a classic spiral and a starburst-core galaxy. They're 0.6° apart and about 12 million light-years away.

Planning Your Night

So, what's out there in the Great Dark North? More than enough to keep a keen observer busy for many years. The challenge isn't what to see, but what to leave out.

As always, the key to good observing outdoors is good planning beforehand indoors.

When I spread out my charts and guidebooks to plan an observing session — you *do* have detailed charts and guides to spread out, right? — I usually do it with a particular kind of object in mind. Of course, Step 1 is understanding the limits of your telescope and sky conditions. (Remember that bit about making a virtue of necessity.) My Orion EON 120-mm and Tele Vue 127-mm refractors are ideal for bright, wide-field star clusters. Sometimes I go in search of planetary nebulae, especially the most compact ones, whose light is sometimes concentrated enough to penetrate the city sky. On a night when the sky is especially transparent, I'll seek out faint galaxies. Galaxies and planetary nebulae want aperture; they look their best in my 11-inch Celestron Schmidt-Cassegrain.

Another important factor is the season. The Big Dipper is always above my horizon, but it's low for most of the autumn and winter. Galaxies suffer greatly when they're low in the sky, especially in light-polluted environments. So if you're going to observe the Big Dipper galaxies listed here, do it as soon as you receive this issue (and right after dark) or wait until March. The Cygnus-Lacerta-Cepheus Milky Way is high during August and September evenings, and Cassiopeia is high later in the night. Check the all-sky charts in the center of the magazine for what's high up.

Here's a sample of objects that make the northern sky so appealing to me.

Galaxies

M81 and M82 in Ursa Major are the "odd couple" of bright galaxies. They're an especially fine sight in a wide field of view (1° or more) that encompasses both well. M81 is a favorite of sketchers and photographers for its classic spiral shape (in a big scope) and 7th-magnitude central bulge (good in small scopes). M82 is its nemesis, if you like. Just 0.6° to the north, M82 is an elongated ghostly chalk mark with hints of dark dust lanes depending on your telescope and sky.

Ursa Major offers several other notable galaxies, including **M108**, **M101**, **M109**, and **M51** (the Whirlpool), all right around the Big Dipper, and **NGC 2841** in the Great Bear's front leg. Draco's **NGC 5866** is sometimes considered to be the "missing" 102nd entry in the Messier catalog.

For a good test of urban galaxy viewing, try the pair of objects pictured on page 66.

Star Clusters

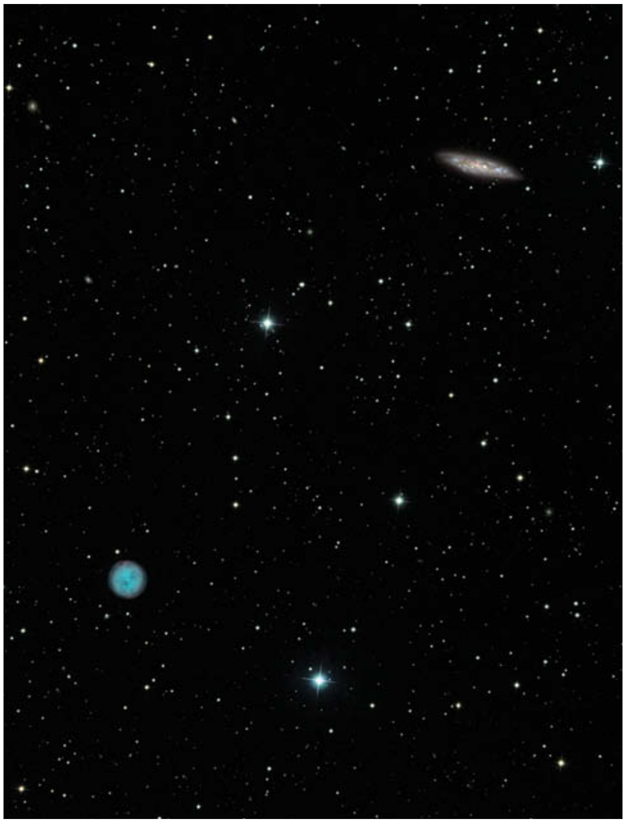
The north circumpolar sky has many clusters, but few prompt such delight as the Double Cluster, **NGC 869 and 884**, in northern Perseus. Binoculars reveal their dual nature, but a small, wide-field telescope excels in showing them off. I judge the sharpness of the night's seeing by the clarity of the "Little Necklace" of faint stars in the center of the western cluster, NGC 869.

Around Cassiopeia's W pattern nearby, check out **NGC 457** (the Owl or ET cluster), **NGC 663** (the lawnmower), **M103** (the A), and dim but rich **NGC 7789** (Caroline Herschel's cluster).

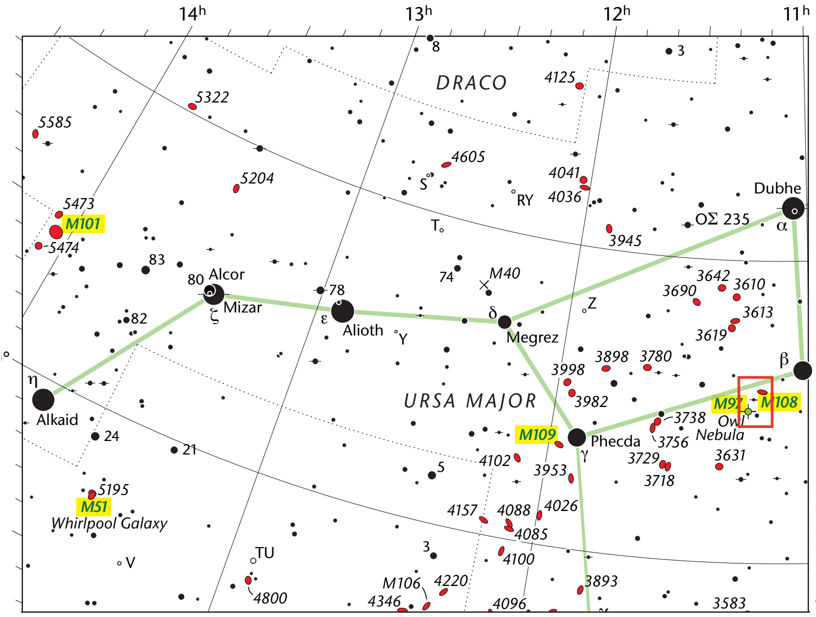
Like NGC 7789, **M52** is very dense and populated by stars of similar faintness. In contrast, NGC 457 and (in Cygnus) **M39** have fewer but brighter stars.

Faint Lacerta more than makes up for its naked-eye obscurity with the cluster-rich Milky Way crossing it. Here lie **NGC 7243** and **NGC 7209**, both distinctive and well-populated. And check out the four-star "cluster" **8 Lacertae**, a little 1′ arc of stars magnitudes 5.6 to 10.

NGC 1502 in Camelopardalis is distinctive due to its



DAVID JURASEVICH



S&T: POCKET SKY ATLAS

DIPPER DECO Near Beta (β) Ursae Majoris in the Big Dipper's bowl is the favorite northern combo at left: the galaxy M108 and the dim, round planetary nebula M97, the Owl Nebula, 0.9° to its southeast. Three 7th- and 8th-magnitude stars in the field help guide the way; two are plotted on the section of *Pocket Sky Atlas* Chart 32 above (in the small red box near the right edge). Highlighted on the chart are the other galaxies mentioned near the Big Dipper. The ticks along the left edge are 1° apart. The *Pocket Sky Atlas* charts have a scale about 40% smaller than those of *Sky Atlas 2000.0* and include stars only to magnitude 7.6.

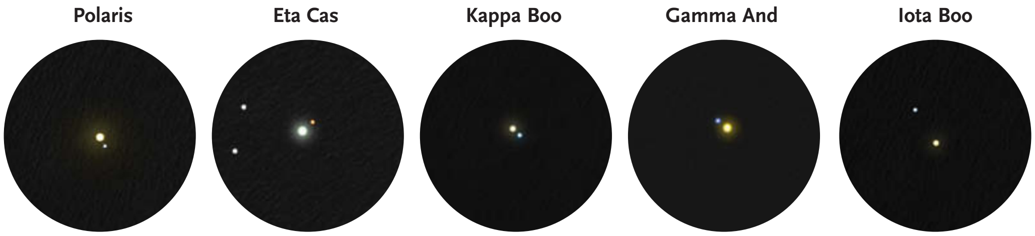
How North Is North?

Exactly what counts as your "northern sky"?

Taking a broad view to include everything you can see looking north *sometime*, that would mean anything that's closer to the celestial pole than either your zenith or your north horizon is. That means anything above a declination equal to either your latitude, or 90° minus your latitude, whichever is less.

A more restrictive version would be just your *circumpolar* sky: the part that's always above your horizon, all night and all year (ignoring local obstructions and atmospheric extinction). That means anything with a declination of 90° minus your latitude.

The farther south you live, the smaller your north circumpolar region is. The farther you live from latitude 45°(either northward or southward), the *larger* the region is that sometimes comes into your northern view.



DOUBLES ON PARADE Jeremy Perez sketches double stars as seen in his 6-inch f/8 reflector, including their subtle apparent colors.

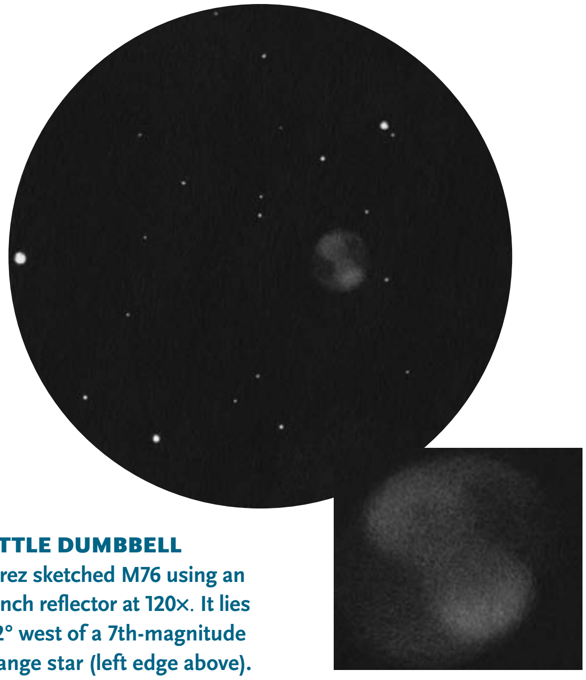
abundance of bright double stars. The collection of pretty pairs suggests to me a group of ballroom dancers standing and waiting for the tempo to change.

Tracing nearby **Kemble's Cascade** with binoculars or a small telescope is a unique treat. This jagged 5° star chain was first noted to the world several decades ago by a countryman of mine, Father Lucian Kemble.

Planetary Nebulae

The Cat's-Eye Nebula, **NGC 6543** in Draco, is famous for its stunning Hubble photos. Even modest instruments show the spherical shape of its small inner part, which has a fairly high surface brightness. Coax out more detail by using high power and an oxygen-III filter.

Other planetary nebulae worth a lookup in the circumpolar sky include **IC 3568** and **NGC 1501** in Camelopardalis, **NGC 40** (the Bow Tie) in Cepheus, and **M76** (the Little Dumbbell) in Perseus. I disagree with many who consider M76 challenging. I can see it, complete with the two lobes that give it its name, with my 120-mm and 127-mm refractors. The O III filter enhances it enormously.



LITTLE DUMBBELL Perez sketched M76 using an 8-inch reflector at 120×. It lies 0.2° west of a 7th-magnitude orange star (left edge above).

Double Stars

The most attractive double stars for me are close pairs that contrast in brightness and/or color. The closer they appear, the more likely they are to be an actual binary pair rather than a chance alignment of a far star behind a near one. Mizar and Alcor in the Big Dipper's handle may or may not qualify, but Mizar itself is certainly a true binary. It can be split into two white stars in any small telescope.

Gamma Andromedae is circumpolar for me, but it may not be for you. Farther north we find **Eta Persei,** one of the most stunning doubles in any direction. Cassiopeia's finest doubles are **Iota**, **Sigma**, and **Eta**. Cepheus boasts **Beta**, **Delta**, and **Xi**. In Boötes, **Kappa** and **Iota Boötis** are far enough north to qualify, and if you use a low-power eyepiece you can see both pairs in a single field of view.

And don't overlook **Polaris**. It's a beautiful brightness-contrast double (magnitudes 2 and 9) with subtle colors.

ROBERT & JANICE FERA

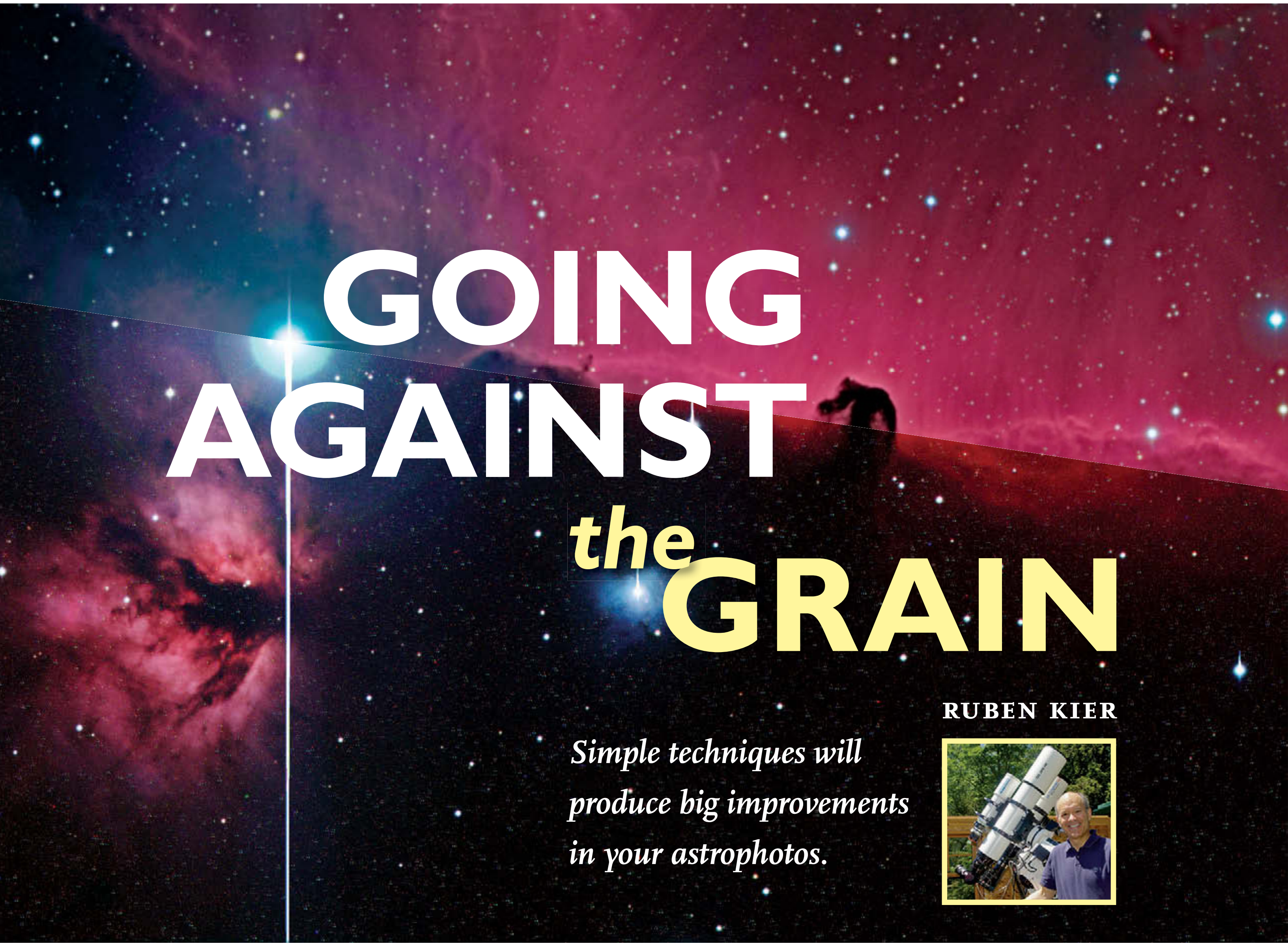
STAR-SPANGLED CAS NGC 457 is one of the many open clusters near the Cassiopeia W. This one seems to blow northwestward from 5th-magnitude Phi (ϕ) Cassiopeiae and its wide, 7th-magnitude companion.

And More

You'll notice I haven't mentioned nebulae or globular clusters. Diffuse nebulae — mostly faint and subtle, though large — tend to be the first casualties of a light-polluted urban sky. As for globular clusters, **M92** and **NGC 6229** in Hercules lie just within my north circumpolar sky. But most globulars swarm in the part of the celestial sphere centered on southerly Sagittarius. You can't have everything. ✦

David A. Rodger, the first Director of Vancouver's H. R. MacMillan Planetarium, has been a serious amateur since the great Mars opposition of 1956. He lives in North Vancouver, British Columbia, at north latitude 49°.

GOING AGAINST *the* GRAIN



RUBEN KIER

Simple techniques will produce big improvements in your astrophotos.

All images by Ruben Kier

DAYTIME PHOTOGRAPHS captured with your digital camera look smooth and rich, with vivid colors. So why do celestial images from the same camera appear riddled with noise? The answer is quite simple: galaxies, nebulae, and star clusters are extremely faint and thus require long exposures to reveal them as the colorful subjects seen gracing the pages of this magazine. But individual long-duration exposures reveal annoying speckles of noise, which detract from the image. Fortunately, amateur astronomers have several techniques to suppress image noise.

To beat the noise, we have to understand what it is. Much of what is commonly called noise is actually signal. If we examine a single CCD exposure, we find that most

The bane of deep-sky astrophotography is a grainy appearance in the final image. Author Ruben Kier explains some easy techniques that will greatly reduce the unwanted speckles in your images and allow you to concentrate on producing breathtaking astrophotos. This image of the Horsehead Nebula shows the difference between a single set of hydrogen-alpha (H*α*), red, green, and blue images *(below)*, and the results of combining many exposures through each filter *(top)*.

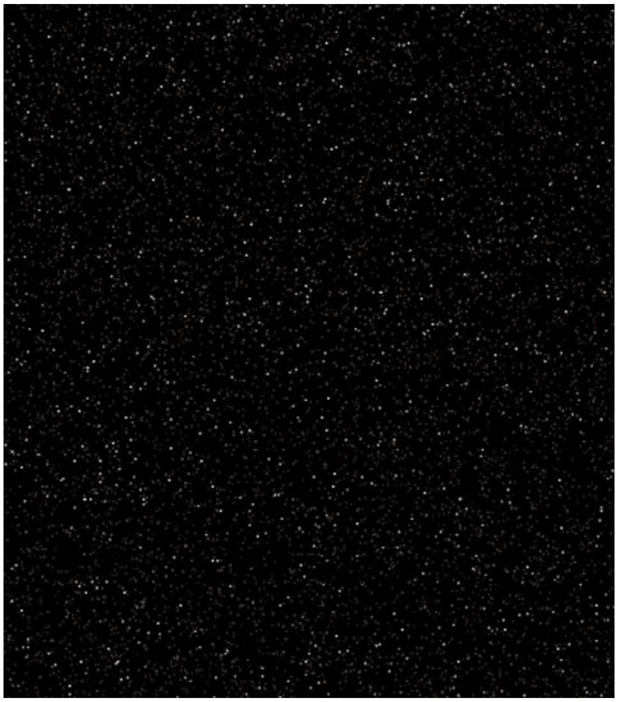
See more of Ruben Kier's stunning astrophotography at SkyandTelescope.com/ReduceNoise.

speckles are associated with dark current (a type of signal generated by thermal electrons in the CCD chip), which increases linearly with the exposure length. Strictly speaking, noise is a small, random component of this signal that prevents us from precisely measuring the amount of signal recorded. A nighttime exposure that lasts many minutes may contain a thousand times the dark current of a daytime snapshot. Additionally, the visibility of this noise also depends on the ratio of the signal to the noise. Daytime photos have much more signal than astronomical images, and thus they have a very good signal-to-noise ratio. Furthermore, because deep-sky objects are so faint, we have to stretch the image to see the object, which also makes noise more apparent.

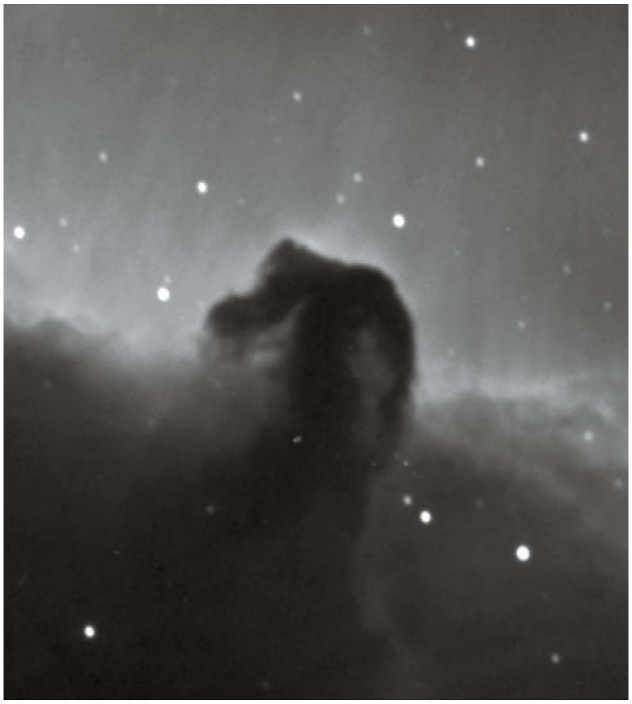
More Light!

Images are created by photons hitting your camera's CCD or CMOS chip. The signal of incoming light increases linearly with longer exposures because you are collecting more photons. Randomness in the flux of incoming photons, called "shot noise," increases by the square root of the number of photons. So the signal-to-noise ratio in your image, which is a primary factor in the apparent smoothness of your image, roughly doubles when you increase exposure time from one minute to four minutes. Although you can gain a similar improvement by summing four exposures of one minute, this also adds four

This single, uncalibrated 5-minute exposure recorded with an SBIG ST-10XME CCD camera cooled to –30° Celsius displays the common salt-and-pepper look of thermal noise (dark current), cosmic-ray artifacts, and other unwanted signal.



Recording dark frames and subtracting them using astronomical image-processing software will reduce much of the unwanted dark current and hot pixels from individual exposures. Subtracting the dark frame at left from the image at the top of this page produced the result shown at right. But the image still displays a grainy appearance due to the residual shot noise not removed by image calibration, as well as a cosmic-ray artifact — the faint, short streak to the upper left of the Horsehead.



Left: **Averaging many calibrated long-duration exposures reduces the visibility of shot noise and cosmic-ray artifacts. The author produced this smooth result by combining 15 individual 5-minute Hα exposures that were dithered, or offset, between each exposure.** *Right:* **Combining all of these simple techniques produces smooth data that he can aggressively process to reveal subtle details. This view of the Horsehead Nebula was assembled from 75 minutes of Hα, 70 minutes of red, 40 minutes of green, and 25 minutes of blue-filtered exposures using an ST10XME camera and an Astro-Physics 130EDFGT refractor operating at f/4.5.**

times as much "read noise," which is introduced by the camera's electronics each time an image is read out from the detector. In practice, limitations on the length of each exposure are dictated by the accuracy of your mount's tracking, the background skyglow, the brightness of the object, and your patience!

To eliminate cosmic-ray artifacts and trails from airplanes and satellites, astrophotographers combine three or more exposures, and this integration time adds up quickly, especially if you are shooting color images through multiple filters. But the payoff is that the more signal you can acquire, the better your results will be. I usually obtain a series of 5-minute exposures with my CCD camera, unless the subject is particularly bright, such as M45 or the Orion Nebula. From a dark-sky site with an anti-blooming camera, I often shoot 10-minute exposures because I'm not limited by light pollution.

Cooling and Calibration

Many CCD cameras use electronic cooling, water pumps, and small fans that reduce the temperature of the detector. Depending on the chip in your camera, thermal noise is cut by half or more with every drop of about 6° Celsius. If you can cool your camera by 20°C, you can eliminate more than 90% of your dark current. As the camera is cooled more, the reduction in dark current is less, so you'll have diminishing returns on the benefits.

A basic method for reducing dark current in CCD images is to subtract dark frames. A dark frame is simply an exposure with the same time and temperature as your light frame, but with the shutter closed or with the dew cap on your telescope. The dark frame will record primarily the CCD's dark current, and subtracting it from your light exposure will greatly reduce so-called hot pixels in your image.

Just like light frames, each dark frame will have some shot noise. To reduce this you can average at least three dark frames and subtract the result from your light images. Combining five dark frames or more allows you to use more efficient combining methods such as standard-deviation masking to eliminate outlying data (such as cosmic-ray artifacts) on each individual dark frame. I usually try to obtain and combine 10 dark frames to generate an excellent "master" dark frame, but I'm satisfied with the result of five dark frames if time is limited. Also, a camera will vary slightly over time, so I replace my master dark frames every month after each new Moon cycle.

Another calibration frame used to help generate quality images is known as a flat field (March issue, page 72), used to correct for pixel-to-pixel variations in sensitivity, which typically can be as much as 1% on CCD detectors. Although 1% seems small, it will cause images of diffuse nebulosity to show mottling in otherwise smooth regions after stretching the data. Flat-field calibration also corrects for vignetting in your optical system and dust on your detector and filters, which causes shadows in your images.

Dithering Exposures

Obtaining many long-duration exposures boosts the overall signal-to-noise ratio in your images and helps to suppress noise. But another technique, known as dithering, can additionally improve the appearance of your combined shots. Dithering is a technique that moves the telescope just enough to shift the image in a random pattern a few pixels between each exposure. Many camera-control software programs include this option.

If you dither, you can further reduce the impact of thermal noise, read noise, and treacherous hot pixels that typically corrupt about 0.2% of the pixels on a CCD. If you are shooting unguided with a less-than-perfect polar alignment, an inadequate mount, or have some flexure between your guide scope and imaging scope, you are effectively dithering your exposures, but often in only one direction, which can lead to faint stripes in your combined image. These stripes occur when tiny variances left over after calibration become reinforced as the individual frames are registered with an offset in a consistent direction. Random dithering allows data-combining algorithms such as standard deviation or sigma reject, which suppresses the visibility of these variances.

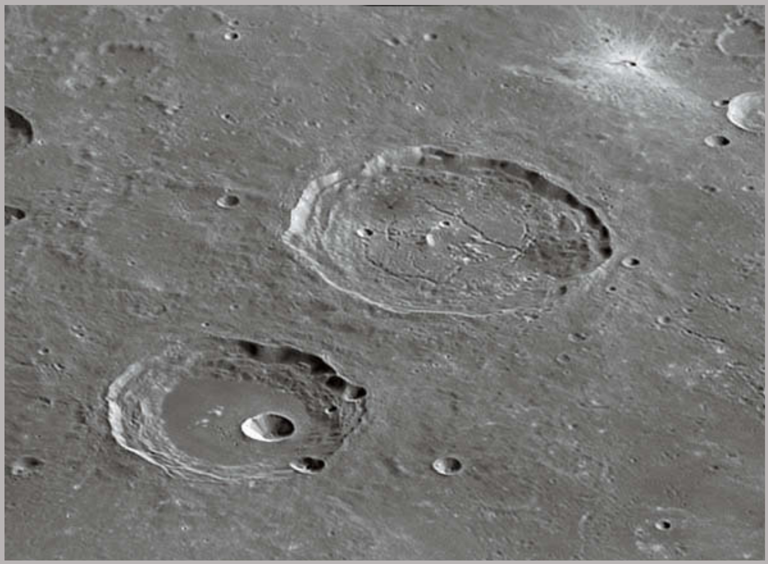
Finally, noise-reduction software is available that can additionally smooth your results. But it's best to produce the best data you possibly can before resorting to these software solutions. Noise-reduction is best used with restraint at the very end of your image-processing workflow, to avoid obliterating subtle details in your image.

Putting It All Together

Using these techniques will allow you to create noise-free data that you can enhance much more than single exposures. Efficiently cooling your camera, obtaining at least three images with each filter, and dithering between exposures can reduce much of the unwanted noise in your results. Additionally, good dark- and flat-field calibration also helps peel the veil of noise off of your data, allowing you to concentrate more on bringing out the fine details in your images. You will be amazed how smooth and rich your photographs appear. ✦

Ruben Kier *is the author of* The 100 Best Astrophotography Targets: A Monthly Guide for CCD Imaging with Amateur Telescopes.

This richly detailed image of M33, the Pinwheel Galaxy in Triangulum, begins to resolve individual stars that otherwise would be indistinguishable in a grainy photograph.



▶ **GREEK HEAVYWEIGHTS**
Damian Peach
Both Hercules (lower left) and Atlas (top right) are lava-flooded craters, but large fractures that riddle the floor of Atlas are telltale signs of later volcanic modification.
Details: *Celestron C14 Schmidt-Cassegrain telescope with Point Grey Research Flea3 video camera. Stack of hundreds of individual video frames.*

▼ **ETA CARINAE AND THE KEYHOLE**
Wolfgang Promper
The orangish bipolar nebula surrounding Eta Carinae at left contrasts with the faint clouds of the Keyhole Nebula.
Details: *16-inch f/8 Hypergraph with FLI MicroLine ML8300 CCD camera. Total exposure was 4 hours through color filters.*

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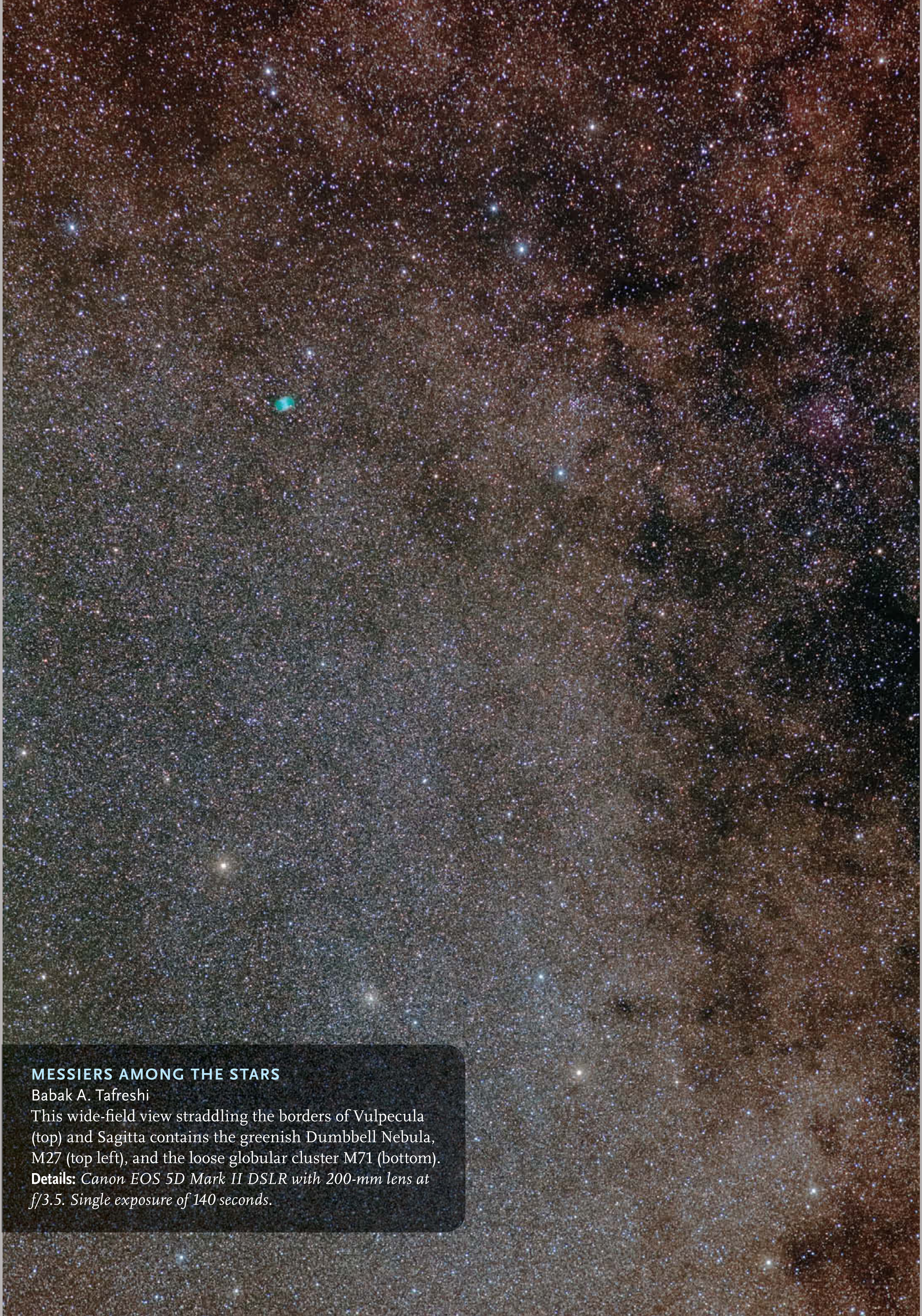

MESSIERS AMONG THE STARS
Babak A. Tafreshi
This wide-field view straddling the borders of Vulpecula (top) and Sagitta contains the greenish Dumbbell Nebula, M27 (top left), and the loose globular cluster M71 (bottom).
Details: *Canon EOS 5D Mark II DSLR with 200-mm lens at f/3.5. Single exposure of 140 seconds.*

◀ **DEEP WITHIN SHADOW**

Tunç Tezel

The June 15th lunar eclipse featured deep hues of orange at mid-totality. The Moon passed through the center of Earth's shadow, allowing cameras to record faint stars in Sagittarius close to the Moon's limb with relatively short exposures.

Details: *8-inch Meade LX10 Schmidt-Cassegrain telescope with Canon EOS 5D DSLR camera. Total exposure was 20 seconds at ISO 3200.*

▼ **ENDEAVOUR'S FINAL LAUNCH**

Chris Hetlage

NASA's Space Shuttle *Endeavour* blasts off under low clouds last May 16th, on its final journey to the International Space Station. ✦

Details: *Canon EOS 40D DSLR camera with 20-mm lens. Single 1⁄1,000-second exposure at f/8.*

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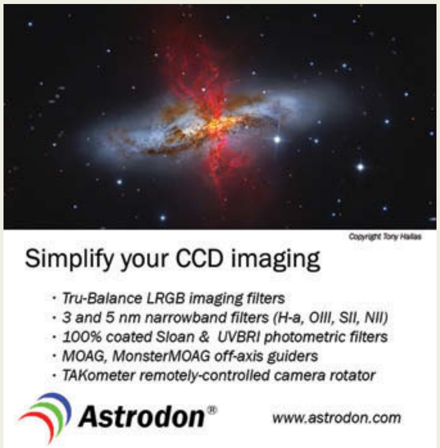

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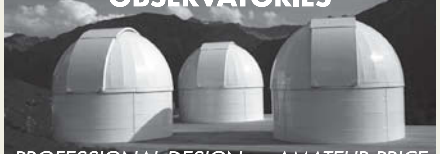

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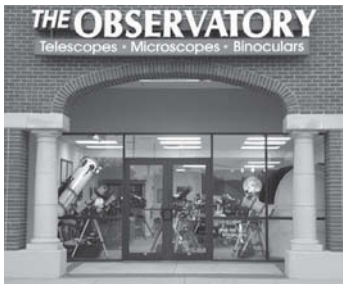

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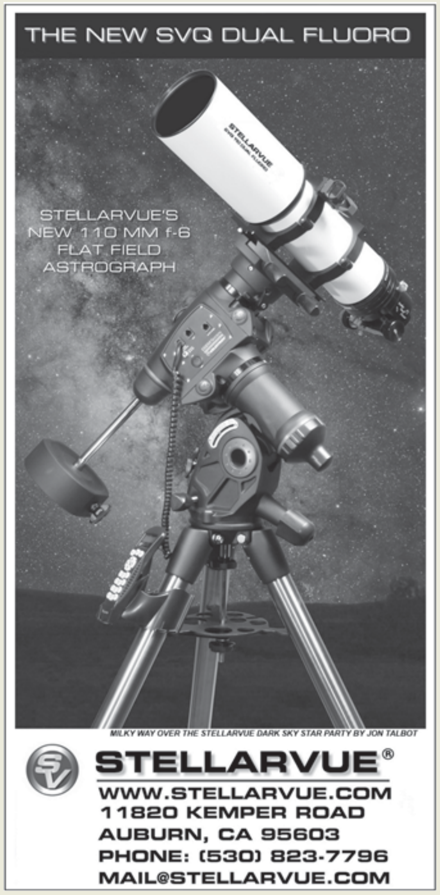

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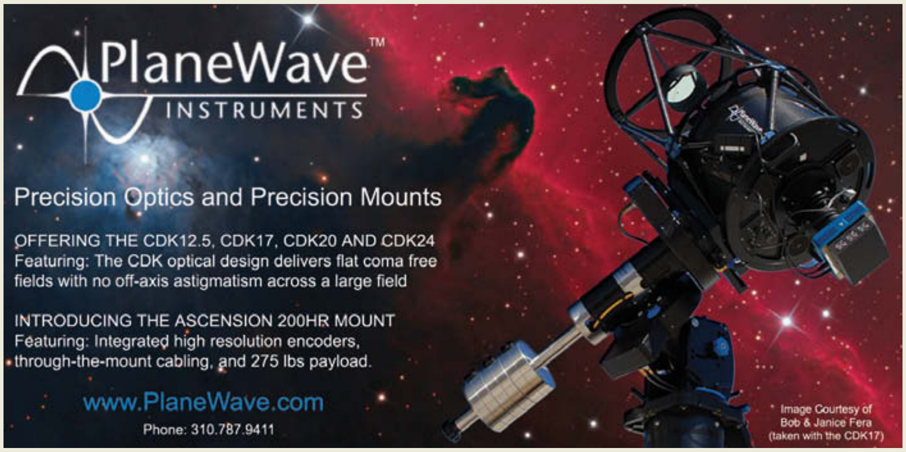

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Light Pollution's Medical Effects

Excessive light is a problem for everyone, not just amateur astronomers.

S&T READERS ARE WELL aware of the many problems associated with light pollution, such as energy waste, sky glow, and environmental impact. But not many people know about the burgeoning growth of research that demonstrates direct human-health issues related to excess light. In fact, health effects might ultimately be the most important reason to control light pollution. The energy wasted by excessive lighting is produced mainly by burning fossil fuels, leading directly to air pollution that causes higher asthma rates and increased respiratory problems for people with lung disease and other medical issues.

Glare is the most common health safety problem resulting from poorly designed outdoor lighting. You have probably noticed poor vision stemming from glare on a dirty windshield. Over time, calcifications build up in the lenses of our eyes, which eventually develop into a cataract. These calcifications and other lens and eye imperfections scatter light in a similar fashion to a dirty windshield. This effect grows more severe with age, and it's the primary reason why elderly people have a difficult time driving at night near poorly designed streetlights. Most people with this problem are not even aware that glare is the main cause of their poor night vision, and that they could drive more safely if streetlights were properly designed. Recognizing this fact, the American Medical Association (AMA) adopted a resolution in 2009 urging full shielding for all public street lighting.

A hot new area of research is how night light disrupts our circadian rhythm. Numerous papers over the past 15 years have led medical researchers to conclude that night light increases the incidence of certain cancers, most notably breast cancer. In fact, researchers now estimate that up to 30% of breast cancers may be due to light at night suppressing circadian rhythm. The research basis for this conclusion has become so compelling that the World Health Organization recently declared circadian-rhythm disruption to be a class 2A carcinogen — placing it on the same level of severity as the effects of tobacco smoke on lung cancer.

The biochemical mechanism for this problem has been thoroughly researched and is thought to result from the suppression of melatonin production by the pineal gland in the center of our brain. This gland produces melatonin while we sleep. Repeated exposure to light at night markedly suppresses melatonin production. Previous research has shown that this hormone helps the immune system suppress the development of several types of cancers.

As an elected member of the AMA's Council of Science and Public Health, I have asked the world's five foremost researchers on this subject to help me draft a review paper to summarize these important studies. This report should be available to the public within a year, and I hope it will help governments adopt sensible and rational lighting policies. ✦

***Mario Motta, M.D.**, is a cardiologist at the North Shore Medical Center in Salem, Massachusetts, and a recent president of the Massachusetts Medical Society. A devoted amateur astronomer, he authored the article about building his dream observatory in the May 2011 issue (page 32). To watch a video of Dr. Motta discusing light pollution, visit SkyandTelescope.com/Motta.*

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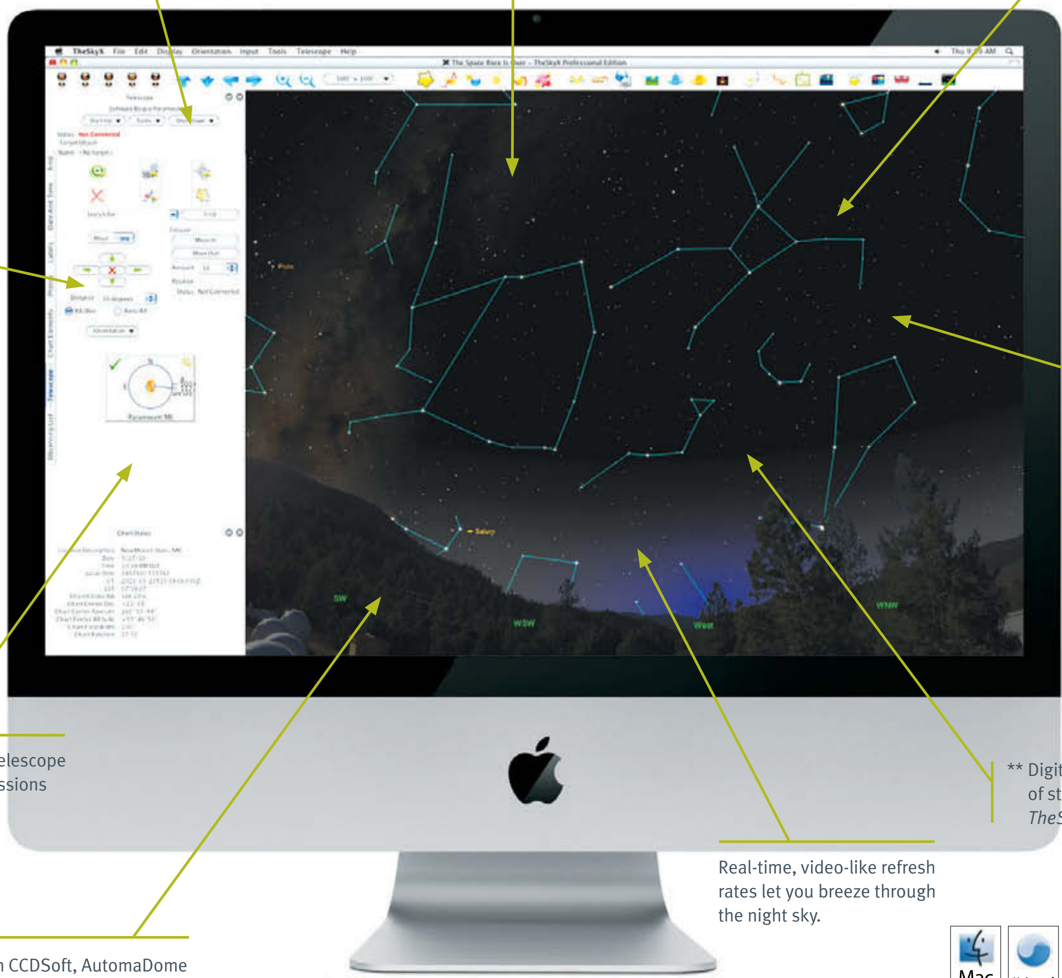

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