35 HOT PRODUCTS: 2014's COOLEST NEW GEAR p. 62

COMET ISON'S FINAL ACT p. 36

THE ESSENTIAL GUIDE TO ASTRONOMY

SKY & TELESCOPE

JANUARY 2014

Glorious Winter Star Clusters p. 38

Giant Ice Cube Observatory p. 18

FREE 2014 Sky Events POSTER

Jupiter Shines in Prime Time

Amateurs Witness Jupiter's Upheavals p. 30

Tuning in to Radio Jupiters p. 24

See Details on Jupiter's Moons p. 54

See Venus's Spectacular Crescent p. 48


NEW FROM
SBIG
THE STT and STXL SERIES CAMERAS
Ethernet and USB 2.0
Built-in Web Server
Variable Speed Fans
Built-in RBI Pre-flash
12VDC Operation
Full Frame Image Buffer
Liquid Cooling Ready
Low Noise 10MHz Readout
2-Stage Cooling -55C to -60C with Air
Adaptive Optics Option
Remote Guide Head Option
16-bit Full Frame Download < 1 sec
Multi-Coated Sapphire Window
Even-Illumination (Photometric) Shutter
Self-Guiding CCD in Front of Filters
User Rechargeable Desiccant Plug
User Selectable Internal Image Processing
Full Featured 64-bit Software Included
No compromises. The STT and STXL Series cameras represent the culmination of over 20 years of experience in astronomical imaging.
The new STT and STXL Series cameras each come with a new filter wheel design that places the self-guiding CCD in front of the filters. In addition, the new filter wheels use a precise positioning mechanism that re-positions each filter over the imaging CCD to better than 5 micron accuracy no matter how many times the carousel is moved, yielding superior flat field frames. Models available with 1603ME, 3200ME, 8300M, 6303E and 11002M CCDs.
SBIG ASTRONOMICAL INSTRUMENTS
Santa Barbara Instrument Group, a Division of Aplegen, Inc., 150 Castilian Drive, Santa Barbara, CA 93117
Tel: (805) 571-7244 Fax: (805) 571-1147 Home page: http://www.sbig.com E-mail: sbig@sbig.com

SKY & TELESCOPE

January 2014 VOL. 127, NO. 1

On the cover: Cassini took the images for this true-color mosaic when it passed Jupiter in December 2000.
NASA / JPL / SSI

OBSERVING JANUARY

FEATURES

ALSO IN THIS ISSUE

There's more to find online @
SkyandTelescope.com

WEEKLY NEWSLETTER
Have the latest astronomy news delivered to your inbox.
SkyandTelescope.com/newsletters


NASA / JPL / SPACE SCIENCE INSTITUTE

SKY ON THE GO
Find information about all our skygazing apps, from *SkyWeek* to *JupiterMoons*.
SkyandTelescope.com/SkyApps

FIND PRODUCTS & SERVICES
Our easy-to-use directory will help you find what you need.
SkyandTelescope.com/directory

TIPS FOR BEGINNERS
New to astronomy? Here's everything you need to jump into the fun.
SkyandTelescope.com/letsgo

Find us on Facebook & Twitter

SKY & TELESCOPE (ISSN 0037-6604) is published monthly by Sky & Telescope Media, LLC, 90 Sherman St., Cambridge, MA 02140-3264, USA. Phone: 800-253-0245 (customer service/subscriptions), 888-253-0230 (product orders), 617-864-7360 (all other calls). Fax: 617-864-6117. Website: SkyandTelescope.com. © 2014 Sky & Telescope Media, LLC. All rights reserved. Periodicals postage paid at Boston, Massachusetts, and at additional mailing offices. Canada Post Publications Mail sales agreement #40029823. Canadian return address: 2744 Edna St., Windsor, ON, Canada N8Y 1V2. Canadian GST Reg. #R128921855. POSTMASTER: Send address changes to *Sky & Telescope*, PO Box 420235, Palm Coast, FL 32142-0235. Printed in the USA.

January 2014 Digital Extra

BONUS WEB CONTENT

- **Jupiter Watchers**
  Join these organizations to report the next storm or meteor smash on Jupiter.
- **Radio Jupiter**
  NASA's Radio Jove project gives you the tools to see Jupiter in a different light.
- **Science from the South Pole**
  Learn how scientists built IceCube and other Antarctic observatories.

Photo Gallery

Image by Alson Wong

PBS PROGRAM SKY WEEK

EXPLORE OUR WEBSITE

- **Observing the Planets**
  Read the essential guides to observing our neighbors in the solar system.
- **Product Videos**
  Senior editor Dennis di Cicco brings the latest products to life.
- **Join the Fight Against Light Pollution**
  Use our resources to keep your night skies dark.

JANUARY PODCAST AUDIO SKY TOUR

OBSERVING HIGHLIGHTS

Sign up for Newsletters, AstroAlerts, and Observing Tools

THIS WEEK'S Sky at a Glance

DOWNLOAD OUR PLANET GUIDE APPS

Shop @ Sky

DIGITAL BACK ISSUES:

October, November, and December

Find us on Facebook & Twitter

ONLINE PHOTO GALLERY

Carmelo Zannelli captured this shot of Jupiter in January 2013. See more beautiful shots at our online photo gallery, and submit your own!

Imaging Conference

I MUST CONFESS that I consider myself an eyeball-to-eyepiece astronomer, and have dabbled only in the most cursory way in astrophotography. I've taken a few decent shots of eclipses and transits, and shots of the Moon over trees and buildings. But that's about it (for now, at least). So it was with mild trepidation that I accepted an invitation to speak at October's 10th Advanced Imaging Conference (AIC), held in Santa Clara, California.

I need not have worried, even though parts of some of the most technical talks whizzed over my head. I continue to be amazed by the incredible shots being produced by amateurs, and I learned a lot about the techniques needed to create them. I also got a sneak preview of new technologies that are just starting to enter the amateur domain. In my talk, I reaffirmed that *S&T* remains committed to providing broad coverage of the field, with articles aimed at beginner, intermediate, and advanced imagers, and that we will continue to cover deep-sky, planetary, nightscape, lunar, solar, and other types of astrophotography. And we will continue to publish a wide variety of authors, who bring different perspectives to this burgeoning hobby.

Robert Nemiroff (left) and Jerry Bonnell (center), who run Astronomy Picture of the Day, accept the AIC's Hubble Award from Ken Crawford.

RAY GRALAK / AIC

Conference organizers Ken Crawford and Jay GaBany announced that AIC will skip 2014, but it will come back bigger and better than ever in 2015, with more emphasis on different types of astrophotography besides deep-sky.

Before closing, I am mourning the mid-October passing of my friend Peter Smitka, who founded Mag1 Instruments and built my trusty 12½-inch Portaball reflector. Along with my Tele Vue 102, this is the scope that I have used most frequently over the past 15 years. I have fond memories of conversing with Peter during the period I lived in Wisconsin in the late 1990s. Peter was committed to building a quality product that could be customized for the observer, a telescope that was easy and fun to use, and one that delivered razor-sharp views with its Zambuto-made primary mirror. Peter will be in my thoughts every time I whip out my Portaball.

On a much happier note, MIT astrophysicist Sara Seager, author of both the August 2013 *S&T* cover story on exoplanets and two articles in our *Astronomy's 60 Greatest Mysteries* special issue, is a 2013 recipient of a MacArthur Foundation "Genius Grant" for her cutting-edge research on worlds beyond our solar system. See **skypub.com/seager** for more information. Congratulations Sara! ✦

Robert Naeye
Editor in Chief

SKY & TELESCOPE

Founded in 1941 by Charles A. Federer, Jr. and Helen Spence Federer

The Essential Guide to Astronomy

EDITORIAL
Editor in Chief **Robert Naeye**
Senior Editors **Dennis di Cicco, Alan M. MacRobert**
Associate Editor **Tony Flanders**
Imaging Editor **Sean Walker**
Assistant Editor **Camille M. Carlisle**
Web Editor **Monica Young**

Editor Emeritus **Richard Tresch Fienberg**
Senior Contributing Editors **J. Kelly Beatty, Roger W. Sinnott**

Contributing Editors **Jim Bell, Trudy Bell, John E. Bortle, Greg Bryant, Paul Deans, Thomas A. Dobbins, David W. Dunham, Alan Dyer, Tom Field, Ted Forte, Sue French, Steve Gottlieb, David Grinspoon, Paul J. Heafner, Ken Hewitt-White, Johnny Horne, E. C. Krupp, Emily Lakdawalla, David H. Levy, Jonathan McDowell, Rod Mollise, Donald W. Olson, Fred Schaaf, Govert Schilling, Gary Seronik, William Sheehan, Mike Simmons, Alan Whitman, Charles A. Wood, Robert Zimmerman**

Contributing Photographers **P. K. Chen, Akira Fujii, Robert Gendler, Babak Tafreshi**

ART & DESIGN
Design Director **Patricia Gillis-Coppola**
Illustration Director **Gregg Dinderman**
Illustrator **Leah Tiscione**

PUBLISHING
SVP / General Manager **Tina Battock**
Advertising Sales Director **Peter D. Hardy, Jr.**
Advertising Services Manager **Lester J. Stockman**
VP, Production & Technology **Barbara Schmitz**
Production Manager **Michael J. Rueckwald**
IT Manager **Denise Donnarumma**

VP / Circulation **Nicole McGuire**
Circulation Director **Deb Westmaas**
Assistant Marketing Manager **Adriana Maldonado**
Consumer Marketing **Nekeya Dancy, Hannah di Cicco, Bryan Griffith, Joseph Izzo, T. J. Montilli**

NEW TRACK MEDIA LLC
Chief Executive Officer **Stephen J. Kent**
Executive Vice President / CFO **Mark F. Arnett**
Office Administrator **Laura Riggs**

Editorial Correspondence: *Sky & Telescope,* 90 Sherman St., Cambridge, MA 02140-3264, USA. Phone: 617-864-7360. Fax: 617-864-6117. E-mail: editors@SkyandTelescope.com. Website: SkyandTelescope.com. Unsolicited proposals, manuscripts, photographs, and electronic images are welcome, but a stamped, self-addressed envelope must be provided to guarantee their return; see our guidelines for contributors at SkyandTelescope.com.

Advertising Information: Peter D. Hardy, Jr., 617-864-7360, ext. 2133. Fax: 617-864-6117. E-mail: peterh@SkyandTelescope.com Web: SkyandTelescope.com/advertising

Customer Service: Magazine customer service and change-of-address notices: skyandtelescope@emailcustomerservice.com
Phone toll free U.S. and Canada: 800-253-0245.
Outside the U.S. and Canada: 386-597-4387.
Product customer service: skyprodservice@SkyandTelescope.com
Phone toll free: 888-253-0230.

Subscription Rates: U.S. and possessions: $42.95 per year (12 issues); Canada: $49.95 (including GST); all other countries: $61.95, by expedited delivery. All prices are in U.S. dollars.

Newsstand and Retail Distribution: Curtis Circulation Co., 730 River Rd., New Milford, NJ 07646-3048, USA. Phone: 201-634-7400.

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.

Go Social: it's a Good Thing

I was excited to see David Dickinson's article "The New Social Face of Astronomy" (August issue, page 36) because I know from my own experience how on-point and pertinent the article is. The next big thing in astronomy is not gear or an astronomical occurrence. It's the community learning to use social media to further our astronomical endeavors.

When a longtime friend and solar observer moved to Arizona, we stayed in touch by starting a Facebook group named SOLARACTIVITY. We uploaded our images and talked about processing, camera specifications, and the merits of solar gear; we posted reference articles and files, too. Before long, our friends were joining and inviting their friends. Then a prominent imager joined and began posting world-class images. Other imagers followed. With them onboard, the group grew faster, and now two years later we have more than 1,200 members from around the globe. That is the connective power Dickinson spoke of and his vision in actual practice.

I do see the pitfalls of social networking, but with a little caution anybody can join a group and gain hitherto inaccessible virtual benefits. Social networking is a positive move for amateurs.

John W. O'Neal, II
Via e-mail
www.facebook.com/groups/solaractivity

Of Times and Tenses

We read with interest Robert Zimmerman's sidebar (June issue, page 23), "A Galactic Snack," describing the emission astronomers hope to observe as the gas cloud G2 is ripped apart by the Milky Way's supermassive black hole. Upon reflection, we realized that although these events are upcoming from our viewpoint on Earth (approximately 26,000 light-years away), in reality they happened 26,000 years ago, before the dawn of human civilization. This reflection naturally led to the question of whether a past event is rightly described in present and future tenses, as it is in Zimmerman's article. We wanted to suggest the use of a conglomerated "imperfect simple-present future tense" ("The cloud was falling-falls-will fall" in current usage), but if G2's disruption will be (has been?) followed by a powerful jet, then perhaps "imperfect present-perfect future" tense ("the cloud was falling-has fallen-will fall") might be more appropriate. Alas, we couldn't find any such tenses in grammar texts, so we eagerly anticipate your advice on how best to describe this complicated conundrum.

Leo Towle and Haroon Papa
Chicago, Illinois

Editor's Note: *We fear at this historical juncture it is too much to ask of grammarians to modify the English language to include light-travel time. But even were they amenable, we still would favor describing astronomical events according to Earth's perspective, because astronomy for us is rooted in observers. A novel verb tense for cosmic double-think is alluring, but we would still need the present and future tenses to tell people when to look or to expect results. Perhaps someday we'll have wormholes with which to evade the problem. For now, we'll have to settle for bending our minds, not grammar.*

Defining "Planet": Reprise

I must admit that David Grinspoon did a very good job of beating a dead horse (August issue, page 14). I do agree that exoplanets are a kind of planet, and that the IAU should at some point update its definition of planet to encompass them. However, I have little sympathy for revisiting the issue of Pluto. By the time it was reclassified as a "dwarf planet" in 2006, I had come to consider Pluto as the incredible shrinking planet. When it was discovered in 1930, initial calculations indicated that Pluto's mass was as large as Earth's!

By the time I was an 8-year-old kid in the mid-1960s making clay models of the planets, the estimate of Pluto's size had dropped to being just half of Earth's. Over time and with better observations, the size and mass estimates continued to shrink, until astronomers determined Pluto was smaller than the Moon. Had its true size and mass been known back in 1930, Pluto would never have been considered a planet.

As for Grinspoon's suggestion that dwarf planets be considered a type of planet, I see little need for that. The IAU definition works well in the solar system, and we need to see how it does in other contexts. The IAU has had two opportunities to "fix" its 2006 definition and has passed on it both times. It is time to move on and leave the issue of Pluto alone.

Edward Schaefer
Falls Church, Virginia

About the only thing I agree with in Grinspoon's column is his opening statement: "It's mid-2013 and I can't believe I'm still writing about this." I also can't believe he is still writing about this. While the current definition of a planet might not be perfect, it is not "embarrassingly wrong." And despite his assertion that kids will ask why all the Pluto-size Kuiper Belt objects can't be planets, the hundreds of college students I teach each year have no problem with the new definition once it is explained properly. Rather, they wonder why others are upset about it.

I do grant that we could use the terms "terrestrial," "Jovian," or "dwarf" as descriptive subcategories of the overarching word "planet," with a dwarf still defined as one that hasn't cleared its neighborhood (as in the current IAU definition of "dwarf planet"). But I urge Grinspoon and readers to consider the dynamics-based definition by astrophysicist Steven Soter (American Museum of Natural History) that appeared in the December 2006 *Astronomical Journal*. (Read the paper at **http://bit.ly/17xyxtO**.) According to that definition, the oft-criticized requirement that a body clear its neighborhood makes perfect sense: if you calculate the ratio of a body's mass to that of all the other matter it can influence in its orbital zone, the ratio is greater than 5,000 for the eight major planets but is less than 1 for Pluto, Eris, and Ceres. That's a clear distinction.

Joe DalSanto
Glen Ellyn, Illinois

There are different definitions of "twilight" — astronomical twilight, nautical twilight, and civil twilight — that meet the needs of different communities. Definitions of "planet" could function the same way. The definition I would propose is similar to Grinspoon's: *An object massive enough to achieve hydrostatic equilibrium but not massive enough to initiate deuterium fusion and which is not a moon.* People can add adjectives such as dwarf, terrestrial, subgiant, and so on as they see fit. Nothing will eliminate all gray areas, but with pragmatic usage (such as Grinspoon's "once a planet, always a planet") and allowing for a little flexibility (such as adopting system names for near-equal binaries), we could avoid trouble.

Gerald D. Nordley
Sunnyvale, California

Stars Above and Below

I thoroughly enjoyed John Dvorak's story "The Women Who Created Modern Astronomy" (August issue, page 28). Having volunteered as a tour guide at the U.S. Naval Observatory, I immediately recognized Antonia Maury — but for a different reason: her cousin, Matthew Fontaine Maury, was the first superintendent of the U.S. Naval Observatory and renowned for his work in meteorology and oceanography. Her father actually edited Maury's geographical series from 1875–1895. I had the pleasure once to provide a USNO tour to a bright young woman with direct kinship to Maury, and I tip my hat to them as an American family worthy of recognition.

Max Corneau
Rockwall, Texas

Regarding the stellar classifications *OBAFGKM*, when I was studying astronomy at the University of Texas at Austin in the mid-1950s it was *OBAFGKMRNS* — or "Oh Be A Fine Girl Kiss Me Right Now Smack." What happened to the *R*, *N*, and *S* classes?

Larry Wadle
Houston, Texas

Author's Note: *These three classes of stars aren't included because their compositions are significantly different than those in the* OBAFGKM *sequence.* N *and* S *stars are low-temperature stars and are all extremely red in color;* R *stars are a further division of* N *stars.* N *stars are richer in carbon than oxygen (which is opposite to most other stars, including the Sun). The spectra of* S *stars show an abundance of zirconium oxide, instead of titanium oxide, which is abundant in* M *stars. Both* N *and* S *stars are giants, and so both represent stars in the late stages of evolution. The most intensely studied* N *star is CW Leonis, while the Mira-type variable Chi Cygni is the brightest* S *star visible from Earth.*

For the Record

✷ *ALMA's superconducting electronics are not cooled by liquid helium, but by helium gas cooled to a temperature close to that of liquid helium (November issue, page 22).*

✷ *In the opening image of the November issue's Going Deep column (page 58), the globular cluster G35 is the slightly brighter object 3.5 mm left of the labeled star, barely below the line and between the "3" and "5" of the label "G35."*

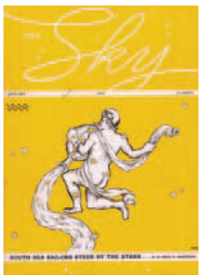
75, 50 & 25 Years Ago

Roger W. Sinnott

January 1939

Cosmic Rays "Studying cosmic rays is a problem which closely resembles detective work. No one has ever seen a cosmic ray, nor can one be directly measured in any way. All the information which we have obtained about them has been gathered through analyzing the effects which they produce. By an analysis of the deed, we have reconstructed the perpetrator. . . .

"The principal deed of which the cosmic rays are capable is that of ionization, or smashing atoms into their component parts. . . . It is for this reason that, in order to measure cosmic rays, we use any apparatus capable of responding to ionization . . . the electroscope, the ionization chamber, and the counting tube."

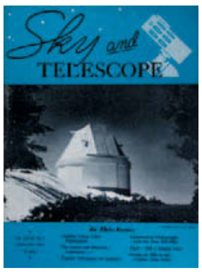


For physicist Serge A. Korff, then in his early 30s, cosmic rays became a lifelong pursuit. Astronomers think several sources shoot these high-energy particles around the universe, including supernova remnants, active galactic nuclei, and shock waves in turbulent star clusters.

January 1964

High-Flying Eye "On November 26th, the Stratoscope II 36-inch telescope was launched beneath tandem balloons from Palestine, Texas. The 3½-ton instrument observed successfully for 12 full hours at an altitude of 80,000 feet. . . .

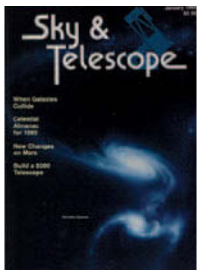
"Three sensitive infrared detectors developed by Texas Instruments, Inc., scanned the spectra of Jupiter and seven red giant stars[:] . . . Aldebaran, Betelgeuse, Mira, Mu Cephei, Mu Geminorum, R Leonis, and Rho Persei. Several strong absorption bands were recorded, apparently most intense in the coolest stars, but further study is necessary to identify the gas molecules concerned."



The stars' outer layers turned out to contain water vapor, which can exist at the red giants' low temperatures. (Stratoscope II was too high up to be fooled by water vapor in Earth's own atmosphere.) Pioneering balloon studies such as this one helped get infrared astronomy rolling. The Palestine facility is still used as a headquarters for balloon-mission launches.

January 1989

Crash! "Six hundred tons of steel smashed to the ground as the 300-foot radio telescope at Green Bank, West Virginia, collapsed without warning on the evening of November 15th. Amazingly, no one was injured in the incident. The antenna is 'just a pile of twisted metal,' according to Paul A. Vanden Bout, director of the National Radio Astronomy Observatory."



NRAO replaced the 26-year-old antenna with an even larger one in 2000. With a collecting area of about 2 acres, the Robert C. Byrd Green Bank Telescope is the world's largest fully steerable dish. Its future is uncertain due to funding.

Learn more about the Russian meteor at skypub.com/RussianMeteor.

METEORITE | Russian Fireball Fragment Found

After an 8-month salvage effort, divers finally brought a giant fragment of the Chelyabinsk meteorite up from the murky bottom of Russia's Lake Chebarkul.

Locals discovered an 8-meter (25-foot) hole in the lake's frozen surface after the mini-asteroid roared over Chelyabinsk, Russia, on February 15th (*S&T*: May 2013, page 10). The lake is about 80 km (50 miles) west of the city of 1.1 million.

Just a few weeks after the once-in-a-century event, researchers from nearby Ural Federal University released a tantalizing magnetometer scan hinting that multiple, big masses lurked on the silt-covered lakebed. Subsequent months brought only vague reports of an object up to 6 meters across. Some questioned whether a meteorite had actually punched the hole.

The wait ended on October 16th, when a team of divers and researchers removed a meter-long stone from the lake bottom and dragged it onto shore. Although experimental tests haven't conclusively confirmed that it's a piece of the Chelyabinsk impactor, the giant rock sure looks the part.

"It's a typical meteorite, judging by its appearance," Viktor Grokhovsky (Ural Federal University) told a reporter for *RIA Novosti*. "There's no doubt about that."

Divers pulled this potential fragment of the Chelyabinsk impactor from Lake Chebarkul. The last weight reading — before the meteorite broke the scale — was 570 kg.

AP PHOTO / ALEXANDER FIRSOV

The recovery team attempted to weigh the rock, but the scale broke during the measurement. The last reading was 570 kg (1,260 pounds).

The Chelyabinsk impactor had an estimated diameter of 17 to 20 meters and a mass of roughly 10,000 metric tons. The vast majority of it was likely vaporized or pulverized to dust when it slammed into the atmosphere and released the kinetic energy equivalent of about 500,000 tons of TNT, or about 30 times the explosive power of the Hiroshima atomic bomb.

■ **J. KELLY BEATTY**

EXOPLANETS | False Signal for Alien Life?

New research suggests that an exoplanet's atmosphere could contain lots of oxygen — none of it created by life — if it's bathed in the wrong mix of ultraviolet radiation from its host star.

Free oxygen exists in Earth's atmosphere thanks to photosynthetic organisms, which kicked up the element's abundance 2.4 billion years ago. Without life, free oxygen wouldn't stick around: it's orders of magnitude out of equilibrium with the other gases.

Astrobiologists hope the same holds true on Earth-like worlds circling other stars. They have suggested that the presence of oxygen in an exoplanet's atmosphere would be a strong indication of abundant biological activity.

Well, maybe not, said Feng Tian (Tsinghua University, China) and colleagues on October 7th at the American Astronomical Society's Division for Planetary Sciences meeting. Tian's team showed that planets circling in the habitable zones of *M* dwarfs could have lots of free oxygen but be completely lifeless.

M dwarfs have some advantages for exoplanet searches because they're the most common stars in our galaxy; they have long, stable lifetimes; and they have the cool, dim, and low-mass characteristics that make finding small planets around them relatively easy.

Earlier in 2013, Tian and colleagues found that five of six *M* dwarfs studied with the Hubble Space Telescope cranked out a thousand times more far-ultraviolet energy, compared with near-ultraviolet, than the Sun does.

That strongly skewed ratio, says Tian, makes all the difference in cooking up compounds in an exoplanet's atmosphere. The far-UV photons can break up carbon dioxide (CO_2) to yield oxygen atoms and, eventually, oxygen molecules (O_2) and ozone (O_3). Byproducts from reactions with hydrogen include H_2O_2 and HO_2 (note: not H_2O). But there are far too few near-UV photons to keep the reactions going in a way that would reconstitute the CO_2. Ultimately, the oxygen levels build up.

So will oxygen's presence always be a false positive for biologic activity? No, but as Tian cautions, "We need to know more about the ultraviolet environment before claiming the existence of life on exoplanets."

■ **J. KELLY BEATTY**

IN BRIEF

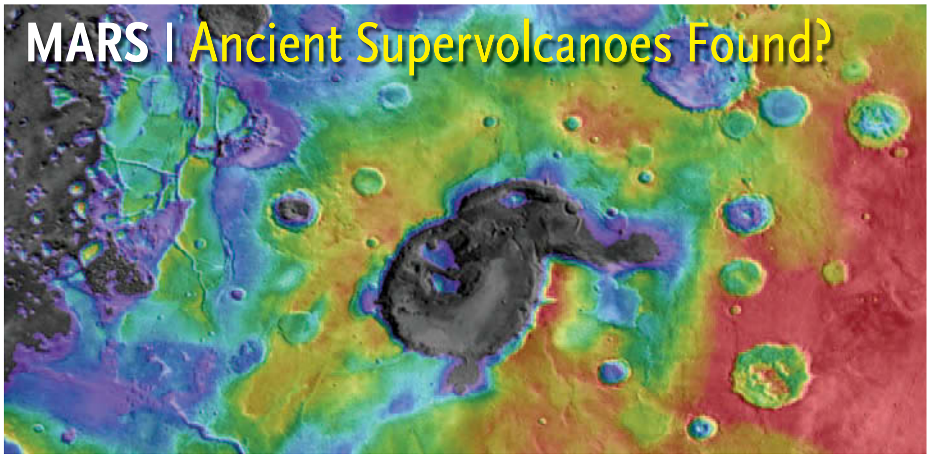
Exoplanet Clouds Detected. Visible and infrared observations suggest that the hot Jupiter Kepler-7b has a large patch of clouds on one side, Brice-Olivier Demory (MIT) and colleagues report in the October 20th *Astrophysical Journal Letters*. Kepler-7b is about half Jupiter's mass and whizzes around its 1.4-solar-mass star in less than 5 days, but it's cooler than expected. The potential cloud cover might explain why. The clouds are slightly offset from the star-facing side of the tidally locked planet.
■ CAMILLE M. CARLISLE

Fomalhaut Family Grows. Fomalhaut has not just one, but two distant stellar companions, report Eric Mamajek (University of Rochester and Cerro Tololo Inter-American Observatory, Chile) and colleagues in the *Astronomical Journal*. The 12th-magnitude star LP 876–10 (now Fomalhaut C) lies 2.5 light-years from Fom A and 3.2 light-years from Fom B. Due to the system's proximity to Earth, A and C appear 5.7° apart in the night sky. The triplet is one of the most widely separated systems known, besting both the Alpha Centauri–Proxima Centauri and Alcor–Mizar systems.
■ MONICA YOUNG

Orphan Planet Found. A free-floating planet dubbed PSO J318.5338–22.860 lurks just 80 light-years from Earth with a mass of only six Jupiters, Michael Liu (University of Hawaii) and colleagues report in an upcoming *Astrophysical Journal Letters*. PSO J318.5338–22 turned up in a survey for *L*-type brown dwarfs, but its spectrum looks more like a young planet in a dusty cocoon and its calculated temperature (roughly 1160 K, or 1630°F) is cooler than similar-looking *L* dwarfs. The team estimates the planet formed just 12 million years ago. Based on its motion, it probably escaped from the Beta Pictoris moving group, a clutch of 17 young stellar systems roughly 150 light-years from Earth.
■ J. KELLY BEATTY

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

MARS | Ancient Supervolcanoes Found?



NASA / JPL / GSFC / ARIZONA STATE UNIVERSITY

This image combines Mars Global Surveyor digital elevation data with Mars Odyssey daytime thermal-infrared images of Eden Patera, one of several features on Mars that geologists think might be ancient, collapsed volcanoes. Red is high elevation and purple-gray is low. The caldera is approximately 1,800 meters deep and 70 km wide in the longest dimension.

When it comes to volcanoes, Mars has always outclassed Earth. But a new analysis of spacecraft data suggests that the most gigantic calderas have lain disguised on the Red Planet's surface. Joseph Michalski (Planetary Science Institute, Tucson, and the Natural History Museum, UK) and Jacob Bleacher (NASA Goddard) propose in the October 3rd *Nature* that a series of blob-shaped pits on our planetary neighbor might represent a new class of Martian volcanoes: the supervolcano.

Terrestrial supervolcanoes are broad, low-lying features that erupt more than 1,000 cubic kilometers of volcanic ash and lava at once. (For comparison, Mount St. Helens only blew off 1 km^3 in 1980). Earth has seen few volcanic eruptions of this magnitude, but notable examples include the Deccan Traps, which erupted 65 million years ago and spread in a single eruption 9,000 km^3 of lava across much of what is now India.

Michalski and Bleacher suggest that Mars was once home to similarly catastrophic eruptions. Using satellite imagery, the geologists mapped the Arabia Terra region of Mars, which forms part of the border between the planet's drastically different northern and southern terrains. They found seven irregular pits, each upwards of 20 km across; the largest are more than 50 km. These Martian pits were once thought to be irregular impact craters, too low in relief to be volcanoes. However, the new analysis points out telling volcanic features, such as distinct ridges and terraces, that more closely resemble terrestrial calderas.

The team interprets the pits as bowl-shaped craters formed as magma erupted from a subsurface chamber so explosively that the volcano collapsed. Oregon's Crater Lake formed this way, although, at only 8 km across, it is dwarfed by these potential Martian calderas.

Such catastrophic eruptions on ancient Mars could have drastically altered the planet's climate. On Earth, supervolcano eruptions often result in "volcanic winter," a global chilling caused by fine atmospheric ash reflecting away solar energy. Mars's climate likely suffered a similar chilling as these supervolcanoes erupted.

If the giant pits of Arabia Terra are extinct volcanoes, they might be responsible for the thick deposits of ashlike debris that blanket Mars's equatorial region. NASA's Opportunity rover investigated this debris at its Meridiani Planum landing site, and the Curiosity rover is now encountering it inside Gale Crater. Geologists have debated whether this thick debris layer formed from vast deposits in ancient lakes or volcanoes. The supervolcanoes of Arabia Terra might at last be the cause.
■ SELBY CULL

Watch a video exploring the three largest supervolcanoes: skypub.com/marsvolcanoes.

STELLAR | First Flip-Flop Pulsar Found

Astronomers have discovered the Dr. Jekyll of pulsars. Alessandro Papitto (Institute of Space Sciences, Spain) and colleagues caught a pulsar repeatedly changing between X-ray- and radio-emitting states, a prelude to a final metamorphosis long predicted but never observed.

In what's called a low-mass X-ray binary, a neutron star is spun up to a millisecond rotation period by material siphoned from its regular stellar companion. Superheated material pours onto the neutron star in a fitful fashion, emitting X-rays and creating a brighter X-ray outburst on the surface when it reaches it. Researchers have suspected that when the downpour finally shuts off forever, all X-rays will fade, leaving behind a whirling radio pulsar.

Evidence for this theory has been indirect until now. But Papitto's team reports in the September 26th *Nature* that it has finally spotted an object in the betwixt-and-between state, demonstrating that X-ray pulsars really do decay into radio ones.

The team detected the X-ray transient IGR J18245–2452 on March 28th using ESA's Integral spacecraft. The source sits in the globular cluster M28, which lies right above the Teapot's lid in Sagittarius. Checking a list of known radio pulsars in M28, the team discovered that the pulsar PSR J1824–24521 was in the same location.

Over the next two months and using a slew of X-ray and radio telescopes, the astronomers watched the pulsar switch from X-ray pulses to radio pulses within a few days. Digging through archival data from the last several years, they confirmed that the source is a flip-flopper.

"It is a great result," says pulsar expert Sandro Mereghetti (IASF Milano, Italy). "This object is the long-sought missing link between two different populations of neutron stars that were believed to be connected by evolution."

The system will probably remain as is for tens of millions of years.

The mechanism behind this transitional state is complicated. The neutron star is sucking material off its companion at a roughly constant rate, building up a disk around itself. But this disk is like a bucket being filled with water: it has to load up before it hits a tipping point and pours its contents onto the pulsar's surface. The buildup happens for two reasons: one, the disk itself transfers material intermittently; two, the neutron star's strong magnetic field and the radio emission it helps create push back on the infalling material. Accretion becomes a competition between the gas's pressure and the pulsar's radiation.

But at some point — perhaps because the accretion rate increases or because the disk material builds up enough — the gas's pressure overcomes the radiation and pours down onto the neutron star's surface, compressing the magnetic field to one-tenth its previous size. Because the pulsar can only produce radio emission in a "clean" environment, the downpour halts the radio pulses. The infalling gas heats up the neutron star's surface, creating the X-ray outbursts that the team detected. When the material is drained, the neutron star's magnetic field reinflates and reactivates the radio pulses.

The changing signals the team detected reveal this magnetic collapse-inflation process. "We actually witnessed the breath of a neutron star," Papitto says.

Once accretion shuts off for good, the pulsar will slowly spin down over tens of billions of years, using its rotational energy to power its radio emission. Assuming no cosmic interruptions, the pulsar will ultimately end just as Hyde did: a corpse.
■ **CAMILLE M. CARLISLE**

IN BRIEF

Uranus's Unlikely Companion. The object 2011 QF_{99} is the first known Trojan body sharing the ice giant's orbit. Trojans are small bodies that sit 60° ahead of or behind a planet in the same orbit, at the gravitationally stable niches called the L_4 and L_5 Lagrangian points. While Earth, Mars, Jupiter, and Neptune have Trojan populations, dynamicists thought Saturn and Uranus couldn't. But Mike Alexandersen (University of British Columbia) and colleagues discovered a 60-km body near Uranus's L_4 point that appears to be staying put. As detailed in the August 30th *Science*, Uranus potentially caught 2011 QF_{99} less than 100,000 years ago. The object will gradually spiral its way out of the planet's gravitational grip in the next million years. The team also found that, at any given time, about 1% of bodies within 34 astronomical units of the Sun should linger around Uranus as temporary Trojans, and another 2% around Neptune.
■ **J. KELLY BEATTY**

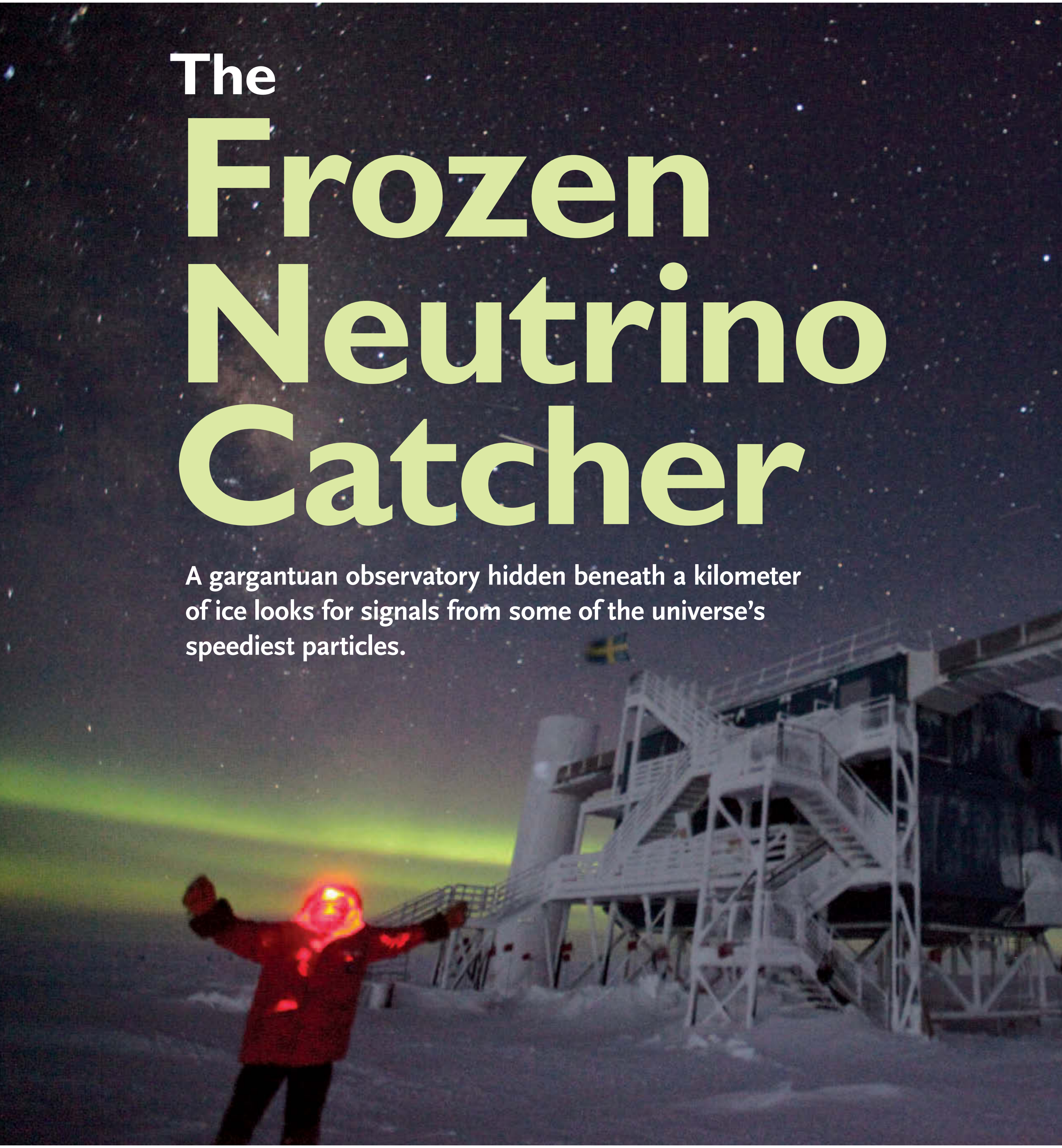
Tiny Diamonds Pepper Jupiter & Saturn. Work based on Cassini observations and lab experiments suggests that diamond is the most stable form of carbon for roughly half of the gas giants' atmospheres, Mona Delitsky (California Specialty Engineering) and Kevin Baines (University of Wisconsin–Madison) reported October 9th at the American Astronomical Society's Division for Planetary Sciences meeting. On Saturn, solid diamond should exist from about 6,000 to 36,000 km below the cloud tops, reaching more than halfway down into the planet (Saturn's equatorial radius is 60,000 km). A thinner layer should exist on Jupiter as well. But these layers are sparse: the team estimates that there should be only one millimeter-size diamond per cubic kilometer of atmosphere in Saturn's diamond layer, and a factor of 20 less on Jupiter.
■ **CAMILLE M. CARLISLE**

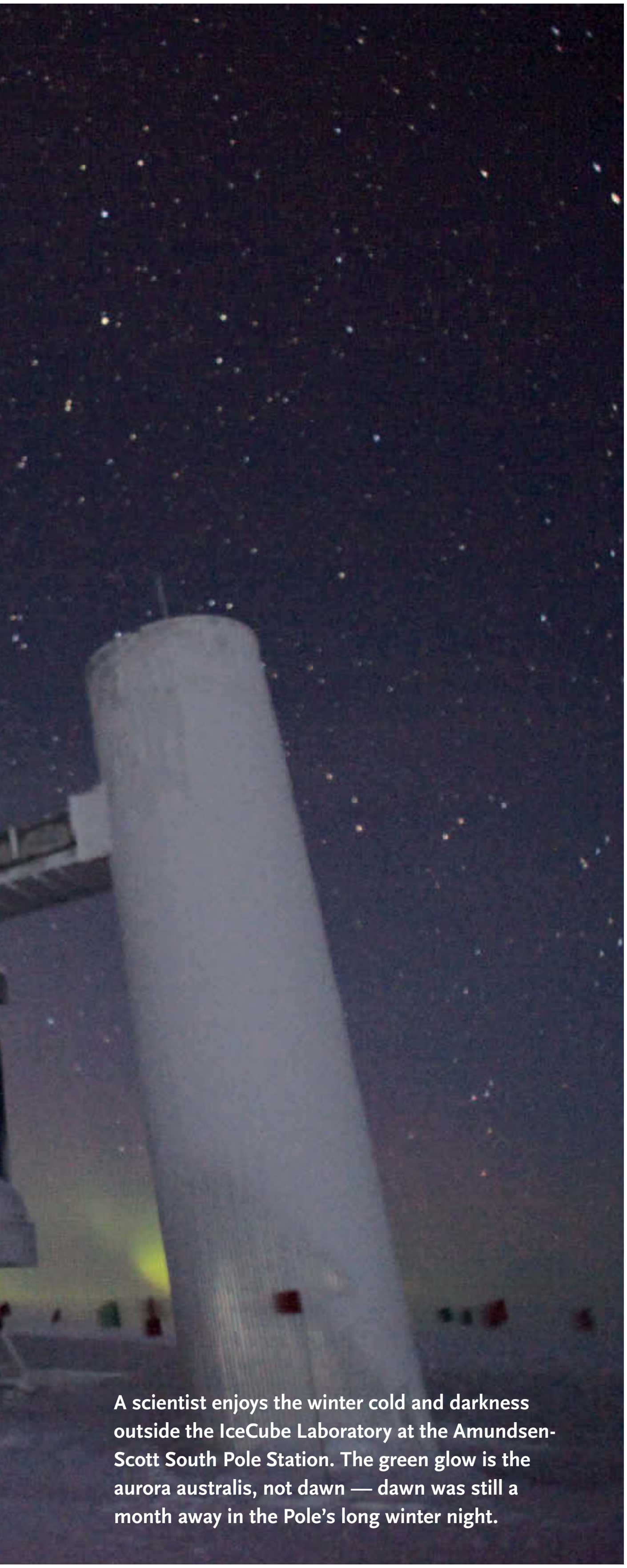
Planck Mission Ends. On October 23rd, ESA shut down its Planck spacecraft on schedule. Planck produced exquisite maps of the cosmic microwave background (*S&T*: June 2013, page 10) as well as closer-to-home vistas, receiving two extensions before the mission team closed up shop. Despite the end of observations, work continues: the next major data release is slated for mid-2014. ✦
■ **CAMILLE M. CARLISLE**


TelescopeS.NET
by Woodland Hills Camera & Telescopes
MEADE
LX850
Built-in guiding for imaging
CELESTRON
CGE Pro 1400 HD
Your ultimate portable 14" scope
PlaneWave INSTRUMENTS
Why wait for your favorite CDK when you can have one now?
EXPLORE SCIENTIFIC
100 degree eyepieces for as little as $249
TAKAHASHI
An amazing wide field refractor
AIS Apogee IMAGING SYSTEMS
The Aspen by Apogee The 16803 chip that never quits
OFFICINA STELLARE
Veloce RH 200
8" f/3.0 astrograph
SBIG ASTRONOMICAL INSTRUMENTS
STi
The must have guider from $595
Shelyak INSTRUMENTS
Exciting and affordable spectrograph from Shelyak
$759
SKYRIS
Afordable new 120 FPS, USB3 imager from Celestron
CORONADO
Rich View SolarMax II
An amazing H alph as little as $1299
LS35TH Dedicated H-Alpha Solar Telescope
Basic $598
Deluxe (shown) $673
Paramount MX
Engineered for productivity
SOFTWARE BISQUE
FLI
Finger Lakes Instrumentation
Atlas Digital Focuser
High payload precision focuser
TeleVue
Visionary
Tele Vue NP127 IS, Incredibly sharp, astrophotography ready
Canon
EOS 60Da DSLR Astrophotography Camera
Last call while supplies last!
Incredible StarLapse System
Performance and versatility
$695.00
LOSMANDY
Vixen Optics
Sphinx SXD w/tripod
Rock solid, unparalleled controller
$1,995.00
ATIK CAMERAS
Titan CCD Camera
Planetary and deep-sky imager
$689
888-427-8766 Intnl: 818-347-2270 • 5348 Topanga Canyon Boulevard, Woodland Hills, CA 91364

The Frozen Neutrino Catcher

A gargantuan observatory hidden beneath a kilometer of ice looks for signals from some of the universe's speediest particles.





A scientist enjoys the winter cold and darkness outside the IceCube Laboratory at the Amundsen-Scott South Pole Station. The green glow is the aurora australis, not dawn — dawn was still a month away in the Pole's long winter night.

SVEN LIDSTROM / NATIONAL SCIENCE FOUNDATION

Govert Schilling

Struggling with thin air and extreme cold, I slowly make my way from the tracked snow vehicle to a building that vaguely reminds me of a *War of the Worlds* fighting machine. The frozen landscape around me is blindingly white. The wind chill is about –40°C. This is Earth's South Pole, one of the most inhospitable places on the planet, but also a Valhalla for astronomers.

Inside the building, scientists collect data on high-energy neutrinos from outer space, sniffed out by thousands of sensitive detectors buried in the Antarctic ice sheet. The giant IceCube Neutrino Observatory begins more than a kilometer beneath my feet, completely out of sight.

"You should've come to Madison 10 years ago," says Francis Halzen (University of Wisconsin–Madison) during a telephone interview long after I returned from the pole. "Back then, many detector modules were lying around here." Halzen, a Belgian-born theoretical physicist, is IceCube's principal investigator. The observatory was completed in December 2010 and will be operational for at least 20 years. "In retrospect, we didn't experience any setbacks," says Halzen. "We've been very lucky all the time."

That may have been true for IceCube's construction, but scientists have been less lucky with obtaining groundbreaking results. Even when the IceCube Collaboration announced the long-awaited discovery of 28 high-energy neutrinos from space at a Madison conference last May, the particles' true nature and origin remained mysterious. As Halzen's colleague Nathan Whitehorn (UW–Madison) commented, "Definite answers are still missing."

Neutrinos — elusive elementary particles with no electrical charge and almost no mass — were discovered experimentally in 1956. Produced in the Big Bang, but also in stellar interiors and energetic cosmic events, they race through the universe mostly unimpeded at almost the speed of light and in unimaginable numbers: trillions of neutrinos fly through your body every single second. Because they travel so freely, neutrinos can directly convey information about their sources that other high-energy particles transmit in a garbled way.

The idea of using the Antarctic ice as a neutrino detector was first suggested by Halzen at a physics meeting in Poland in 1987. "It was a trial balloon," he says. "Surprisingly, nobody laughed." The idea is simple: every now and then, a neutrino smashes into an atomic nucleus in the ice. This interaction incites a chain reaction that produces a shower of charged particles, such as muons, the heavy cousins of electrons. Because the charged particles move faster through ice than a photon can, they create tiny flashes of radiation, which light-sensitive detectors called digital optical modules (DOMs) register. Detecting this so-called Cherenkov radiation from muons is particularly revealing: from the data, scientists deduce the travel direction and the energy of the muon and, thus, of the original neutrino.

GARY HILL / NSF (2)

Far left: A "winter-over" — a person willingly stranded at the South Pole for eight months to work during Antarctic winter — signs the final digital optical module before it's deployed into the array. *Near left:* A module begins its descent into the dark, clear Antarctic ice, where it will look for signals from neutrinos smashing into ice atoms.

In principle, this is how the IceCube team deduced the travel directions of the 28 high-energy events. But even with complex, time-consuming data analysis, the resulting sky positions aren't very precise. Frustratingly, there are no hints of significant clustering, and apparently there's no correlation with the locations of known astronomical objects such as active galaxies or stellar-mass black holes in the Milky Way Galaxy.

Frozen Strings

Freezing 5,160 DOMs into a cubic kilometer of ice is no mean feat. "It was a huge logistical operation," says Paul Sullivan, the science support manager of the National Science Foundation's Amundsen-Scott South Pole Station. "It took 48 hours on average to drill each of 86 holes and to deploy a 2.5-kilometer-long cable into each hole before it froze tight again." Attached to each cable like widely separated beads on a string are several dozen DOMs, mounted in spherical pressure vessels 33 centimeters (13 inches) across, the deepest lying some 2.4 km under the surface.

From the top of the stairs that take me into the IceCube Laboratory at the Pole, I can barely make out the small flags in the ice that mark the strings' locations. The data cables from each string are buried just below the frozen surface and converge inside the two shiny towers on either side of the building that give the edifice its characteristic sci-fi appearance. From there, the bundles of cables are fed into a huge computer room.

"Everything is shielded here to prevent electrostatic interference from aircraft or auroras," says system administrator Ralf Auer. "We wear special wrist bands to discharge ourselves on metal every time we enter the server room."

A colorful pattern of dots and lines on one of the computer screens is the visual representation of a muon-induced event in the IceCube detector. Auer says that they register around 2,500 events per second, but the vast majority are created by cosmic rays, charged particles (mostly protons) that zip through space at almost the speed of light. Cosmic rays produce muons and neutrinos when they run

IceCube Competitors

IceCube is certainly not the only big neutrino detector hunting for high-energy neutrinos from outer space. Below are some characteristics of the main competitors.

Name	Completion	Medium	Volume	Number of Detector Modules	Location
ICECUBE	December 2010	Ice	1 km^3	5,160	South Pole
ANTARES: Astronomy with a Neutrino Telescope and Abyss environmental RESearch	May 2008	Water	0.035 km^3	900	Mediterranean Sea off France
BDUNT: Baikal Deep Underwater Neutrino Telescope	April 1998	Water	0.0002 km^3	192	Lake Baikal, Russia
KM3NeT: Cubic Kilometer Neutrino Telescope	Under construction	Water	Several cubic kilometers, split among 3 locations	About 12,000	Three locations in Mediterranean Sea

into nitrogen or oxygen atoms in the atmosphere. But these have nothing to do with the high-energy neutrinos from outer space. "For every astrophysical neutrino, we see about a hundred thousand *atmospheric* neutrinos and billions of cosmic ray muons," explains Halzen.

Developing the hot-water drill method and understanding the optics of the ice were two big challenges for the IceCube project, says Halzen. But finding the rare cosmic needles in the giant particle haystack turned out to be almost as challenging, at least as far as the atmospheric neutrinos are concerned. Filtering out the muons produced by cosmic rays is straightforward — the only thing you have to do is look down, not up. Unlike neutrinos, muons don't easily penetrate through miles of solid rock, so if a muon in the IceCube detector is moving upward, it must have been produced in the ice by a neutrino that first traversed our planet "from below."

But finding the scarce high-energy cosmic neutrinos in the background of atmospheric neutrinos is a more daunting task. One way to recognize them would be if they arrived in bursts. Brief showers of high-energy neutrinos have been predicted from gamma-ray bursts, among the most energetic explosive events in the universe. But although Halzen and his colleagues have been on the lookout for GRB neutrinos, they haven't found any so far. "We don't see the predicted flux," he says, "which, of course, is interesting in itself."

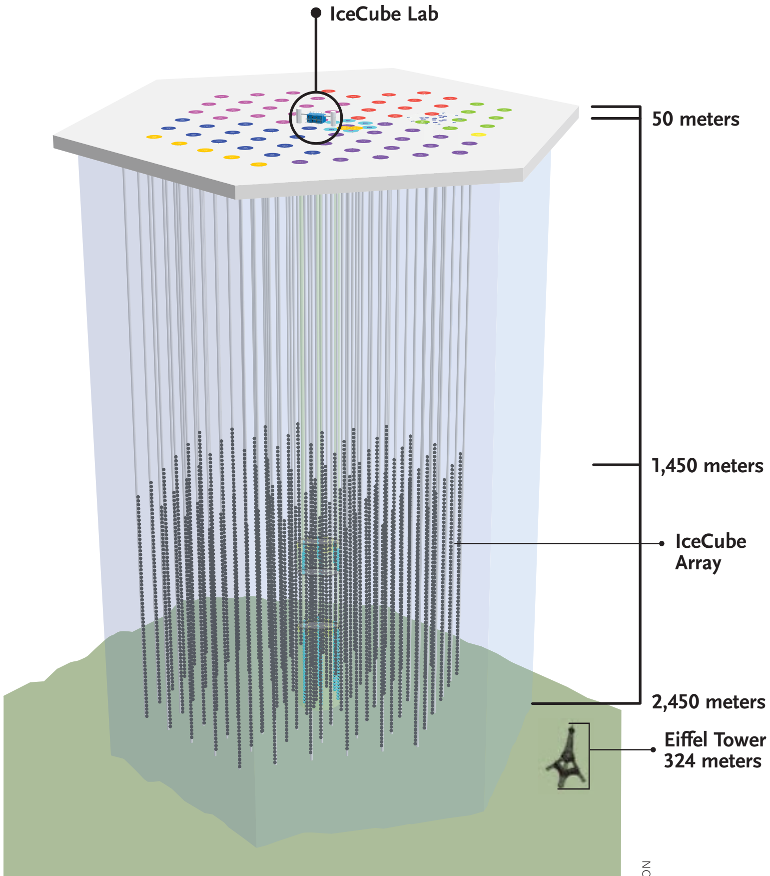
Bert, Ernie, and Their Friends

Another way to distinguish cosmic neutrinos from atmospheric ones is by focusing on the highest-energy events. At energies above 100 teraelectron volts (TeV) — more than a dozen times more energetic than protons accelerated at CERN's Large Hadron Collider — there's no background anymore, explains Halzen. On August 9, 2011 and January 3, 2012, the team saw two events at a staggering 1,040 and 1,140 TeV. These events, nicknamed Bert and Ernie, defy any conceivable explanation as conventional atmospheric neutrinos. But no one has a clue as to their origin.

An obvious third way to identify cosmic neutrinos would be as an excess from a particular region on the sky. "The atmosphere produces a uniform flux," says Halzen, "but if there are discrete sources of high-energy neutrinos in the universe, like active galactic nuclei, we should be able to find them, even if they're responsible for a mere two or three events per year."

But so far, the IceCube scientists have no point sources to report, Auer says. "It's a big surprise. It looks like the theoretical predictions were wrong."

So what about the other 26 energetic neutrino events found in the IceCube data from 2010 through 2012? First of all, they all have less oomph than Bert and Ernie. Based on statistical expectations, about a dozen of them might be rare high-energy atmospheric neutrinos instead. Second, they don't show statistically significant clustering on the

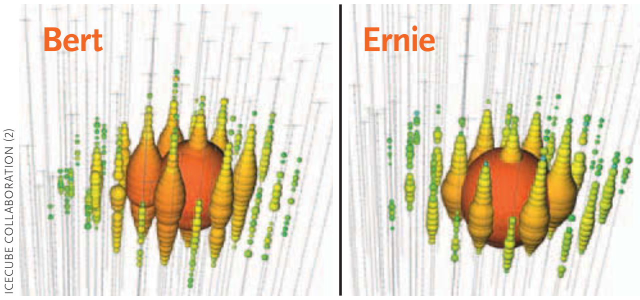


Buried deep beneath the surface, the IceCube array is a gigantic construction of cables and detectors frozen into Antarctica's clear ice. The sci-fi lab building on top is dwarfed in comparison — as is the Eiffel Tower, shown to scale to the lower right of the observatory.

S&T: GREGG DINDERMAN
SOURCE: ICECUBE COLLABORATION

Selected IceCube Results

- **January 2005:** Detection of first neutrinos with (incomplete) IceCube observatory
- **July 2009:** IceCube publishes its first results on the nondetection of point sources in neutrino observations
- **July 2009:** IceCube announces the detection of the Moon's "shadow" in the observation of muons from cosmic ray showers
- **April 2012:** IceCube announces that gamma-ray bursts do not appear to produce high-energy neutrinos
- **October 2012:** IceCube announces that it doesn't observe neutrinos from annihilating dark matter
- **April 2013:** Publication of the detection of two very-high-energy neutrinos, nicknamed Bert and Ernie
- **May 2013:** Announcement of the detection of an additional 26 high-energy neutrinos, most of which are very likely of (unknown) astrophysical origin



Known affectionately as Bert and Ernie, the two highest-energy neutrinos IceCube has detected appear as colorful blips in the array. Each colored dot represents a digital optical module; the sizes represent the amount of light observed at that module, and the redder the color, the earlier the signal. Ergo, large red spheres indicate a lot of light seen at early times, whereas tiny green ones indicate a small amount seen later.

sky. Third, they don't seem to come from known sources.

"Active galactic nuclei are still the most popular candidate," says Halzen. "But of course it's always possible that Nature is more clever than us. The right response to this is not to speculate but to get more events, and that is what we are doing." They are already analyzing another year of data.

What's Next?

Even though IceCube has only completed its third year of full operations, scientists are already thinking about future upgrades. "If a certain type of interesting signal would be found, you'd like to optimize the detector for that particular signal," says Halzen. Additional strings could be deployed in a much larger volume of ice for relatively little money. Or the team could insert extra strings inside IceCube: decreasing the spacing of individual detectors would make the observatory more sensitive to lower-energy neutrinos. "We could address a lot of interesting questions about neutrinos for a fraction of the costs of accelerator experiments," says Halzen.

Meanwhile, another neutrino observatory is already taking shape at the South Pole. Right in front of the entrance of the IceCube Laboratory, engineers and technicians warmly dressed against the Antarctic cold are building the Askaryan Radio Array (ARA). Simple dipole radio antennas are melted up to 200 meters into the ice to catch the brief, directional pulses of polarized radio waves from neutrinos that are produced when ultra-high-energy cosmic rays crash into our atmosphere. Eventually, ARA will consist of dozens of antenna clusters, spread out over an area of some 80 square kilometers.

Looking out over the vast Antarctic ice sheet, I can't help being impressed by the cleverness of particle physicists and astronomers in unravelling the secrets of the high-energy universe. Neutrinos have been traversing our small planet for billions of years, but only recently did we manage to catch them with intricate, subglacial eyes.

IceCube electrical engineer Perry Sandstrom (UW–Madison) is likewise impressed. "When I came into the project, I thought: you guys must be crazy," he says. "But by now, all the hard stuff has been figured out. We've built a discovery machine, and we just don't know what we can expect to see — it's thrilling." Asked about the future of the 5,160 individual detectors, Sandstrom strikes a philosophical note. "They may survive mankind," he muses. "Getting them out of the ice is harder than retrieving satellite electronics. Only when the ice sheet melts, in the distant future, will they end up in the ocean. Aliens might take them for souvenirs." ✦

Sky & Telescope contributing editor ***Govert Schilling*** *visited the South Pole on December 10, 2012 as part of the National Science Foundation's Antarctic media visit program.*

Learn more about science in Antarctica and watch a time-lapse video of the team building IceCube at skypub.com/icecube.

Waiting for Another Supernova 1987A

On February 23, 1987, three neutrino observatories detected a handful of energetic neutrinos that had been emitted some 165,000 years before when the blue supergiant star Sanduleak –69° 202 in the Large Magellanic Cloud exploded as a supernova (*S&T*: April 1987, page 382). According to principal investigator Francis Halzen, the IceCube Neutrino Observatory is more than ready to detect neutrinos from the next nearby supernova. "That would be the astronomical event of the century," he says.

IceCube is much more sensitive than the three relatively small observatories that detected SN 1987A: Kamiokande II near Hida, Japan; the Irvine-Michigan-Brookhaven detector at Lake Erie; and the Baksan Neutrino Observatory in the Russian Caucasus. "We would have detected a few thousand neutrinos from Supernova 1987A," says Halzen. "A supernova in our own Milky Way Galaxy would produce millions of events. It would be very easy to pick up." A stellar explosion in the Andromeda Galaxy, however, would probably be just out of reach.

IceCube scientists have been looking for supernova signatures since 1995, when construction of the observatory's precursor took off. But neither this smaller-scale AMANDA (Antarctic Muon And Neutrino Detector Array) project nor the bigger IceCube detector has ever found a supernova-related burst. That may not be too surprising, given that the average supernova rate in our galaxy is around two or three per century.

Halzen can't wait. "Supernova neutrinos arrive at Earth before the visible light of the explosion," he explains. "We could alert the astronomers, so they should be able to see the supernova when it occurs. It may happen today."

GOTO

Leading India to the Stars

Ujjain Planetarium

The central India city of Ujjain has been a focal point of mathematical and astronomical thought and research for over 1,000 years. A famous Ujjain mathematician, Brahmagupta is credited with first writing about the concept of zero and negative numbers, and others helped to develop trigonometry. Ancient astronomical observatories operating there over two millennia set Ujjain as the “Greenwich of India”, defining the prime meridian and zero longitude in Indian geography. And astronomers have used stone instruments there to chart the motions of the planets and positions of stars for centuries.

So it is no wonder than this holy city draws not only millions of Hindu pilgrims, but also attracts those searching for knowledge in the stars. And now, as India pushes toward its goal of manned space flight by the year 2016, Ujjain will again play an important role. In support of that goal, Ujjain has created the new Ujjain Planetarium, where young and old will come together to learn about the sky, to be inspired, and to have a new appreciation of the heavens.

The leadership of the Ujjain Planetarium set forth a plan for a 12 meter planetarium with seating for 124 people. They determined that the projection equipment must give a superb and accurate view of the night sky, and that it must also be capable of showing the dynamic concepts of modern astronomy education in an exciting manner. So after examining several different technologies, their choice was for a GOTO CHRONOS II HYBRID system.

The CHRONOS II, with its sharp LED sky, fast and accurate sun, moon, and planet projectors, and 10,000,000 star Milky Way shows the sky in all its glory. And the synchronized VIRTUARIUM II fulldome video system complements this sky with educational overlays as well as full-color animations to help educate and entertain audiences. Finally, the HYBRID control console allows operators to customize live programs for students of all ages.

It is said that time flows slowly for the friendly people of Ujjain. But the pace of India’s race for space is accelerating at the Ujjain Planetarium.

To learn more, contact:

GOTO INC

4-16 Yazakicho, Fuchu-shi,
Tokyo 183-8530 Japan
Tel : +81-42-362-5312
Fax : +81-42-361-9571
E-Mail : info2@goto.co.jp
URL : http://www.goto.co.jp

GOTO LIAISON

5715 Susan Drive East,
Indianapolis, IN 46250
Tel : +1-317-537-2806
E-Mail : gotousa@earthlink.net
Contact : Ken Miller

Tuning in

DYNAMIC DUO
Jupiter interacts with its volcanic moon Io to produce intense radio emission that can outshine the Sun. The duo is shown here in a composite image from NASA's New Horizons spacecraft.

NASA / JOHNS HOPKINS UNIV. APPLIED PHYSICS LABORATORY / SOUTHWEST RESEARCH INST. / GODDARD SPACE FLIGHT CENTER

The race is on to find the first radio waves from a world beyond our solar system.

Fantastic exoplanet discoveries have become almost routine in recent years. Hardly a month goes by without another announcement: the smallest exoplanet yet, the most elliptical orbit, or the most crowded planetary system. Yet the vast majority of the thousands of exoplanet candidates are indirect detections, made by observing the planet's effect on its parent star rather than the planet itself. The planet's light often disappears amidst the much brighter star's glare in visible and infrared light, where most of these detections are made. So astronomers settle for catching the stellar wobble induced by a planet's gravitational tug, or the blip in light as the planet crosses in front of its parent star. Far fewer planets are imaged directly.

But planets emit more than visible light. Could other wavelengths offer views with more favorable contrast? Radio astronomers have been suggesting it for decades, and technology is finally catching up. Now that detection is becoming feasible, the race is on to find the first radio waves from an extrasolar planet.

Making a Radio Storm

Astronomers have already been recording intense radio storms from the closest gas giant for decades, ever since Bernard Burke and Kenneth Franklin discovered Jupiter's radio outbursts in 1955 (see box on page 28). The storms

to Radio Jupiters

Yvette Cendes

originate in Jupiter's magnetosphere, a giant cocoon that protects the planet from the onslaught of solar wind particles. The Jovian magnetosphere is one of the biggest structures in the solar system, large enough to encompass the Sun and the visible corona. It spans 1½° in our sky, three times the angular diameter of a full Moon.

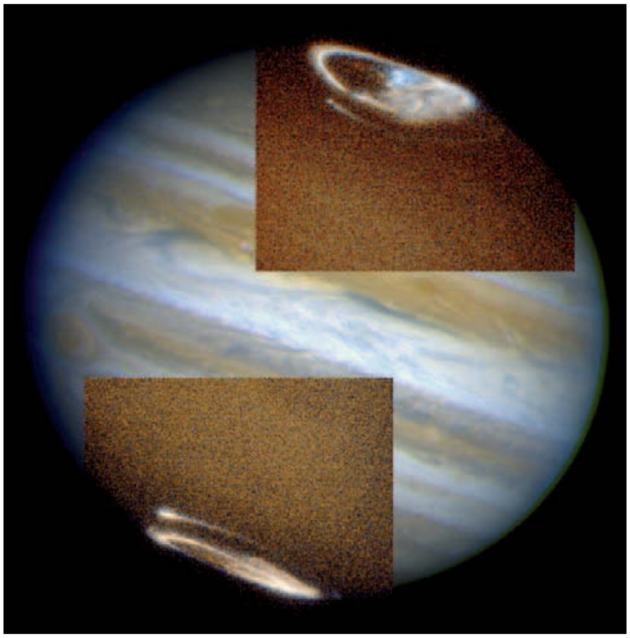
Jupiter's field is strong enough to deflect most of the charged particles streaming from the Sun. Though a few manage to penetrate the magnetic cocoon, most of the plasma inside the magnetosphere comes from within, spewed by Io's volcanoes. Jupiter's magnetosphere sweeps up the sulphur and oxygen ions that escape Io's gravitational grip, as well as the accompanying electrons, spreading the plasma into a donut-shaped region that rings the planet's equator. Electrons from the plasma donut, and from Io itself, race along Jupiter's magnetic field lines to rain down on the poles. As the electrons spiral ever more quickly around the field lines, they rouse the surrounding plasma, which releases radio waves in coherent bursts.

During an outburst, Jupiter becomes the brightest radio source in the solar system. The radiation beams into a hollow cone, so we see it only when an edge of the cone is directed straight toward us. Following Jupiter's rotation, the beam whirls around every 9.9 hours like a lighthouse — in fact, Jupiter can be thought of as a weak radio pulsar.

Due to the constant source of plasma, Jupiter's auroras are permanent, though they vary in brightness. That's in contrast to Earth's transient auroras, which depend on solar activity. With no moon to provide plasma, Earth's auroras appear whenever our planet's magnetic field lines align with the Sun's, allowing solar particles to pass into Earth's magnetic cocoon, and into Earth's ionosphere.

Compared to Earth's auroras, Jupiter's radio storms are intense. When they're "on" they can outshine the Sun, and amateur radio astronomers can pick up the signals. The two most common signals are long bursts, which sound like ocean waves crashing on a beach, and short bursts, which sound more like pebbles scattered against a tin roof. Think you're hearing a Jovian signal but can't be sure? Try tuning the radio to a slightly different frequency. If the sound persists, it's likely to be Jupiter and not a radio station fading in and out. Armchair astronomers can also listen online at NASA's Radio JOVE project website (radiojove.gsfc.nasa.gov).

Regardless of whether you're listening to your own radio or listening online, you'll have to time things carefully. It's not enough for Jupiter to be above the horizon — for a successful observation, you'll want to consult tables that predict Jupiter's outbursts based on factors such as Io's position relative to Jupiter and Earth.



JPL / NASA / STSCI

AURORA AT JUPITER This Hubble Space Telescope composite image shows Jupiter's auroral ovals in ultraviolet light, superimposed on a visible-light view.

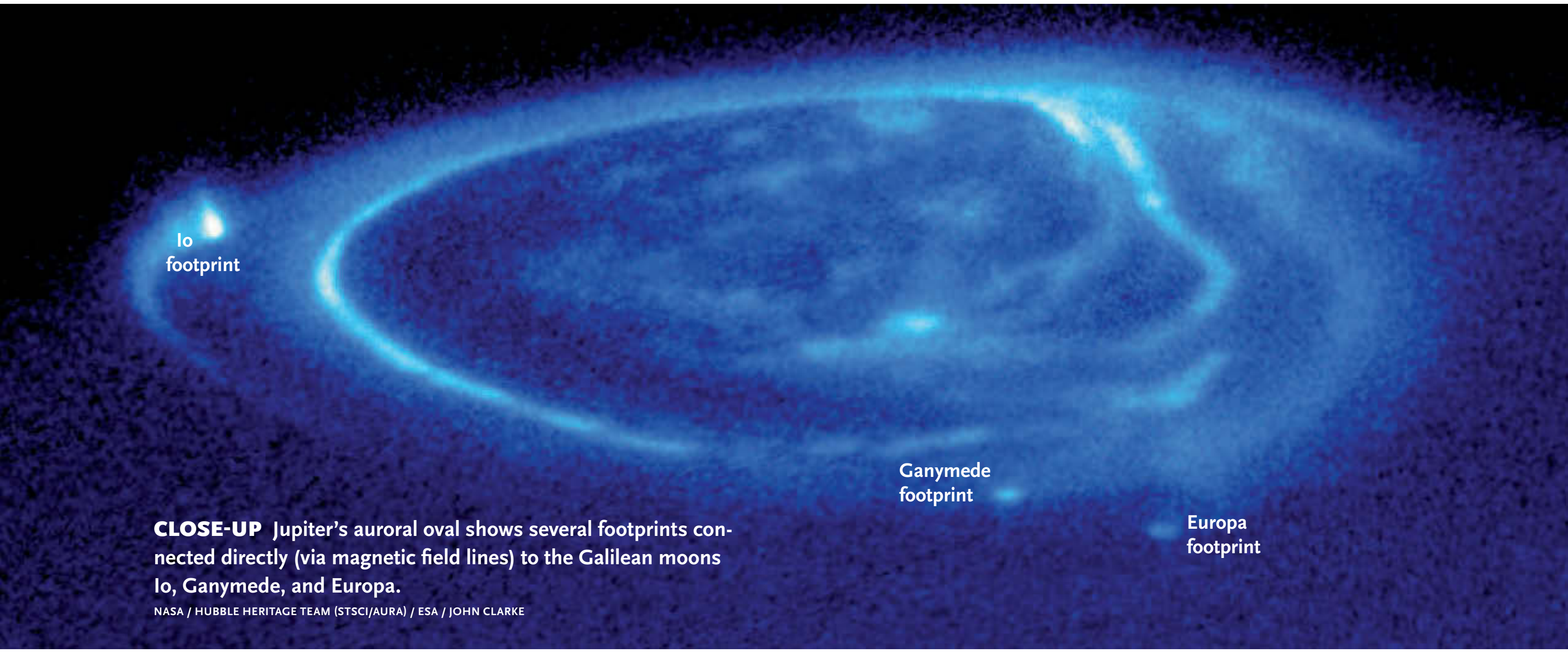
Finding Radio Jupiters

Radio astronomers, who had collectively been studying Jupiter's outbursts for decades, naturally wondered: if Jupiter can shine so bright in the radio, can we apply what we know about Jupiter to the detection of exoplanets? The suggestion isn't new — the idea was first published in 1976 or earlier, before any exoplanets had even been detected — but now capabilities of low-frequency radio arrays are improving, and exoplanet searches have revealed several promising targets.

Low-frequency radio observations are still difficult. Among other things, background emission from the galaxy is quite bright, and both natural and man-made interference can muddy an observation. But a radio detection promises details that are difficult or impossible to infer from visible-light observations, such as the planet's magnetic field strength, rotation rate, and the nature of the star-planet interaction.

Several teams of astronomers have already seen strong emission from brown dwarfs and even low-mass stars in the high-frequency radio range — that is, at gigahertz frequencies, instead of the megahertz frequencies of Jupiter's emissions. The outbursts are brighter and higher-frequency because the objects have far stronger magnetic fields, but the polarized radio signals probably come from the same mechanism as on Jupiter. In fact, Jonathan Nichols (University of Leicester, UK) and his colleagues showed last year that a simple model extrapolated from Jupiter's auroral emissions could reproduce the strength and beat of the radio signals observed from brown dwarfs and low-mass stars alike.

Detecting radio emission from less massive objects, such as Jupiter-sized exoplanets, would require special circumstances. Current radio arrays would only catch Jupiter-strength outbursts from about a light-year away, less than the distance from Earth to Alpha Centauri (the nearest star system). No exoplanets so close by are known, so an exoplanet's magnetosphere would have to emit much stronger signals to be detected from farther away. There are a seemingly infinite number of ways to amp up a hypothet-



CLOSE-UP Jupiter's auroral oval shows several footprints connected directly (via magnetic field lines) to the Galilean moons Io, Ganymede, and Europa.

NASA / HUBBLE HERITAGE TEAM (STSCI/AURA) / ESA / JOHN CLARKE ical exoplanet's radio emission, so astronomers limit the playing field by extrapolating from what they already know, both about our own solar system and about exoplanets.

Several teams of astronomers think the best bet involves "hot Jupiters," gas giants that orbit their parent star too closely to keep moons of their own. High doses of stellar wind particles buffeting the tightly orbiting planets could produce strong auroral radio emission.

But there's a catch: a hot Jupiter has a good chance of becoming tidally locked, like the Moon around Earth. To always shows the same face to its star, its rotation must slow, so the strength of its magnetic field will decline. But even with no magnetic field, the planet could still play the role of Io, donating plasma to its host star. As long as the star is highly magnetic, the system could then produce outbursts up to 1 million times brighter than Jupiter's.

If the hot Jupiter model holds, radio telescopes could detect hot Jupiters up to about 100 light-years away — a distance that includes several known exoplanets.

The second possibility involves systems more like our own, where a gas giant orbits a few astronomical units from its parent star and has its own Io-like moon. In a 2011 study, Nichols estimated that current or upcoming radio telescopes could detect Jovian-like systems from tens of light-years away, providing the planet has one (or more) of the following: more rapid rotation than Jupiter, a stronger magnetic field, or copious amounts of ultraviolet radiation and X-rays from its parent star. The strongest signals would likely come from a combination of all three.

Nichols calculates rough estimates that suggest, given the right conditions, as many as 40 nearby star systems could be within reach of the Low-Frequency Array

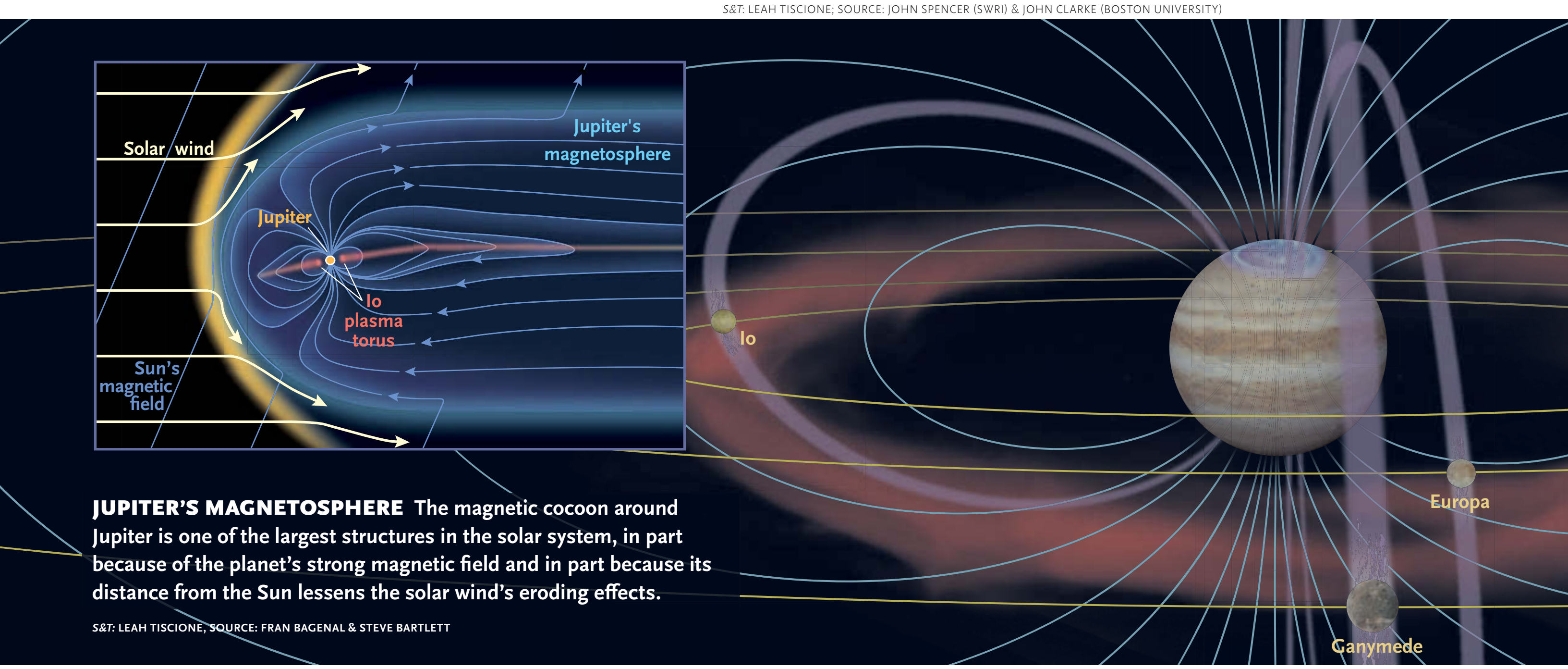
NATIONAL CENTRE FOR RADIO ASTROPHYSICS, INDIA

EXOPLANET SEARCH The Giant Metrewave Radio Telescope, a 45-meter dish in western India, is the only telescope so far that has seen hints, but no confirmations, of exoplanet radio emissions.

Though we haven't found radio signals from exoplanets yet, you can still listen to Jupiter's storms. Learn more at skypub.com/radiojove.

DONATING PLASMA *Below*: The Io-fed plasma reservoir ensures permanent Jovian auroras. Some of the moon's charged particles flow directly toward Jupiter's poles (purple tubes); others are first swept into a torus (red donut-shaped region) by Jupiter's magnetosphere. Even if an exoplanet isn't very magnetic, it could still produce radio emission by interacting similarly with its parent star.

S&T: LEAH TISCIONE; SOURCE: JOHN SPENCER (SWRI) & JOHN CLARKE (BOSTON UNIVERSITY)



JUPITER'S MAGNETOSPHERE The magnetic cocoon around Jupiter is one of the largest structures in the solar system, in part because of the planet's strong magnetic field and in part because its distance from the Sun lessens the solar wind's eroding effects.

S&T: LEAH TISCIONE, SOURCE: FRAN BAGENAL & STEVE BARTLETT

(LOFAR), which began regular observations in December 2012. LOFAR's search is still ramping up, with no exoplanet observations published so far.

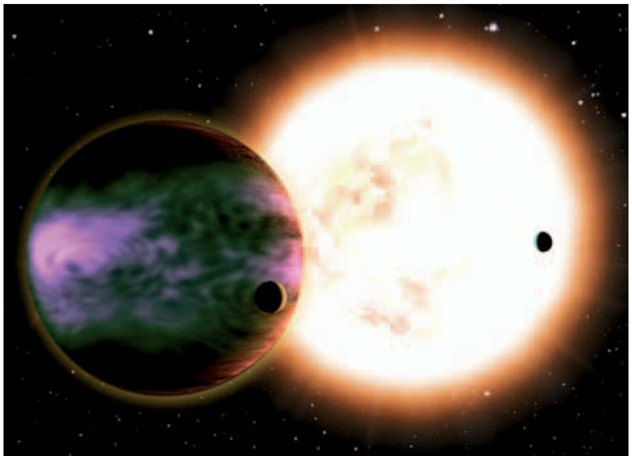
Several other radio telescopes around the world are currently hunting for radio Jupiters: the Giant Metrewave Radio Telescope (GMRT) in India, the Ukrainian T-shaped Radio Telescope (UTR-2), and the Very Large Array (VLA) in the U.S. The Long Wavelength Array in New Mexico could also be used for future observations.

The searches to date have focused on detecting a telltale outburst from known Jupiter-sized exoplanets around nearby stars. So far only the GMRT has seen hints, but no confirmations, of exoplanet radio emissions. One candidate, the hot Jupiter HD 189733b, was only marginally detected; another slightly stronger detection from HAT-P-11b, a transiting Neptune-mass planet, was not seen again during follow-up observations.

But astronomers remain optimistic, and observations continue. "If we find one extrasolar planet, we will find many. There is a huge range of ignorance," says Philippe Zarka (LESIA and CNRS-Paris Observatory, France), who was involved with the GMRT observations.

In addition to the difficulty of observing at low radio frequencies, Zarka explains that the theoretical range for detection is so wide, it's unclear if current instruments are even sensitive enough to make such detections. The first exoplanet find will also guide the wavelength range used for future monitoring.

If current technology is capable of finding exoplanets by their radio emissions, the first detection will lead the way to finding more. With a little luck, the first radio waves detected from planets beyond our solar system will open up a whole new field of exploration and insight into these faraway worlds. ✦



RADIO JUPITER This illustration shows auroras produced on a hot Jupiter as it interacts with its host star's magnetic field. Alien auroras might be very different than those in our solar system — in this case, the auroras girdle the planet's equator rather than its poles.

DAVID A. AGUILAR (CFA)

Yvette Cendes is the only person who has visited Everest Base Camp and been punched by a wild mountain gorilla on the same (long) trip. She is a doctoral student in radio astronomy at the University of Amsterdam, The Netherlands.

Discovering Jupiter's Radio Storms

When Bernard Burke and Kenneth Franklin (then at the Carnegie Institution for Science) discovered Jupiter's radio outbursts in 1955, they did so by chance. They had built a 96-acre array in rural Maryland and were using it to observe the Crab Nebula when they noticed strange bursts of interference. The noise occurred about a dozen times in three months. Looking over their data, they noticed the signal appeared earlier every night it was recorded, at a rate of four minutes per night. Burke and Franklin soon realized the bursts coincided with Jupiter's appearance in the sky.

NAPOLEON SARONY

NIKOLA TESLA The scientist and inventor may have been the first to hear radio storms raging on Jupiter, but he mistakenly attributed the signal to intelligent life on Mars.

"It was not smooth, but a very spiky noise, so we did not believe it was real," Franklin said around the time of the discovery's 50th anniversary. "Identifying the source as Jupiter was a tremendous surprise . . . It opened up a whole new field of research, the application of astrophysics to the planets."

But were the two scientists really the first to hear Jupiter? There's a possibility that Nikola Tesla heard the bursts first, say brothers James and Kenneth Corum (Tesla Society). However, the scientist and inventor infamously attributed the sporadic pulses to intelligent life on Mars.

Tesla's contemporaries discounted his discovery in part because Earth's ionosphere is generally opaque to low-frequency radio emission. But it actually becomes transparent near the frequencies Tesla was investigating, the Corum brothers point out. Furthermore, his setup might have been sensitive enough to detect extraterrestrial signals. And Jupiter was also setting late during the summer and autumn evenings of 1899, when Tesla made his observations.

Extrapolating backward from current prediction tables of Jupiter's activity, the science historians identified five windows when Jupiter's storms would have subsided just as Mars disappeared below the western horizon, circumstances which would have led Tesla to conclude the emissions came from Mars. Though it's still possible that Tesla simply heard natural very-low-frequency phenomena within the Earth's atmosphere, he may have been the first to hear radio storms from another planet.

Jupiter Since Galileo

Dean Regas

In recent years, amateur astronomers have made many of the biggest discoveries on the solar system's biggest planet.

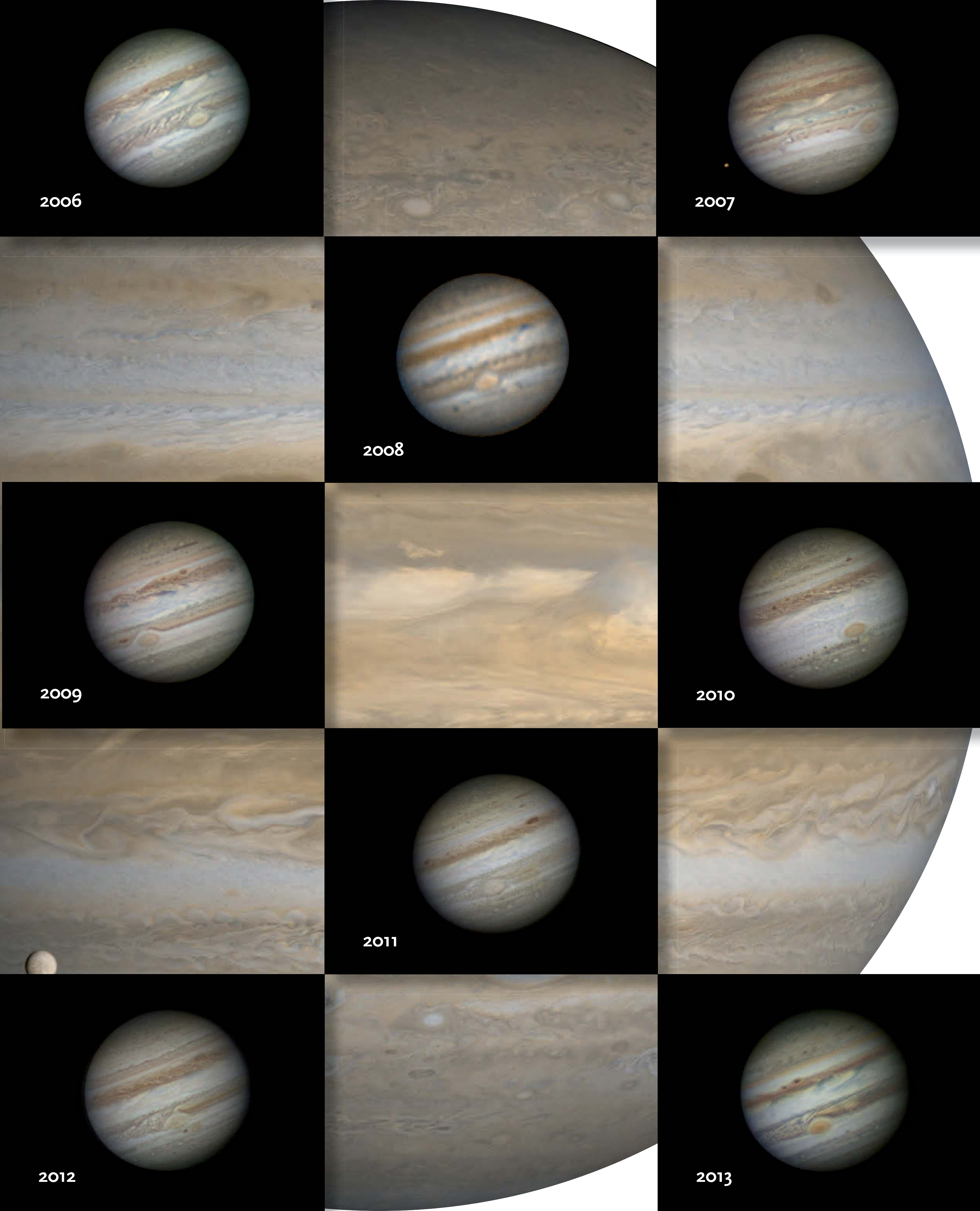
For nearly eight years NASA's Galileo spacecraft orbited Jupiter and returned images of its tumultuous, roiling atmosphere. Galileo captured video of the cyclonic whirl of the Great Red Spot and the crosscurrent eddies of the cloud bands in amazing detail. As it encountered the Galilean moons, the spacecraft provided a family scrapbook of Io, Europa, Ganymede, and Callisto. Over its 35 orbits, Galileo imaged the entire surfaces of these worlds and gave us detailed views of a planetary system in miniature.

As fuel supplies ran low, the team decided to steer the spacecraft into Jupiter. On September 21, 2003, Galileo performed its final mission. Plunging headlong into the gas giant's upper atmosphere, Galileo transmitted data from inside Jupiter right up to its demise.

For the past 10 years the giant planet has entertained only one brief visitor — NASA's New Horizons spacecraft en route to Pluto. But exploration of Jupiter did not end there. With mainly Earth-based telescopes, professional and amateur astronomers have together witnessed dramatic changes on this distant planet. This work is intensifying as Jupiter approaches opposition on January 5, 2014.

STORM CHASER
Small images: British astrophotographer Damian Peach took these pictures over 9 years. Peach and other amateurs have made major scientific contributions by monitoring the ever-changing Great Red Spot along with variations in Jupiter's belts, bands, and storms. North is up in all photos in this article.

JUPITER IN BACKGROUND: NASA / JPL


2006
2007
2008
2009
2010
2011
2012
2013

NASA / JPL / CORNELL UNIVERSITY

BIG EYE Jupiter's celebrated Great Red Spot has been observed since at least the late 1800s and perhaps much earlier. This giant anticyclonic storm system is about twice the diameter of Earth, but its size, shape, and color change from year to year for reasons that remain only partially understood. The frames in this mosaic were taken by NASA's Galileo spacecraft in 1996.

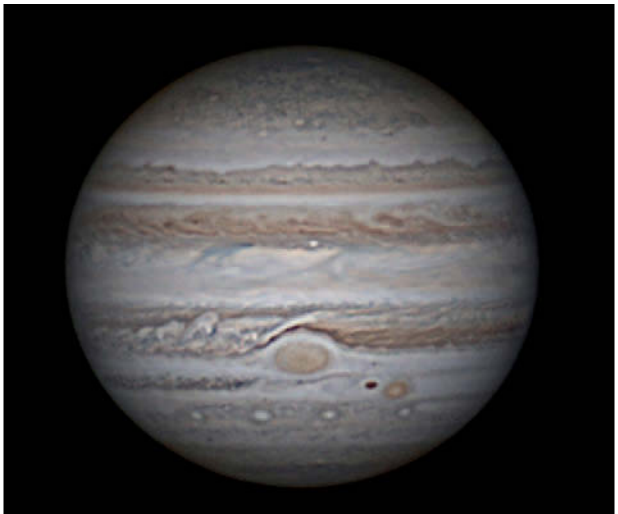
Amateurs and Pros Working Together

"Jupiter continues to surprise me," says Amy Simon-Miller, NASA's Associate Director of Solar System Exploration, who has been following the yearly changes to the cloud tops of Jupiter for the past decade. "I'm always anxious to see what Jupiter will look like when it emerges from its yearly solar conjunction — it never looks the same twice!" She collaborates with professionals and amateurs to try to make sense of all these fluctuations. Professional telescopes cannot monitor the planets full time, so they fill in the gaps with data from amateur groups.

The British Astronomical Association (BAA) is one of those groups. According to BAA Jupiter Section Director John Rogers, new cameras and free imaging software are increasing the ability of amateurs to contribute to the scientific study of Jupiter. "Images of Jupiter, taken every night by observers around the world, give continuous coverage at a resolution that previously could not be obtained even by professional observatories," explains Rogers.

Most notably, amateurs alert professionals when something really unusual occurs, such as an impact or a color change to a cloud band. Then Simon-Miller and other professionals can request time on Hubble and big Earth-bound telescopes to take a more detailed look.

Amateur scopes are set up to image in visible light. But new technologies and techniques have enabled amateurs to take data in near-ultraviolet and near-infrared wavelengths. "Amateur images are a resource that is used by professionals directly," says Rogers. "In several recent papers we have been able to combine amateur and professional observations and analysis to produce an informative synthesis."



RED SPOT JR. In 2000 two white, oval-shaped storm systems merged to produce a larger white oval. But in 2005 this system began to redden significantly and is now affectionately known as Red Spot Junior (to the lower right of the Great Red Spot in this image). Like its big brother, Red Spot Jr. also changes in size and color. David Tyler took this image on November 23, 2012.

Great Red Spot

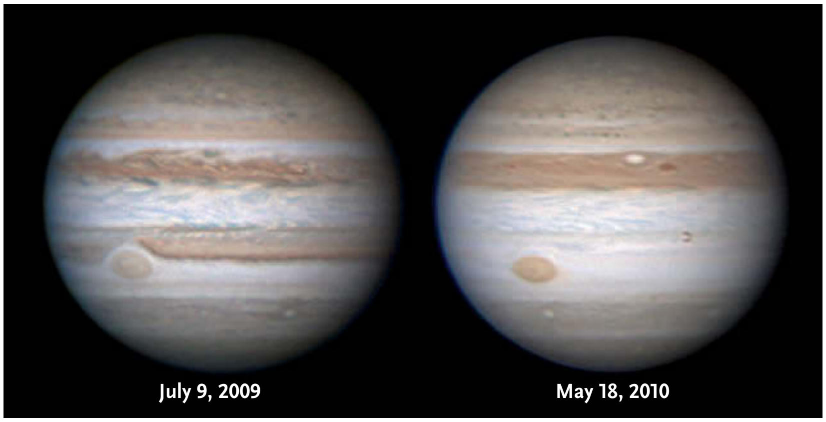
Rogers has been watching Jupiter's most distinctive feature, and largest storm, shrink before his eyes. The Great Red Spot (GRS), sketched by astronomers since at least the 1880s, is a gigantic ruddy eye — more of a Great Red Sausage. Today this anticyclone is more circular than sausage-shaped, and it is more orange than red.

Although the GRS is no longer shrinking in the north-south direction, its width slimmed down 15% between 1996 and 2006. By tracking gray streaks and other discernible, long-lasting features within the GRS, Rogers and the BAA observed the internal circulation period shorten from 4.5 days in 2006 to 4.0 days in 2012. The storm's outer wind speeds of 270 to 425 miles (430 to 680 km) per hour have not diminished — they're as ferocious as ever — but they're packed into a smaller area.

The GRS grew noticeably paler in 2011–12, but it has recently regained much of its characteristic color. In many telescopes you can locate it as a white indentation in the dark-brown South Equatorial Belt. And now, there's a new red spot in town, one about the size of Earth.

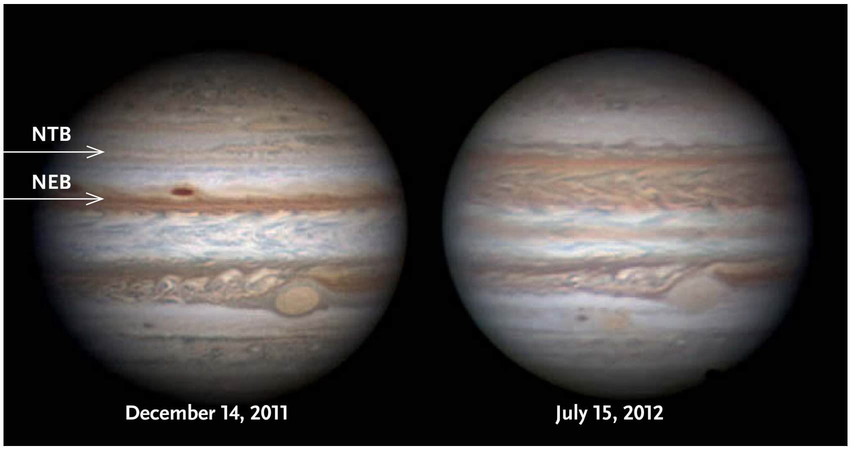
Red Spot Junior and Red III

Called Red Spot Junior, Red Jr., or the Little Red Spot, this feature formed from the merger of three 60-year-old white ovals in the South Temperate Belt (just south of the GRS). Initially, the remaining oval was white in color, but Filipino amateur Christopher Go first noted the sudden reddening in 2006. Go alerted Richard Schmude, Jr., director of the Association of Lunar and Planetary Observers (ALPO), who confirmed the color to be equal to



ANTHONY WESLEY

DISAPPEARING ACT *Jupiter images above:* Images taken by Australian amateur Anthony Wesley on July 9, 2009 and May 18, 2010 show that Jupiter's dark South Equatorial Belt (SEB), just above the Great Red Spot, had vanished, or at least turned white. The GRS had also reddened. The dark SEB came back later in 2010. *Above right:* Wesley poses with his 16-inch reflector.



CHRISTOPHER GO

BELTS AND BANDS *Jupiter images above:* Filipino amateur Christopher Go took these images on December 14, 2011 and July 15, 2012. The pictures reveal how the North Equatorial Belt (NEB) expanded and how the North Tropical Belt (NTB) darkened in early 2012. *Right*: Go poses with his Celestron C14 Schmidt-Cassegrain telescope.

that of the GRS. Thus Red Jr. was born.

The Hubble Space Telescope noted a significant increase in wind velocity in this region since the color change. This led astronomers to think that Red Jr. has reached sufficient size and ferocity to dredge up redder material from Jupiter's interior in order to tint the cloud tops just like the Great Red Spot. New Horizons confirmed these findings during its Jupiter flyby. Red Jr. is still getting stronger and is visible in moderate-sized backyard telescopes. But as Simon-Miller points out, "It's not always distinctly red. Sometimes it is mostly white with a thin red collar."

In May 2009, observing teams for the Hubble and Keck telescopes discovered one more color change in the neighborhood. Another white oval turned red in the South Equatorial Belt. This third red spot lasted only a few months before it collided with the Great Red Spot. GRS chewed up the smaller spot and spit it out in a matter of days.

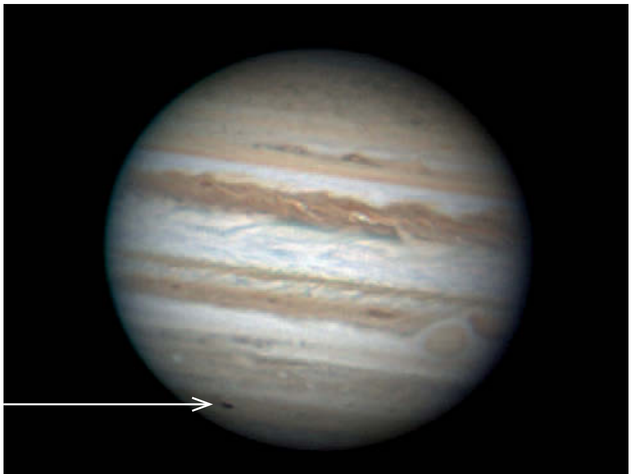
What was happening on Jupiter? New spots were impressive, but in 2010, backyard astronomers were in for a surprise. The entire South Equatorial Belt (SEB), which houses the Great Red Spot, disappeared!

Global Upheaval

The SEB has disappeared before, but it's still a dramatic event. What causes a 250,000-mile-long (400,000-km) feature to vanish? The only part of Jupiter we can study directly is a thin layer of upper atmosphere where the clouds condense. What lies below is largely a mystery, such as why certain clouds visibly rise to the top while others sink out of view.

Glenn Orton (JPL) thinks that the darker band was there all along — it was just covered up by a new layer of opaque clouds. "This sudden upheaval created a series of waves that, in a few months, had engulfed the entire planet longitudinally," says Orton.

This is just one example of a flurry of changes astronomers have observed since 2003. White bands disappeared and reappeared, and violent waves of activity (called



IMPACT! On July 19, 2009, Anthony Wesley imaged a dark spot on Jupiter (arrowed) that resulted from the first known extraterrestrial impact since Comet Shoemaker-Levy 9 rained down on Jupiter in July 1994.

revivals) increased in frequency in the North Temperate Belt and North Equatorial Belt. "It's all part of what we call a Global Upheaval, where many regions get active (or unusually quiet) over a period of years," says Simon-Miller. Astronomers don't exactly know what causes these large-scale climatic events or how long they will last, but the more they note the changes, the better they hope to understand the regions below the cloud tops that we can't see.

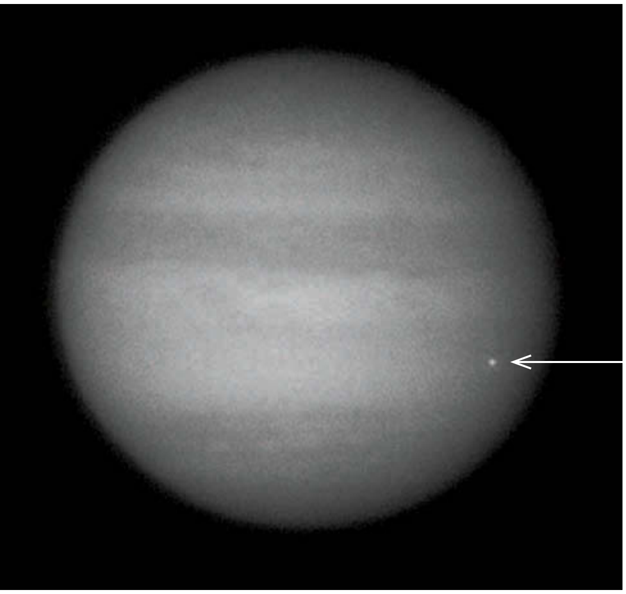
Jupiter: A Glutton for Punishment

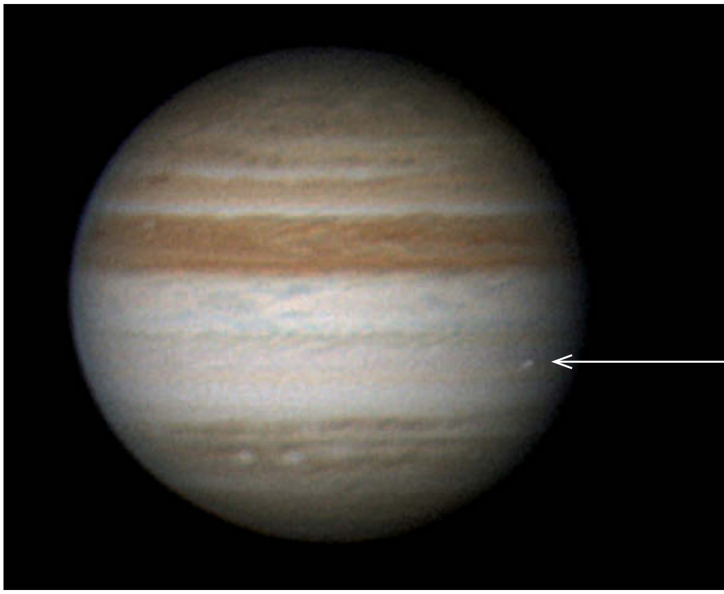
Amateurs who routinely monitor the planets will sometimes observe the right place at the right time. For Anthony Wesley, it happened not once, but twice. Around midnight on July 19, 2009, at his home observatory near Murrumbateman, Australia, Wesley was about to pack up his 14.5-inch reflector for the evening. Just as he was about to click "exit" on his computer, he changed his mind and, "decided instead to simply take a break for 30 minutes and then check back to see if the conditions had improved. It was a very near thing," Wesley wrote in his report.

When he returned to the scope, he noticed a faint black spot on the eastern limb of Jupiter's South Polar Region. At first he couldn't believe his eyes. What was that thing? He ruled out a transiting moon or a moon shadow. Watching it a little longer, the black smudge rotated in synch with other surface features. Wesley consulted his images taken of the same region two days earlier and saw no black spot. "I simply had to convince myself that I wasn't dreaming and that this mark was real," Wesley recalls.

Over the next 30 minutes Wesley hurriedly processed the sharper image and started e-mailing other astronomers. "I had to take a chance and send out an e-mail alert straight away, just in case it really was an impact," he says. Since the only other observed planet impact was Comet Shoemaker-Levy 9 hitting Jupiter in 1994, Wesley was understandably cautious.

Glenn Orton was delighted when he heard about the potential impact. Within 20 hours of Wesley's observation, Orton altered his planned observations with NASA's Infrared Telescope Facility (IRTF) on Mauna Kea to observe Jupiter. He confirmed the mark as an impact site. Keck, Gemini North, the Very Large Telescope, and Hubble also viewed the evolution of the atmospheric aftereffects over the following weeks. Astronomers extrapolated the incoming trajectory of the object and uncovered its make-up. "The most surprising thing is that the impactor was more likely to be rocky than icy," says Orton. The culprit was most likely an asteroid, not a comet. "This was unlike Shoemaker-Levy 9, which was definitely a comet."





ANOTHER STRIKE Wesley (*left*) and Go (*right*) simultaneously captured an impact flash at 20:31:29 UT on June 3, 2010. Unlike the previous year's impactor, this object was not big enough to leave a mark.

On June 6, 2010, Wesley was visiting a friend in Broken Hill, Australia (about 600 miles from his home). He had his telescope and camera with him and was imaging Jupiter when at 6:20 a.m. he saw a flash on the Jovian surface that lasted just over a second. Luckily, he was recording at the time, and captured the flash on video. He immediately knew it was another large meteor impact.

In the Philippines, Christopher Go also captured video of the flash and contacted Orton to press the major observatories into service. This impact was much smaller than the one in 2009 and did not leave any mark. By the time professional telescopes searched for it, the impact site was gone.

2012 Impact

On September 10, 2012, at 6:35 a.m. CDT, amateur Dan Petersen had his eye at the eyepiece at the right time. From his backyard observatory in Racine, Wisconsin, he had his research-grade Meade 12-inch LX200 Schmidt-Cassegrain trained on Jupiter. Suddenly, he saw a faint blip appear and disappear on the planet's eastern limb in only two seconds. After a moment of utter surprise, Petersen knew right away what he saw.

He immediately called nearby Yerkes Observatory. There, astronomer Kyle Cudworth recommended that he make an official report of his "Jupiter fireball" with the IAU's Central Bureau for Astronomical Telegrams website. Then Petersen e-mailed Richard Schmude of ALPO, John Rogers at the BAA, and Christopher Go. Up to this point no one else had reported the Jupiter flash.

Later in the morning, Petersen posted a thread on Cloudy Nights titled, "I observed an explosion on Jupiter this morning!" Says Petersen, "I was hoping to alert fellow imagers as to what had just happened on Jupiter, so they could start imaging the planet in the event that a dark impact scar or debris field had developed within Jupiter's cloud tops."

Amateur George Hall went out that morning and imaged Jupiter from his driveway in Dallas, Texas. Using a Point Grey Research Flea3 video camera attached to his Meade 12-inch LX200 with a filter and a Tele Vue 3× Barlow, Hall recorded images almost continuously between 5 and 7 a.m. "I didn't notice anything unusual while recording the video and spent most of the day processing the clips and attempting to make a 'pretty' image of Jupiter," Hall recalls. "Looking for an asteroid impacting Jupiter was the furthest thing from my mind."

That afternoon Hall browsed Cloudy Nights and read Petersen's post. He cued up the video clip from 6:35 a.m. and there it was — a flash visible on 22 frames. "Once I saw the video," says Hall, "there was no question in my mind that it was an impact." He responded to Cloudy Nights and posted the video. Amateur observers confirmed the similarity to the 2009 and 2010 impacts and within 24 hours Hall's video appeared on dozens of blogs, websites, and on local and national television.

GEORGE HALL / RICARDO HUESO

JUPITER HIT AGAIN At 6:35 a.m. local time on September 10, 2012, Wisconsin amateur Dan Petersen saw a flash on Jupiter. After reading about this visual sighting on the internet, Texas amateur George Hall examined video he took that morning, and found 22 frames showing a bright spot presumably due to an impact. Thanks to these amateur detections, we now know that Jupiter suffers more pummeling than previously thought.

For links to organizations that monitor Jupiter, visit skypub.com/JupiterWatchers.

Amateur Chroniclers

That magical morning impacted Dan Petersen's view of astronomy: "This is one science where amateurs can still make important discoveries and significant contributions to our understanding of the solar system and beyond."

George Hall continues to take video of Jupiter whenever the conditions are ideal. He's still amazed that he was the only person in the world imaging Jupiter at the precise moment of impact. Given the rarity of impacts, he doesn't expect it to happen again to him. "But on the other hand," Hall muses, "the impact that I captured saturated my camera for a dozen or more frames in a row. It's obvious that my equipment could detect much fainter impacts that occur at a much higher frequency."

Glenn Orton shared some observing tips with Anthony Wesley regarding the filter used on the IRTF to confirm his 2009 discovery. "Since then I have purchased that same filter for my own scope," says Wesley. "So if something like this ever happens again, I can do the same analysis straight away."

The solar system is an unpredictable, dynamic realm. Until NASA's Juno spacecraft arrives in the Jupiter system in 2016, only Earthbound observers can chronicle Jupiter's changing cloud tops. Although Hubble and other professional observatories are amazing, amateur astronomers can still make a real contribution by collecting planetary data with their humble backyard telescopes. ✦

Dean Regas *is the Outreach Astronomer for the Cincinnati Observatory and co-host of the syndicated PBS program* Star Gazers. *His e-mail is dean@cincinnatiobservatory.org.*

Comet ISON's Final Act

Comet ISON might be putting on a gorgeous display as you read these words . . . or maybe not.

Robert Naeye

As I write these words in late October, we still don't know whether Comet ISON (C/2012 S1) will be a spectacle or a speck. Some signs are encouraging — the nucleus seems to be intact and only one side is being exposed to the Sun. But the comet was not brightening according to optimistic predictions. In a status update posted on October 15th, comet authority Zdenek Sekanina (JPL) wrote, "C/2012 S1 is looking reasonably healthy but not exuberant."

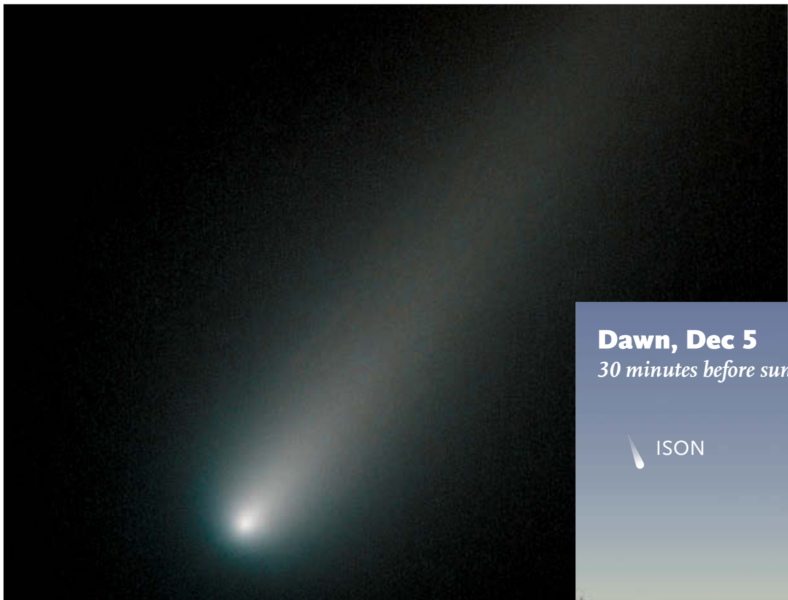
Observations suggest that ISON has sufficient size and tensile strength that it will not break apart prior to reaching perihelion on November 28th (Thanksgiving Day in the U.S.). But there remains a wide range of possibilities over what will happen before, during, and after its close brush with the Sun, only 730,000 miles (1.17 million km) above our star's visible surface (photosphere).

As the comet is increasingly exposed to the Sun's searing heat and tidal forces, its nucleus could disintegrate before perihelion, with uncertain ramifications for observers. Alternately, exposure of new surface regions to sunlight could trigger a significant release of volatile material, making the comet much brighter. It could break apart after perihelion, liberating a huge quantity of fresh ices and dust, greatly brightening the comet's head and tail — in which case ISON could actually live up to its hype as "the comet of the century." Or ISON could survive after a modest visual display and head back to the outer solar system, not to return for hundreds of thousands of years.

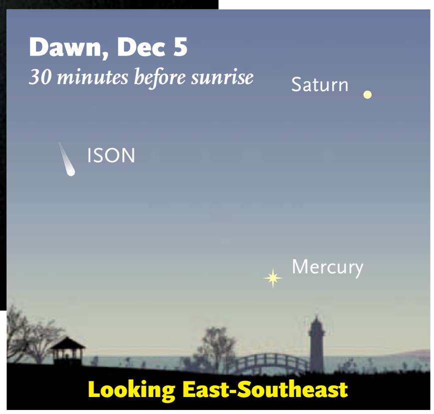
Comet expert John Bortle says a key sign of what we can expect from ISON after Thanksgiving will be revealed by the tail around December 3rd. "If the tail is visually short but bright, say 5 to 7 degrees long, and if it can be spotted in the brightening dawn twilight by that date, then something spectacular will almost certainly be in the offing for observers by 10 to 15 days after perihelion."

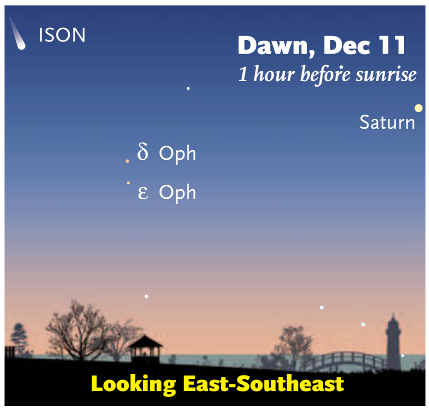
For the first week of December, look low in the east-southeast 30 minutes before sunrise as shown in the maps below. If the comet is spectacular 10 to 15 days after perihelion (December 8th–13th), you will have no trouble finding it in the east-southeast in the hour before sunrise. Comet ISON will gradually fade in mid-December as it climbs higher in the sky, into the constellations of Serpens, Hercules, then Corona Borealis, and will be visible up to 90 minutes before sunrise (see last month's issue, page 33). But we expect the show to be largely over by the final week or two of December, and the comet (or whatever remains of it) will be visible only in telescopes. ✦

For up to date information, visit skypub.com/ISON.
Visit skypub.com/photocontest for information about our comet photo contest.



ISON INTACT The Hubble Space Telescope captured the comet on October 9th. There are no signs of fragments, suggesting that ISON's nucleus remains intact.





The Messier Open Clusters of Winter

Bright, beautiful, and easy to locate, these old friends are always worth revisiting.

Rod Mollise

As a novice astronomer, I loved to observe the Messier open clusters, those loose collections of young stars. They were easier to find than dim galaxies and looked good in my small telescope from suburban skies. I still think they're wonderful. M37, for example, stacks up well against the best globular star cluster, nebula, or galaxy.

Winter, with the arch of the Milky Way stretching overhead, is a great time to visit the Messier clusters. Included in this tour are my seasonal favorites, and a few even contain some "lagniappe," a little something extra, for observers old and new. All of the clusters in this tour are plotted on the all-sky chart on page 44.

M45, the Pleiades cluster, rides high all evening long in the winter. It's so prominent that many people mistake its tiny dipper-shaped asterism for the Little Dipper, Ursa Minor. The cluster is both close (around 400 light-years away) and young — about 100 million years old — and looks it with blue-white stars as bright as magnitude 3.

If anything prevents M45 from being the best Messier cluster, it's size. The dipper alone measures 1° across, and outlying stars increase that to 2°. So you need a small, wide-field telescope or binoculars to take in the entire cluster. But M45 is magnificent even in the 8-inch and 12.5-inch scopes that I used for most of the observations in this article — littered with countless diamond stars in a low-power field of view.

M45 rewards persistence and observing experience. It's drifting through and illuminating an unrelated cloud of dust. The icy blue nebulosity enrobes the brightest cluster stars, especially 4.1-magnitude Merope, and appears quite prominent in photographs (see page 47). The Merope Nebula, often described as "baby's breath on a mirror," isn't easy to see through an eyepiece, but I usually catch traces of it from dark sites with my wide-field 4-inch f/4 scope.

Northeast of M45, the great pentagon-shaped constellation Auriga holds three excellent groups: M36, M37, and

ALL PHOTOS A. AYIOMAMITIS UNLESS OTHERWISE NOTED

M35 and NGC 2158 are both very rich clusters, but M35 is about 3,000 light-years distant and 100 million years old, whereas NGC 2158 is roughly four times farther and ten times older.

POSS-I / CALTECH / PALOMAR OBSERVATORY

M38, which my father and I called "The Big Three" on the long-ago evenings when we would observe together.

I always stop at **M37** first. It's not only the best of the Auriga Three, it may be the finest open cluster in the northern sky. It's a huge cloud of more than 500 stars, so rich that it looks like a globular cluster in my 66-mm refractor. At a size of 14′ across, M37 is well framed in almost any telescope, and the bright combined magnitude of its stars, 5.6, makes it a showpiece.

Other than M37's sprawling shape, which reminds me of a spider suspended in its web, its prime attraction is its central star. Like quite a few clusters, M37 has a red-orange star located near its heart (see the box on page 40).

M36 and M38 pale in comparison to M37, but they're also excellent. Each is composed of a couple of dozen stars of magnitude 8–10 and legions of dimmer ones. **M38** is the larger of the two (20′ across and shining at magnitude 6.4), so it's best in a wide-field eyepiece. Its twisting chains of bright stars are overlaid on an oval of dimmer ones.

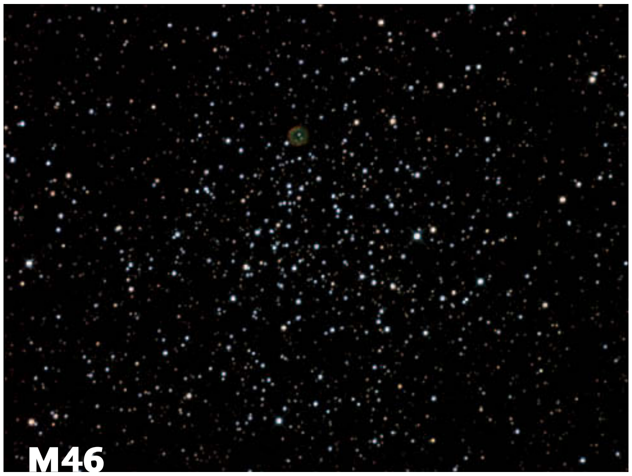
M36 shines at magnitude 6.0, slightly brighter than M37, but it's only half the size, 10′ in diameter. At 150×, my 8-inch reveals a clump of 30 to 40 blue-white suns. Under a dark sky, my 12.5-inch Dobsonian pulls out 50 or more, and begins to show a few pale yellow stars.

Gemini's **M35**, another favorite of mine, isn't as compact as M37 and doesn't have that "loose globular" look. It's larger, 25′ across, and whereas the combined light of its estimated 400 stars is in fact brighter, magnitude 5.1, it doesn't *seem* as bright as M37 to me. In my 8-inch telescope, crowds of dimmer stars fill the field of a medium-power eyepiece, and two strings of 8th-magnitude gems seem to form the numeral "7."

That's not all there is to M35. The lagniappe, which makes it fully the equal of M37, is **NGC 2158**, a distant cluster located a degree to the west. Under dark skies, NGC 2158 is visible in a 6-inch telescope as an unresolved cloud 5′ across. Seeing nearby M35 (roughly 3,000 light-years away) in the same field with distant NGC 2158 (11,000 light-years) gives me a true feel for the depth of space.

East of Orion is the lackluster constellation Monoceros, the Unicorn. It may be dim, but it contains a spectacular cluster, **M50**. This group stands out because of a size that's perfect for most telescopes (15′), a bright magnitude (5.9), and a distinctive shape. Years ago, I was surprised to hear M50 referred to as the Heart Cluster. All I'd ever seen there was a bunch of stars 8th-magnitude and dimmer. But once I knew I should see a heart, that's exactly what I saw: two looping chains of bright stars forming a big valentine.

Puppis, the Poop Deck, is just south of Canis Major. It's high enough to be out of the muck near the horizon



by 10 p.m. on early winter nights. Two outstanding Messiers float in its northwest corner: M47 and M46. **M47** is bright and bold at magnitude 4.4. The main body of the group is made up of a dozen stars, magnitude 6 to 9, stretching across a 25′ background of dimmer ones. If ever a star cluster could be described as "diamonds on black velvet," this is it.

At 20′ across its longest dimension, **M46** fits perfectly in the field of my 8-inch f/10 telescope at medium power. It's fainter than M47, magnitude 6.1, but it's also much richer. In addition to a handful of stars ranging from magnitude 8 to 10, which form a rectangular shape, there are several hundred dimmer ones down to magnitude 14 and fainter.

Take a good look at M46 and you'll get a surprise. The tiny 11th-magnitude planetary nebula **NGC 2438** peeps out among the cluster's stars. It's visible in a 4-inch, and an 8-inch telescope at 200× reveals a tiny ring shape superposed on two close cluster stars. Opinions have varied as to whether this planetary nebula is a member of M46, but today we think it's a foreground object that just happens to be along our line of sight to the cluster.

When I finally pull myself away from M46, it's late and the dew is getting heavy. Time for a warm drink and a few minutes contemplating the wonders I've seen. On the cosmic timescale, open clusters, nests of relatively young stars, are temporary objects that will disperse as their members wander off under the influence of gravity. But for ephemeral creatures like me, they're as eternal as the sky itself and will be there for my telescope over a lifetime of clear nights. ✦

Contributing editor ***Rod Mollise*** *observes the night sky from his home in Mobile, Alabama.*

Cluster Science Through Backyard Telescopes

Open clusters aren't just eye candy; you can tell a lot about them by their appearance through a telescope. Most obviously, nearby clusters such as the Pleiades are easy to resolve in small telescopes because their individual stars appear brighter. Nearby clusters also tend to appear bigger.

Young clusters such as M35 tend to have stars that vary widely in brightness. Massive young stars shine bright and blue, and they use up their fuel rapidly. In mature clusters such as M46, the brightest stars have already burned out, leaving the remaining stars much more uniform in appearance.

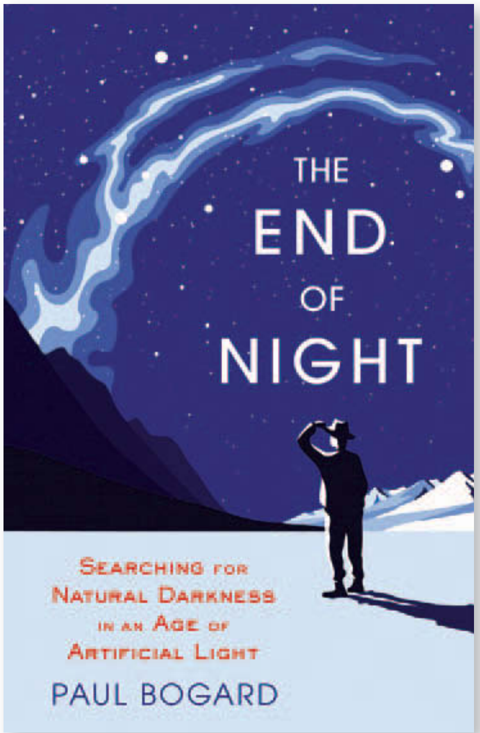
Massive stars migrate inward as a cluster ages, so a mature cluster's brightest stars tend to be near the center. Often, as in M37, these central stars appear red because they have entered their red-giant phase, the last stage before turning into white-dwarf embers.

Young clusters can be fairly sparse in stars, like M36, or extremely rich, like the incomparable Double Cluster in Perseus. But most old clusters are rich, because only the combined gravity of many stars can hold a cluster together for long against the tidal force of the galaxy. That's especially true for clusters near the plane of the Milky Way, where the tidal forces are strongest.

— ***Tony Flanders***

Seeking Dark Skies

The End of Night: Searching for Natural Darkness in an Age of Artificial Light



Paul Bogard
Little, Brown and Company, 2013
325 pages, ISBN 978-0-316-18290-4, $27.00, hardcover.

EXPLAINING LIGHT POLLUTION to those who live in cities and suburbs can be a challenging task, but Paul Bogard has done a masterful job in his new book *The End of Night*.

The book's premise is a search for the few remaining truly dark spaces on Earth's land surface. The author visits some of the world's darkest places, such as Natural Bridges National Monument in Utah and the Moroccan desert. In an engaging and pleasantly readable style, Bogard, an English professor at James Madison University, elicits fond memories of Leslie Peltier's *Starlight Nights*. In both books the authors describe the immense joy and the soaring of the human spirit that occur when observing a beautiful night sky filled with stars. Bogard laments that most humans alive today have never seen the majesty of a truly dark sky, where an arching Milky Way can be bright enough to cast shadows. Even in the few remaining dark places, one can often see some evidence of light pollution on the horizon.

In the course of the author's search, he discusses light pollution with notable activists around the globe. Readers will learn of the environmental damage caused by excess and unnecessary lighting. Given that all life on Earth has evolved with a day/night cycle, it should come as no surprise that our uncontrolled experiment of banishing the dark can affect human and animal physiology. Evidence mounts of increased sleep disturbances, depression, weight gain, and diabetes in heavily light-polluted areas. The glare of poorly designed streetlights harms night vision while driving, an effect made much worse with increasing age.

Some readers might be startled that certain hormonally influenced cancers are significantly increased in light-polluted areas (*S&T*: September 2011, page 86). The pineal gland of all animals, including humans, produces the hormone melatonin in the dark (sleep is not needed). But nighttime lighting markedly diminishes the release of this chemical. As an agent of our immune system, melatonin suppresses many hormonally active cancers such as breast and prostate cancer. In 2007 the World Health Organization listed night-shift work and its subsequent melatonin suppression as a Group 2A carcinogen. Although numerous recent scientific papers highlight these unexpected findings, Bogard's book presents the complex scientific data in a readable, understandable, and accurate format.

With its beautifully written narrative and its coverage of many different angles, *The End of Night* is a valuable book for those wanting to learn more about the insidious effects of widespread light pollution and the beauty of nature that is lost if society fails to correct this problem. ✦

---

*Amateur astronomer and cardiologist **Mario Motta** is President of the American Association of Variable Star Observers and serves on the American Medical Association's Council on Science and Public Health. He also serves on the Board of Directors for the International Dark-Sky Association.*

In This Section

PHOTOGRAPH: NASA / ESA / HUBBLE HERITAGE TEAM
NGC 1275, the brightest galaxy in the Perseus Cluster, is a massive elliptical with an active nucleus; see page 58.

Additional Observing Articles:

Sky at a Glance

JANUARY 2014

1 **DUSK:** Skilled telescope or binocular observers in the western ¾ of North America may be able to spot a nearly record-thin young Moon shortly after sunset; see page 52.

2 **DUSK:** The thin crescent Moon poses beautifully to the upper left of Venus 45 minutes after sunset. In western North America, binoculars and telescopes may show the Moon occult (hide) the wide double star Beta Capricorni.

3 **PREDAWN:** The short-lived Quadrantid meteor shower may be underway before dawn in western North America; see page 51.

5 **ALL NIGHT:** Jupiter is at opposition: rising around sunset, setting around sunrise, and almost at its biggest and brightest for 2014; see page 50.

11 **VENUS** is at inferior conjunction, passing 5° north of the Sun. This is when its crescent appears thinnest and longest through a telescope. Try to catch it just after sunset before this date, and just before sunrise after this date.

14 **EVENING:** Jupiter shines left of the full Moon.

22, 23 **DAWN:** The waning gibbous Moon is lower right of Mars on the 22nd. On the 23rd it's lower left of Mars and very close to Spica.

25 **DAWN:** Saturn shines only 1° or 2° from the waning crescent Moon (for North America).

28, 29 **DAWN:** The crescent Moon shines near Venus.

31 **DUSK:** The very thin crescent Moon shines lower right of Mercury very low in the west-southwest.

Planet Visibilty

SHOWN FOR LATITUDE 40° NORTH AT MID-MONTH

	◄SUNSET	MIDNIGHT	SUNRISE►
Mercury	SW	Visible January 17 through February 7	
Venus	SW	Visible at dusk through Jan. 8 and at dawn starting Jan. 13	SE
Mars		E	S SW
Jupiter	E	S	NW
Saturn			E S

Moon Phases

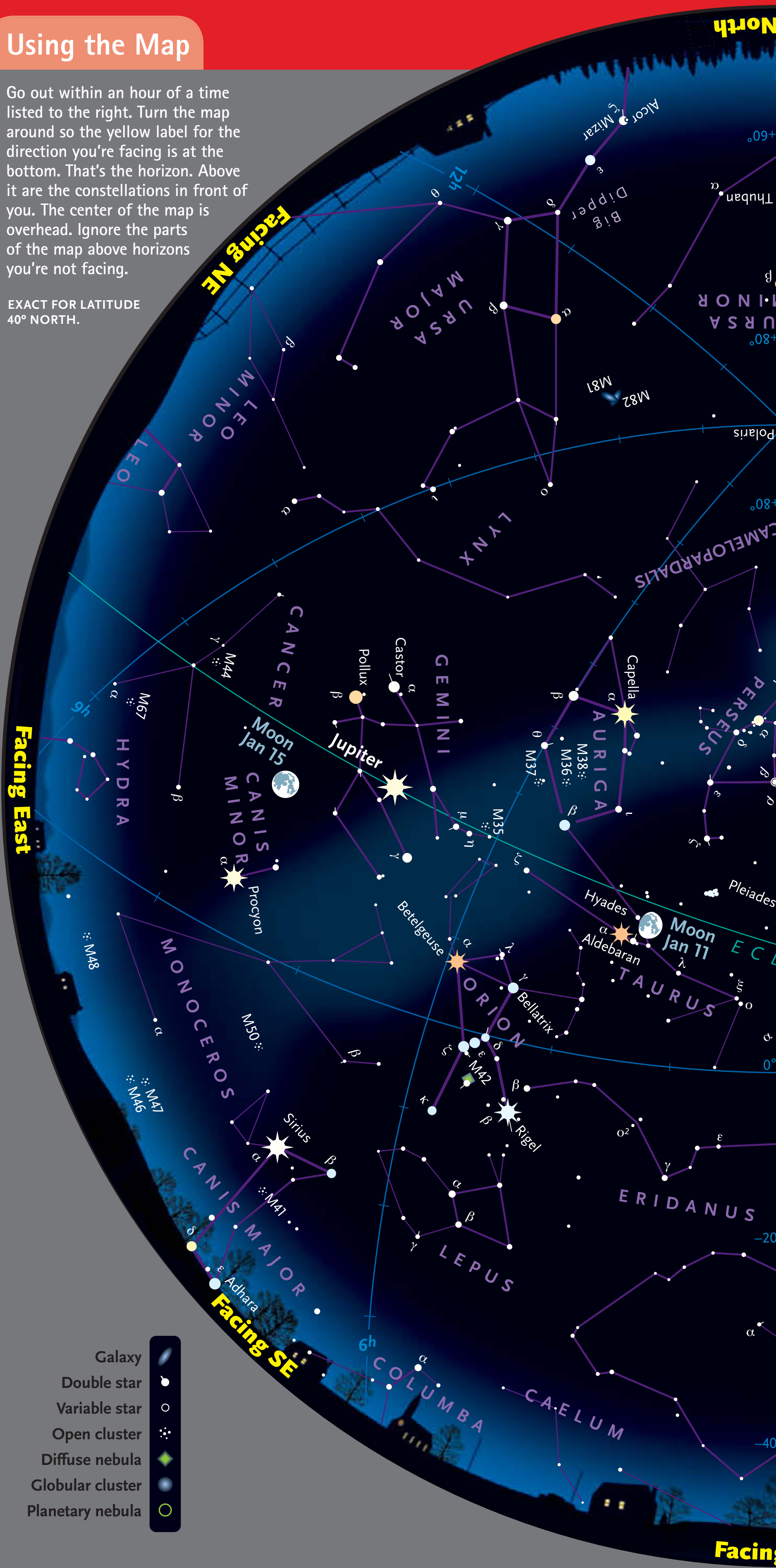
New	January 1	6:14 a.m. EST
First Qtr	January 7	10:39 p.m. EST
Full	January 15	11:52 p.m. EST
Last Qtr	January 24	12:19 a.m. EST
New	January 30	4:39 p.m. EST

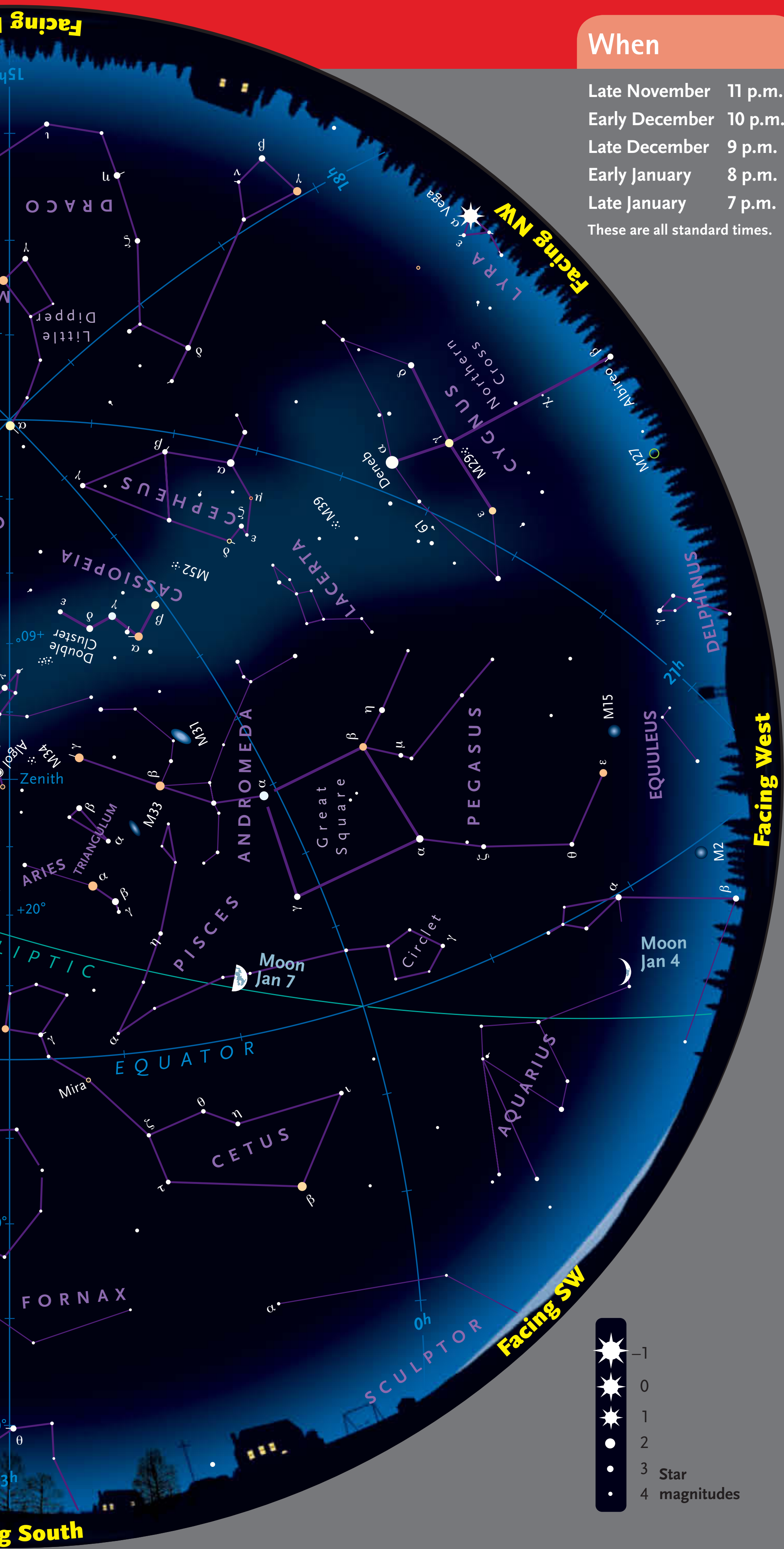
SUN	MON	TUE	WED	THU	FRI	SAT
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	

Using the Map

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

EXACT FOR LATITUDE 40° NORTH.





When

Late November	11 p.m.
Early December	10 p.m.
Late December	9 p.m.
Early January	8 p.m.
Late January	7 p.m.

These are all standard times.

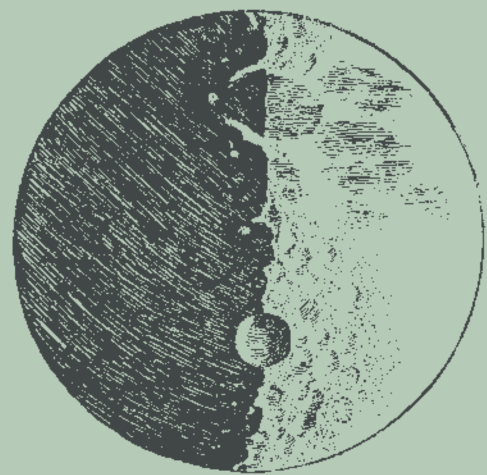
In Galileo's Footsteps

It's very easy to take for granted all the optical wonders at our disposal today. For example, can you imagine what Galileo would think if he could try a pair of modern 10×50 binoculars? True, his telescopes did offer more magnification (mainly 20× to 30×), but when it comes to optical quality, there's no contest. As it happens, this month you have the opportunity to use your binoculars to duplicate all the great astronomer's solar system discoveries.

To begin, turn your binos on the Moon. Even 7× glasses are powerful enough to show that the lunar surface is far from being a perfectly smooth sphere. If you scan near the terminator, you'll be able to pick out dozens of craters — anything bigger than a few tens of kilometers wide is fair game. Like Galileo, you'll be able to appreciate the Moon's "rough and unequal surface."

Next, it's not for nothing that Jupiter's four biggest and brightest satellites are known as the Galilean moons. Chalk up another victory for the Renaissance astronomer's little scope, and your binoculars. Of the four moons, Io is going to give you the most trouble because it never strays far from big Jupiter. Consult the "corkscrew" diagram on page 52 to identify which satellite is which on a given night.

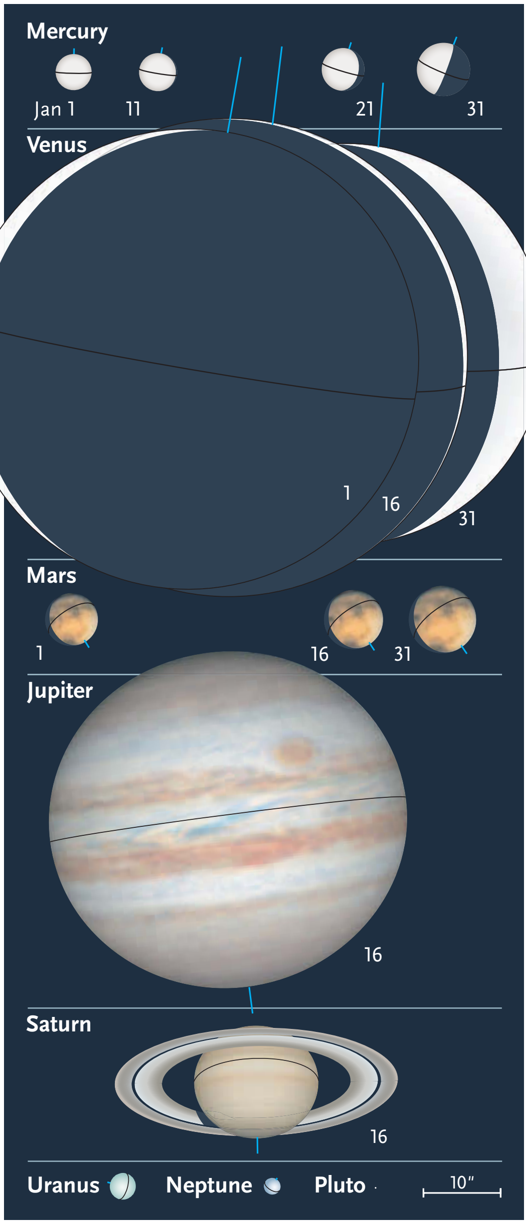
Galileo was also first to note the phases of Venus and to perceive Saturn's rings, even if the true nature of the rings eluded him. The best I can usually do with Saturn in binos is note that the planet clearly appears out of round. As for Venus, the best time to see its phase is when the planet is a slender crescent, as it is at the beginning of January, situated low in the western evening sky. ✦



Here is one of Galileo's first Moon sketches. Can you do better sketching the view through your binoculars?

Watch a SPECIAL VIDEO

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

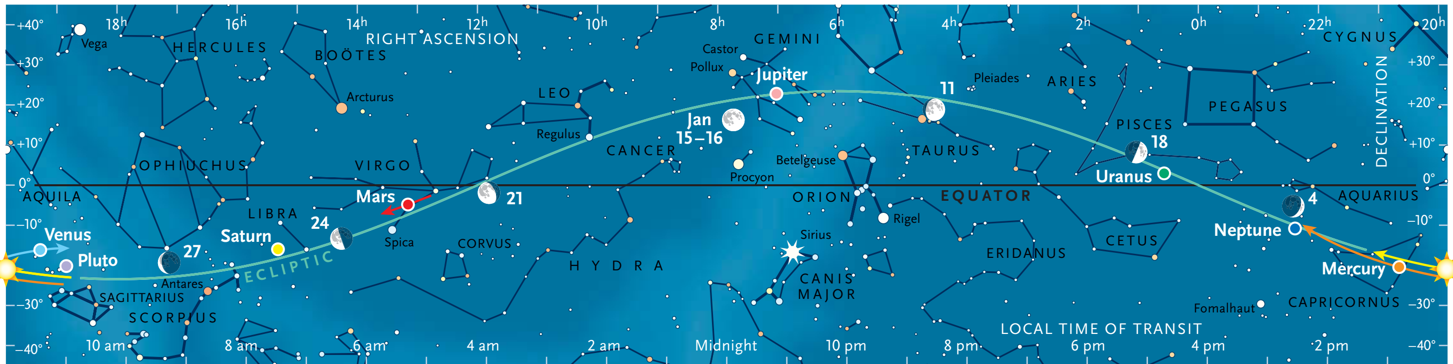


Sun and Planets, January 2014

	January	Right Ascension	Declination	Elongation	Magnitude	Diameter	Illumination	Distance
Sun	1	$18^h\ 44.8^m$	–23° 02′	—	–26.8	32′ 32″	—	0.983
	31	$20^h\ 53.1^m$	–17° 31′	—	–26.8	32′ 28″	—	0.985
Mercury	1	$18^h\ 52.4^m$	–24° 45′	2° Ev	–1.3	4.7″	100%	1.433
	11	$20^h\ 03.5^m$	–22° 34′	8° Ev	–1.0	4.9″	97%	1.363
	21	$21^h\ 11.7^m$	–17° 52′	14° Ev	–0.9	5.5″	86%	1.214
	31	$22^h\ 05.0^m$	–11° 36′	18° Ev	–0.7	6.9″	56%	0.972
Venus	1	$19^h\ 52.8^m$	–18° 15′	17° Ev	–4.4	59.6″	4%	0.280
	11	$19^h\ 28.9^m$	–16° 44′	5° Ev	—	1′ 02.7″	0%	0.266
	21	$19^h\ 05.2^m$	–15° 55′	16° Mo	–4.4	59.3″	4%	0.281
	31	$18^h\ 55.2^m$	–15° 51′	28° Mo	–4.8	51.9″	12%	0.321
Mars	1	$12^h\ 45.5^m$	–2° 32′	89° Mo	+0.8	6.9″	90%	1.365
	16	$13^h\ 08.6^m$	–4° 45′	98° Mo	+0.6	7.7″	91%	1.215
	31	$13^h\ 27.6^m$	–6° 28′	108° Mo	+0.3	8.8″	91%	1.067
Jupiter	1	$7^h\ 09.1^m$	+22° 37′	174° Mo	–2.7	46.8″	100%	4.213
	31	$6^h\ 52.8^m$	+23° 04′	151° Ev	–2.6	45.7″	100%	4.318
Saturn	1	$15^h\ 13.3^m$	–15° 41′	50° Mo	+0.6	15.9″	100%	10.482
	31	$15^h\ 22.0^m$	–16° 10′	79° Mo	+0.5	16.6″	100%	10.036
Uranus	16	$0^h\ 33.2^m$	+2° 51′	73° Ev	+5.9	3.5″	100%	20.296
Neptune	16	$22^h\ 22.5^m$	–10° 52′	38° Ev	+8.0	2.2″	100%	30.749
Pluto	16	$18^h\ 49.4^m$	–20° 13′	14° Mo	+14.2	0.1″	100%	33.533

The table above gives each object's right ascension and declination (equinox 2000.0) at 0h 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-January; the colored arrows show the motion of each during the month. The Moon is plotted for evening dates in the Americas when it's waxing (right side illuminated) or full, and for morning dates when it's waning (left side). "Local time of transit" tells when (in Local Mean Time) objects cross the meridian — that is, when they appear due south and at their highest — at mid-month. Transits occur an hour later on the 1st, and an hour earlier at month's end.

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

Fred Schaaf

The Seven Sisters

The sky's finest naked-eye star cluster is always worth another look.

A new year makes us unusually conscious of time. So I'd like to take a new look at the splendid Pleiades cluster as it relates to time: its appearance in different seasons, its role as a timekeeper for various cultures, and the time in Earth's history that the cluster has been in existence.

Observing the high Pleiades of winter. The Pleiades cluster (M45) is irresistible in autumn, when its stars first rise into the evening scene. But it's easy to lose sight of this cluster as it climbs high in the sky, so that you have to crane your neck upward to see it.

But let's not overlook the aspects of the Pleiades that are best seen on January evenings, when the cluster is the most spectacular object on the sky's central meridian. It's an oasis of brightness. This perception comes partly from the dim stellar desert that spans most of the southwest — but also from the surprising lack of moderately bright stars within a binoculars' field width of the Pleiades. Look through the eyepiece as you swing a telescope toward the Pleiades and you will have the amazing experience of traveling through darkness until the Pleiades' burst of brilliance suddenly swims into your field.

It's also best to view the Pleiades near the zenith if you want to count how many of them you can glimpse with your unaided eyes. As far as I know, the record for most Pleiades stars seen naked-eye is 18, by the late, great *Sky & Telescope* columnist Walter Scott Houston.

Turning your gaze away from the Pleiades when they're on the meridian, you'll see that Deneb is soon to set, Regulus is rising, and the Big Dipper stands upright on its handle.

Pleiadean new years. Most people now begin their civil calendar with January, about 10 days after the December solstice. But the ancient Druids began their year when the Pleiades rose at nightfall and climbed highest in the middle of the night — celebrated with a festival called Samhain, which later gave rise to Halloween. The 19th-century astronomy author Agnes Clerke noted that many primitive cultures based their new years on the Pleiades. She also wrote that "on the day of the midnight culmination of the Pleiades . . . no petition was presented in vain to the ancient kings of Persia" and that the stars of the Pleiades "take the place of a farming-calendar to the Solomon Islanders."

Galileo's Pleiades. The International Year of Astronomy, 2009, commemorated the 400th anniversary of Galileo's first telescopic observations. The Pleiades are roughly 400 light-years distant. So when you view the cluster, you're seeing light that originated around the time that Galileo first turned his telescope to the sky.

NASA / ESA / AURA / CALTECH / POSS-I

Photographs show that the Pleiades cluster (M45) is passing through and illuminating an unrelated cloud of gas and dust. But the nebulosity is quite difficult to detect visually.

The flowering of the Pleiades. Thirty years ago astronomers estimated the Pleiades' age to be about 50 million years. Walter Scott Houston noted this meant that the dinosaurs never got to see the Pleiades, and Carl Sagan wrote that the Pleiades first blossomed into view from their parent nebula around the time that the first flowers opened on Earth.

Recent estimates place the cluster's age anywhere from 70 to 120 million years. The stars aren't quite eternal, but they change more slowly than almost anything else we see. It's not surprising that the 14th-century Persian poet Hafiz of Shiraz wrote to a friend: "To thy poems Heaven affixes the Pearl Rosette of the Pleiades as a seal of immortality." ✦

A Month for Venus and Jupiter

The two brightest planets are on especially fine display.

January 2014 begins with Jupiter rising and Venus setting at dusk. This is the month when both planets are closest to Earth, so they look spectacular through telescopes — Venus as a superthin crescent close to the Sun, and Jupiter as a large, fully illuminated disk opposite the Sun.

January also features brightening Mars beginning to rise before midnight and reaching its highest in the south before dawn. By the end of January, Saturn too is high in the south at dawn, Venus starts rising before the Sun in the east-southeast, and Mercury peeks up into view at dusk.

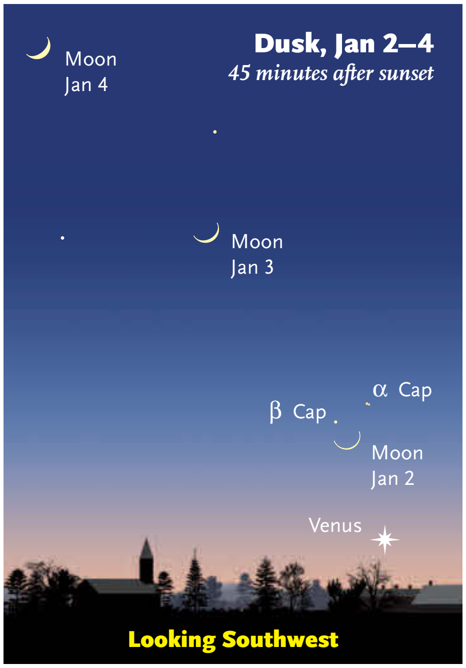
DUSK & EARLY EVENING

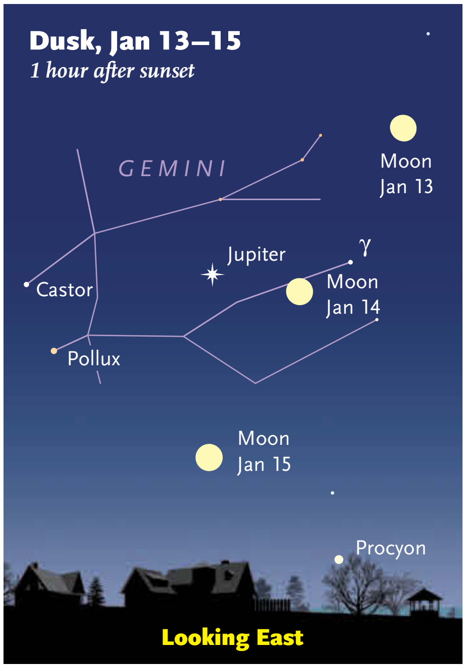
Venus makes a dramatic exit from the evening sky during the opening days of 2014. On New Year's Day the planet blazes at magnitude –4.4 and still sets more than an hour after the Sun. Telescopes — or even steadily supported binoculars — show that its globe is just 3% lit, and this slender crescent measures an amazing 60″ from tip to tip.

Each day after, Venus appears noticeably lower, and its crescent grows even thinner through a telescope. What's the last day you can spot it after sunset? The planet is 5° north of the Sun when it goes through inferior conjunction around 12^h UT on January 11th. But it's less than 2° above the horizon at sunset on that date, so it will be very tough to see even through a telescope. You might have better luck just before sunrise, when it's a little higher due to the angle of the ecliptic.

Mercury was at superior conjunction with the Sun on December 29th, but it should become visible low in the west-southwest at dusk in mid- to late January. Mercury reaches greatest elongation, 18° from the Sun, on January 31st. That evening Mercury is almost 10° high 45 minutes after sunset, with a very slender lunar crescent just a few degrees to its right or lower right. It shines then at magnitude –0.6, and telescopes show that its half-lit disk appears 7″ wide.

Uranus, in Pisces, is still reasonably high in the southwest at nightfall, and **Neptune**, in Aquarius, is low but probably still visible toward the end of evening twilight. For finder charts, see the October 2013 issue, page 50, or **skypub.com/urnep**.





ALL NIGHT

Jupiter arrives at opposition to the Sun on January 5th. The king of planets is already visible low in the east-northeast as the sky begins to darken, and it remains visible all night long. This is an extremely favorable opposition for observers at mid-northern latitudes, with Jupiter quite high in the sky for most of the night.

Jupiter beams at a powerful maximum magnitude of –2.7 for most of January, and its apparent diameter at opposition is 46.8″. In the opening nights of January the retrograding world makes a squat isosceles triangle with Zeta (ζ) and Delta (δ) Geminorum. On the 27th it's halfway between Zeta and Epsilon (ε).

Comet C/2012 S1 ISON, or whatever may be left of it, passes less than 4° from the north celestial pole on January 7th and remains a circumpolar object all month.

MIDDLE NIGHT TO DAWN

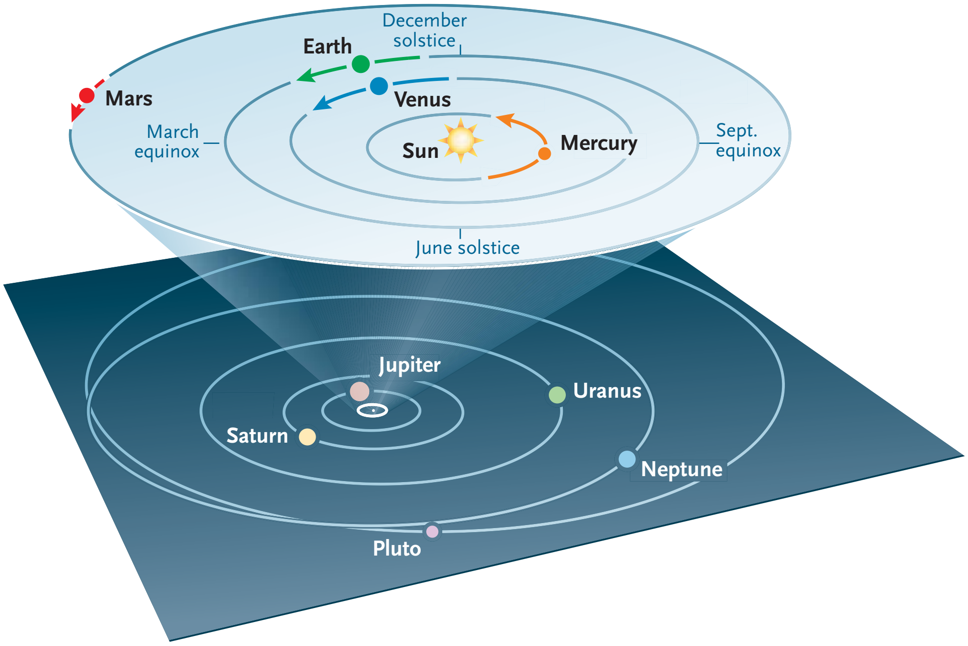
Mars, in Virgo, rises around local midnight as January begins and about an hour earlier when the month ends. The fire-colored point of light brightens dramatically from magnitude +0.9 (slightly brighter than nearby Spica) to +0.3 (still somewhat dimmer than Arcturus) in January. Mars reaches west quadrature, 90° west of the Sun, on January 3rd. This also happens to be the date when it reaches aphelion, its farthest point from the Sun in space.

Telescopes show Mars's 90%-lit gib-

Fred Schaaf

ORBITS OF THE PLANETS

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



bous disk growing from 6.9″ to 8.8″ during January, large enough to start showing a few surface features in good telescopes under excellent conditions. Mars, moving eastward, passes 5° north of Spica on January 28th, the first of three conjunctions between them this year (the others are on March 31st and July 12th).

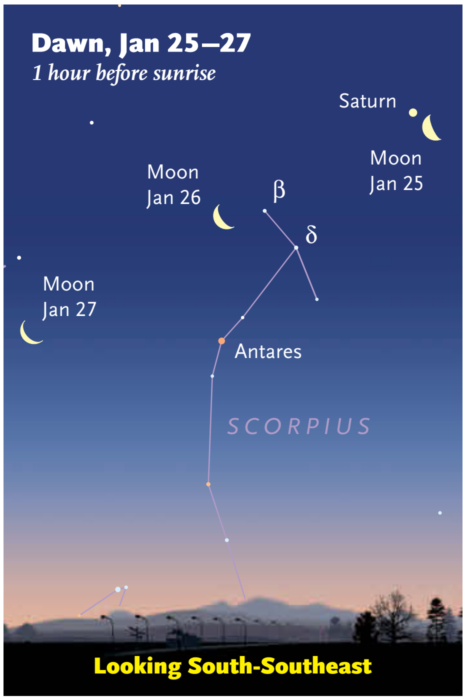
Saturn comes up in central Libra after 3 a.m. on New Year's Day but around 1:30 a.m. at month's end. The gold planet shines around magnitude +0.6 in January. Look in telescopes at the onset of morning twilight to see Saturn highest, with its glorious rings tilted 22° from edgewise.

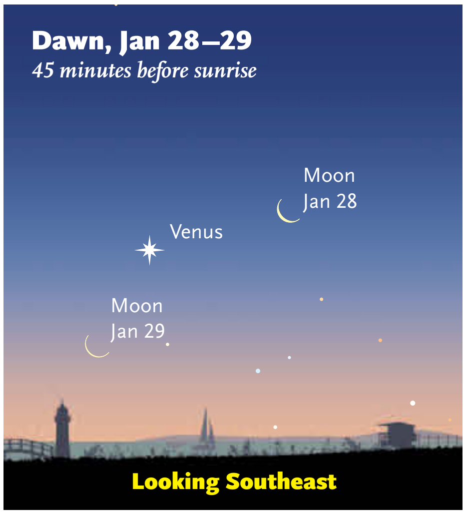
DAWN

Venus emerges into the dawn after inferior conjunction. By the end of January the "morning star" is about 14° high 45 minutes before sunrise, its light has brightened to a splendid magnitude –4.8, and its crescent has shortened to 52″ while widening to 12% lit.

EARTH

Earth comes to perihelion, closest to the Sun in space, around 12^h UT on January 4th. It is then 0.983 a.u. from the Sun.





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.

MOON PASSAGES

The **Moon** is new at 11:14 UT on January 1st. It stands almost directly above the Sun that evening as seen from mid-northern latitudes, and it's at perigee as well, so skilled telescopic or binocular observers in the western U.S. might be able to spot its ultrathin crescent even though it's just 0.7% lit and less than 15 hours old. See page 52 for more information.

A more substantial thin crescent shines upper left of Venus at dusk on January 2nd. In the western part of North America, binoculars and telescopes may show the Moon's earthlit side creep over the wide double star Beta Capricorni and block it from view. For details, see the International Occultation Timing Association website, **www.lunar-occultations.com/iota**.

The waxing gibbous Moon is near Aldebaran on the evening of January 11th and right of brilliant Jupiter on the 14th.

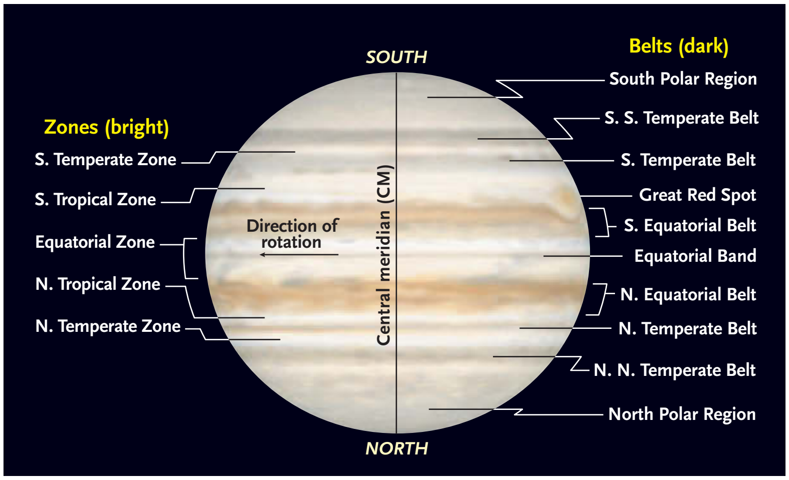
The waning gibbous Moon is very near Spica before sunrise on January 23rd, with Mars to their upper right. Two mornings later the lunar crescent is very near Saturn, and on January 28th and 29th it shines to either side of Venus. Finally, the Moon returns to the evening sky to glow lower right of Mercury on January 31st. ✦

Jupiter in Your Telescope

Get the most from the time you spend with the planet king.

Jupiter is now about as good as we ever see it. When it comes to opposition on January 5th it will appear 47″ wide, and it stays within 2″ of that all December and January. It's also on the northernmost stretch of the ecliptic, in Gemini. For those of us living in the north temperate latitudes, this means that in the middle of the night it shines almost overhead, where the seeing is best.

But I confess that the incredible stacked-video images that many amateurs are taking today, like the samples below, have spoiled me for what I can see of Jupiter even in my 12.5-inch reflector with its tunable mirror. It takes time and effort to see everything that you can see in a visual image, whereas a picture on a page shows everything at first glance.



S&T ILLUSTRATION

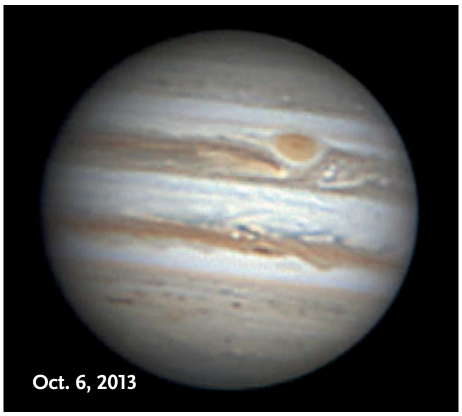
On gas-giant planets, "belts" are dark and "zones" are light. Although they often change width, brightness, position, and sometimes come and go completely, the basic naming scheme above has held for generations.

Nevertheless, there's nothing like watching the real thing in real time. As Robert Burnham, Jr., wrote in his classic *Burnham's Celestial Handbook*, "There is no privilege like that of being allowed to stand in the presence of the original."

Planets are always a challenge to observe well in any telescope. You probably know the basics: Give your scope a good 30 to 60 minutes to cool outdoors before expecting the sharpest views. Keep warm buildings and Sun-heated pavement away from the scope's immediate line of sight; grass and foliage are best. Make sure your scope's optics are perfectly collimated (read how to do it at **skypub.com/collimation**). To catch the rare nights of excellent telescopic seeing, watch your local seeing-quality forecast at Clear Sky Chart (**cleardarksky.com/csk**), not just its cloudiness and sky-transparency forecasts. The site works for anywhere in North America up to 48 hours ahead.

Try different magnifications to find the best for the seeing conditions. A light blue or green filter boosts contrast a bit. Most of all, *keep watching*. The longer you look the more moments of good seeing you'll catch, but in

Below: **Three top planetary imagers recorded Jupiter using video-frame stacking on three dates. *Left:* Jim Phillips of South Carolina employed a 10-inch Maksutov scope. *Center:* Five weeks earlier, when Christopher Go in the Philippines took this shot with a 14-inch Schmidt-Cassegrain, many small features all across the disk were quite different. (The apparent doubling of small linear features is a processing artifact.) *Right:* In May 2010 the South Equatorial Belt was completely missing, hidden under a layer of white clouds, as imaged by Anthony Wesley in Australia. South is up.**



January 2nd occultation: *During twilight, telescope users in western North America can watch the dark limb of the thin crescent Moon occult the wide double star Beta Capricorni, magnitudes 3.1 and 6.1. Check for your local times and details at lunar-occultations.com/iota/iotandx.htm.*

Alan MacRobert

addition, the more that subtle features will simply become plainer to recognize. This is true not just during a given observing session but over an entire season. Familiarity breeds better perception. And sketching is an excellent way to concentrate your perception, as told on page 72.

Focus carefully to make the planet's edge as sharp as possible, and keep testing the focus from time to time. Study the disk closely. Have the belts changed width, darkness, or color since the last time you looked? Can you detect irregularities on their edges? Are any dark or bright marks visible within them? Look for tiny *white spots;* larger *white* or *red ovals;* thinner, deep-red *rods* or longer *barges;* and whitish turbulence, especially trailing behind the following (celestial east) end of the Great Red Spot.

In the bright zones between the belts, can you make out any blue *festoons,* especially in the Equatorial Zone? If you're using at least a 6-inch scope, you might. Is there any trace of the narrow *Equatorial Band?* It's usually absent, but not always.

The *Great Red Spot* is Jupiter's most famous feature. It slowly changes color and contrast (page 30). Very rarely has it ever appeared bright brick red, but as of October it had turned strongly orange, the most color it has displayed in many years. This is quite a change from a few years ago when it was so pale you could hardly see it, and my wife, using the 12.5-inch, named it the Great Cottage Cheese Spot.

The Red Spot sits in an indentation in the South Equatorial Belt called the *Red Spot Hollow.* Usually the RSH is white, as it is now. But in 2011 it was dark gray.

Be warned that the Great Red Spot is a challenge in a small scope. Your best chance will be within an hour of the times when it transits the disk's central meridian. These are predicted for December and January on the next page. Jupiter rotates fast, in just under 10 hours, so on a good night you'll begin to notice that things have moved after just a few minutes of scrutiny.

Many stars are currently thought to lack a Jupiter-sized planet in their planetary systems. Amateur astronomy would be a lot less interesting without the one in ours.

Phenomena of Jupiter's Moons, January 2014

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

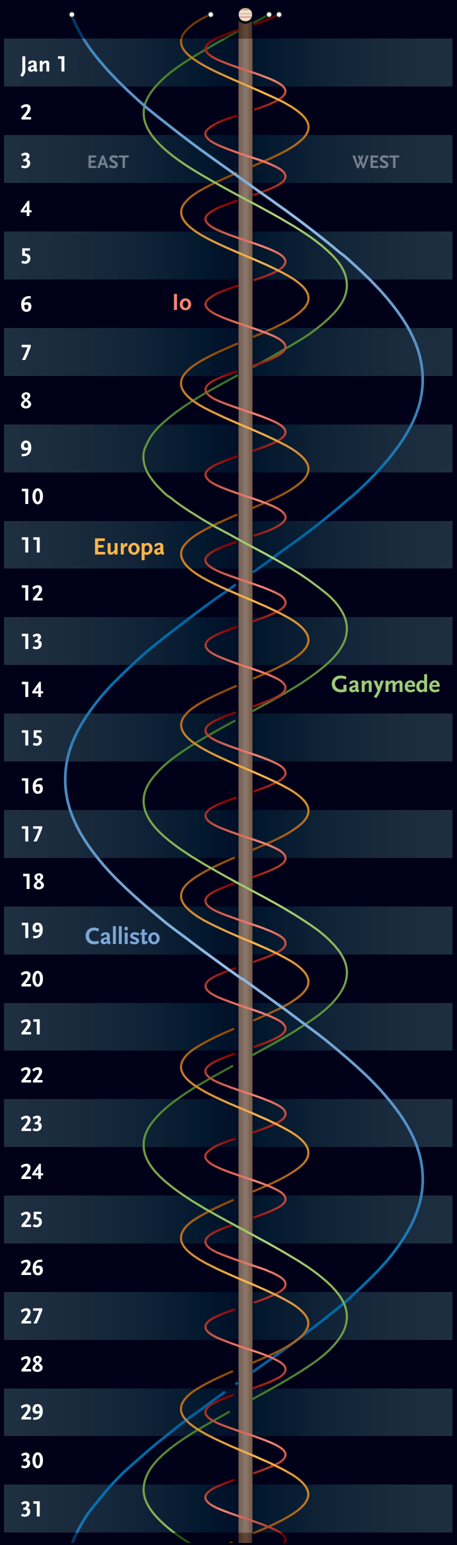
Every day, interesting events happen between Jupiter's satellites and the planet's disk or shadow. The first columns give the date and mid-time of the event, in Universal Time (which is 5 hours ahead of Eastern Standard Time). Next is the satellite involved: **I** for Io, **II** Europa, **III** Ganymede, 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.

Quadrantid Meteors

The annual Quadrantid meteor shower should peak on January 3rd around 19:30 UT. Although the night is moonless, the peak of the Quads lasts for only a few hours and the timing is poor for North America (excellent for the eastern half of Asia). By one prediction, however, the shower may be a few hours early and active before dawn for the West Coast.

For the Moon's librations in January, see skypub.com/librations.

Jupiter's Moons



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

Action at Jupiter

Any telescope shows Jupiter's four big Galilean moons. Binoculars usually reveal at least two or three, and occasionally all four. You can identify them at any time in January with the diagram at left.

Listed below are all the interactions in January between Jupiter, its shadow, and the satellites and their shadows. A 3-inch telescope is often enough for watching these interesting events.

Jupiter's Great Red Spot has turned stronger orange than it was last year, making it easier to see. Here are the times, in Universal Time, when it should cross Jupiter's central meridian. The dates, also in UT, are in bold:

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

January 1, 8:25, 18:21; **2,** 4:16, 14:12; **3,** 0:07, 10:03, 19:58; **4,** 5:54, 15:50; **5,** 1:45, 11:41, 21:36; **6,** 7:32, 17:28; **7,** 3:23, 13:19, 23:14; **8,** 9:10, 19:06; **9,** 5:01, 14:57; **10,** 0:52, 10:48, 20:43; **11,** 6:39, 16:35; **12,** 2:30, 12:26, 22:21; **13,** 8:17, 18:13; **14,** 4:08, 14:04, 23:59; **15,** 9:55, 19:51; **16,** 5:46, 15:42; **17,** 1:37, 11:33, 21:29; **18,** 7:24, 17:20; **19,** 3:15, 13:11, 23:07; **20,** 9:02, 18:58; **21,** 4:54, 14:49; **22,** 0:45, 10:40, 20:36; **23,** 6:32, 16:27; **24,** 2:23, 12:18, 22:14; **25,** 8:10, 18:05; **26,** 4:01, 13:57, 23:52; **27,** 9:48, 19:43; **28,** 5:39, 15:35; **29,** 1:30, 11:26, 21:22; **30,** 7:17, 17:13; **31,** 3:08, 13:04, 23:00.

These times assume that the spot is centered at about System II longitude 205°. If it's not following predictions, it will transit $1\frac{2}{3}$ minutes early for every degree of longitude less, or $1\frac{2}{3}$ minutes later for every degree more.

Any feature on Jupiter is closer to the central meridian than to the limb for about 50 minutes before and after it transits the meridian.

Record-Thin Moon!

Shortly after sunset on January 1st, North Americans can try to spot what's likely to be their personal record for a young crescent Moon. An extremely thin trace of the Moon will be almost straight above the sunset point and, conveniently, 8° to 9° lower right of Venus. *And* the Moon is at perigee.

The sighting will probably be impossible from the East Coast, where the Moon will be just 11 hours old and 7° from the Sun a half hour after sunset. But it may be possible with a telescope in the Central time zone and with binoculars on the West Coast, where the Moon will be approximately 14 hours old and 8.5° from the Sun. Calculate its age from the time of new Moon: 11:14 UT January 1st.

Go out early to mark the spot where the Sun sets, and start watching no more than 15 minutes after sundown. Keep watching for another 25 minutes to catch your time of best visibility, which will depend on your location and sky conditions. If you see the Moon with optical aid, try with the naked eye. See skypub.com/youngmoon for more. ✦

Minima of Algol

Dec.	UT	Jan.	UT
2	15:34	3	4:35
5	12:23	6	1:24
8	9:12	8	22:13
11	6:01	11	19:03
14	2:50	14	15:52
16	23:39	17	12:41
19	20:28	20	9:31
22	17:18	23	6:20
25	14:07	26	3:09
28	10:56	28	23:59
31	7:45	31	20:48

These geocentric predictions are from the heliocentric elements Min. = JD 2452253.559 + 2.867362E, where E is any integer. Courtesy Gerry Samolyk (AAVSO). For a comparison-star chart and more info, see skypub.com/algol.

Spy Surface Markings on Jupiter's Moons

Take advantage of transits to spot albedo features on the Galilean satellites.

NASA / JPL / BJÖRN JÓNSSON

Seeing albedo markings on the Galilean moons is always challenging, but the odds improve when they pass in front of Jupiter, as Io (left) and Europa are doing in this Voyager 1 image.

Discovered by Galileo in 1610, Jupiter's four largest satellites can be seen as tiny disks rather than stellar points of light through a telescope of 5 or 6 inches aperture. The smallest Galilean satellite, Europa, is slightly smaller than the Moon and only subtends 1 arcsecond during a favorable opposition. Although the largest member of the family, Ganymede, surpasses Mercury in size, it never appears larger than 1.8 arcseconds in diameter. Even with superb seeing, spotting surface features on these distant worlds is a daunting challenge that is comparable to studying a penny from a distance of a couple of miles. The best times to try are during transits, when these tiny disks pass in front of Jupiter's disk (see the table on page 51).

Decades ago, Russian astronomer Vsevolod Sharonov, a pioneer in planetary photometry, pointed out that observers can improve the eye's sensitivity threshold to contrast by reducing the difference in brightness between the disk of a planet or satellite and its background. This is why the surface markings of the Galilean satellites are much easier to see during transits, when they are silhouetted against the backdrop of Jupiter's cloud tops (which have a comparable brightness) rather than a dark sky.

Sharonov's comment echoed the experiences of several eminent observers who had managed to discern markings on the Galilean satellites. In 1939 the Greco-French astronomer Eugène Antoniadi wrote:

> It was with varying success that several astronomers have tried to detect spots on these secondary planets, and such an enquiry was usually undertaken in all positions of those orbs around Jupiter. But as contrast enhances the brightness of their limb on the sky, thus fading or quenching marginal dusky markings, it is chiefly during transits across the primary that the configuration of these satellites can best be scrutinized.

Three decades earlier the Spanish astronomer José Comas Solà, who had studied the Galilean satellites using the 15-inch refractor of the Fabra Observatory in Barcelona, emphasized that the most favorable viewing conditions free from glare and irradiation occurred "during the passages of the satellites across the disk of Jupiter."

The visual albedo (the fraction of light reflected in the visible region of the spectrum) of Jupiter is 0.52. This value is an average of the reflectivity of the planet's alternating pattern of bright zones and dark belts. The zones — high, dense clouds of frozen ammonia — have a visual albedo that can exceed 0.66. The visual albedo of the belts, which consist of low-lying aerosols tinted by compounds of sulfur and phosphorous, can be as low as 0.44.

A further Jovian feature that plays a role is limb darkening, the gradual, uniform darkening toward the edge of the planet's disk caused by the absorption and scattering of sunlight by high-altitude hazes located above the main cloud layers.

Because Jupiter's limb is much darker than the center of the planet's disk, all four satellites appear as tiny bright dots when they have just entered or are just about to exit the disk. But when traversing the face of Jupiter, each satellite produces unique and fascinating displays, created by the interplay of the planet's varying backdrops with the transiting Galilean satellites.

Io

Io's most prominent feature is a yellow-white equatorial band that is covered with highly reflective sulfur-dioxide frost. With a visual albedo of 0.63, this bright terrain contrasts starkly with the satellite's reddish-brown polar regions, which have a visual albedo of only 0.30. Composed of elemental sulfur darkened by radiation, these polar markings were sources of confusion to astronomers.

When observed against a dark sky, Io's dusky polar caps tend to blend into the background, distorting the moon's outline. In 1797 this deceptive appearance led William Herschel, the greatest observer of his era, to suggest that Jupiter's satellites might not all be spherical. A century later Harvard astronomer William Henry Pickering mistook Io's bright equatorial band for the satellite itself and concluded that Io was an egg-shaped body that tumbled around Jupiter on its side (*S&T:* January 2004, page 114).

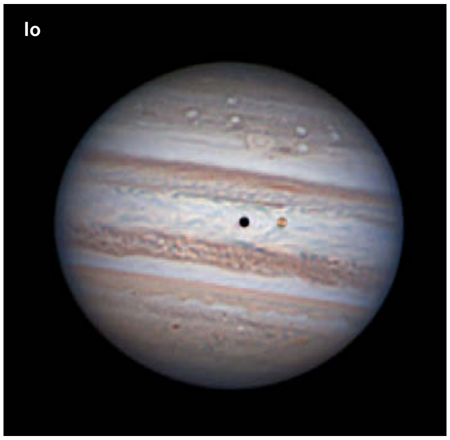
During a transit of Io in 1891, Edward Emerson Barnard dispelled this notion. Observing with the 36-inch Lick refractor, Barnard saw Io as distinctly round, crowned by dark polar caps separated by a bright band running roughly parallel to Jupiter's equator. In recent years this striking appearance has been captured by many webcam imagers.

Europa

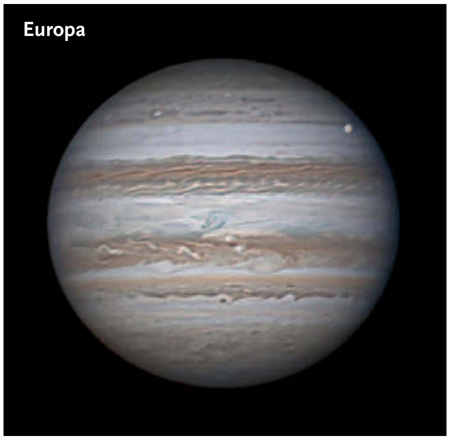
Encased in a smooth shell of virtually pure water ice, Europa has a visual albedo of 0.64, the highest of the Galilean satellites. Appearing as a bright speck throughout an entire transit, Europa can be very difficult to make out when it is near the center of Jupiter's disk overlaid on a bright zone because zones are often almost identical in both off-white color and reflectivity. Although Europa is devoid of prominent markings, its appearance is essentially the muted opposite of Io — brilliant poles and slightly ruddy equatorial regions.

Ganymede

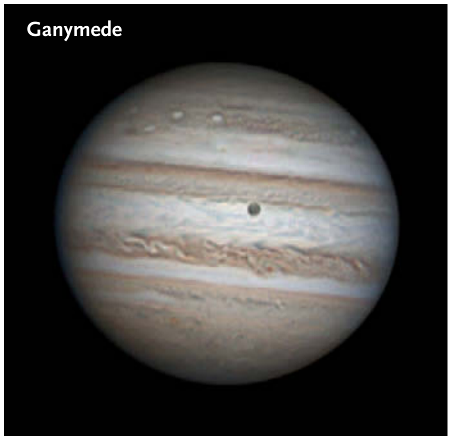
Ganymede has two sharply demarcated types of terrain, both composed of "dirty" water ice containing silicate minerals. One-third of Ganymede's surface consists of tawny gray regions with a visual albedo of 0.35 that are rich in clays or organic matter. These areas are surrounded by lighter yellowish tracts containing a larger proportion of ice that have a visual albedo of 0.46. Polar caps composed of water frost and a dappling of bright rays from recent impact craters are also present.



Io



Europa



Ganymede

DONALD C. PARKER (3)

During transits Ganymede usually blends into the background and is lost to view for an interval of 15 to 20 minutes shortly after ingress and before egress. As it travels toward the central regions of Jupiter's disk, Ganymede's contrast with the ever brighter background gradually increases and it takes on a dusky, dark, or even blackish appearance.

Observing with only a 6.3-inch refractor during an 1849 transit of Ganymede, the eagle-eyed British observer William Rutter Dawes made out a bright polar spot and the prominent dusky marking that is known today as Galileo Regio. Several observers have subsequently remarked that under excellent seeing conditions the appearance of Ganymede in transit through a 12-inch telescope closely resembles the appearance of Mars through a 2-inch telescope in every respect but color.

MIKE SALWAY

Callisto

Densely cratered Callisto is encased in an ancient crust of even dirtier ice than Ganymede, giving it a visual albedo of only 0.20. Descriptions of Callisto's color range from charcoal gray to chocolate brown. Although Callisto lacks the prominent surface markings of Io and Ganymede, its transits can be every bit as captivating to watch because the satellite appears to abruptly transform from a bright dot to an intensely dark one soon after ingress is complete. When passing over one of Jupiter's bright zones, the silhouetted disk appears so dark that it is often mistaken for a shadow. After observing a transit of Callisto in 1859, British astronomer William Lassell remarked that "It was difficult to conceive that any object so dark could ever appear as a bright one."

Veteran observers regard color filters as essential tools for enhancing the contrast and visibility of planetary details. In the case of Galilean satellites, the "background lighting" during transits confers similar benefits. Take advantage of these opportunities to enjoy your best views of these distant worlds. ✦

NASA / JPL / DLR

NASA's Galileo spacecraft captured this family portrait of Jupiter's four largest moons: Io (top), Europa, Ganymede, and Callisto. Each moon is shown to scale.

Star Bound

Many remarkable deep-sky objects lie near the variable star Algol.

Her Perseus joyns, her Foot his Shoulder bears
Proud of the weight, and mixes with her Stars.
— Marcus Manilius, *Astronomica*

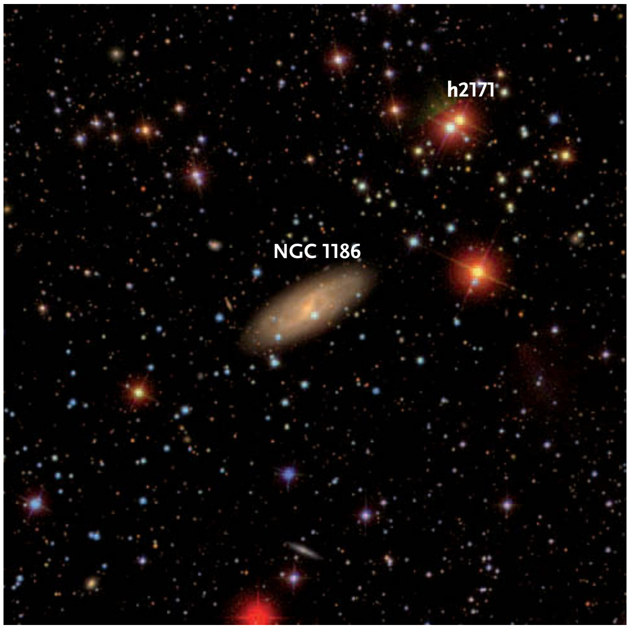
According to Greek myth, the brave hero Perseus rescued Andromeda from the terrible sea monster Cetus and claimed the fair maiden for his bride. At night we still see the couple wedded in the night sky, with Andromeda warming her feet against her husband.

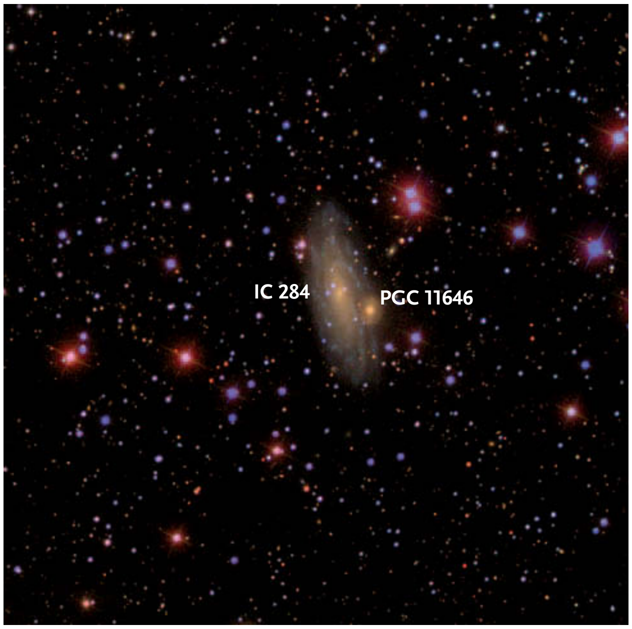
Where foot and shoulder meet, we find the seldom-mentioned star group **NGC 956**. It's not always plotted in the same place, nor listed with the same size. John Herschel discovered the group in 1831 and described it as a moderately rich cluster with two or three bright stars and about 20 diminutive stars of magnitude 13 to 15. The coordinates Herschel gave are for one of the bright stars (SAO 38098, magnitude 9.1), not for the center of the group. Some sources place the center of the NGC 956 northeast of that star, others southwest. What do you think Herschel saw?

Here's my visual impression of NGC 956 through my 130-mm refractor. At 23×, six 9th- to 11th-magnitude stars form a 7′ U, open toward the west. At 37× there are nine stars that lie along the U, two within it, and one to its north. Of the three 9th-magnitude gems decorating the U, the southernmost is gold, the westernmost glows orange, and the remaining one is Herschel's star. At 117× I see a loose collection of 22 suns with a generous assortment of magnitudes.

Whatever John Herschel saw, NGC 956 isn't considered a true cluster now. In a 2008 paper in *Astronomische Nachrichten*, Polish astronomers Gracjan Maciejewski and Andrzej Niedzielski determined that NGC 956 is a chance alignment of physically unrelated stars. The size and center coordinates for NGC 956 listed in the table on the facing page come from this paper.

Let's swing our scopes farther eastward to visit some of the many galaxies that inhabit Perseus. We'll start with **NGC 1186**, which is located 1.9° north-northwest of Algol (β Persei). In my 130-mm refractor at 48×, the galaxy is a faint smudge leaning west-northwest, with a superposed star near the center. The double star h2171 hovers 5′ northwest of NGC 1186, with components weighing in at magnitudes 10.7 and 11.3. At 63× the galaxy displays a 1½′-long, oval core surrounded by a tenuous fringe that spans about 2½′ × ¾′. At 117× most of the fringe is invisible, but it's easier to ascertain that the superposed star is southwest of the galaxy's center. With my 10-inch reflector at





SLOAN DIGITAL SKY SURVEY (2)

171×, I see another overlaid star, this one perched on the southern side of the galaxy's eastern end.

NGC 1186 is sometimes called NGC 1174. The former was discovered by William Herschel in 1786 and the latter by Lewis Swift in 1883. They were given separate entries in the original NGC (*New General Catalogue of Nebulae and Clusters of Stars*, 1888), because Swift's position for NGC 1174 is about one minute of right ascension to the west of NGC 1186. But from Swift's description, it's apparent that the two objects are the same while his position is incorrect. This is made especially clear by Swift's mention of a double star whose similarly bright components point toward his object from the northwest, which neatly fits NGC 1186 and h2171. The identity was first proposed in 1891 by Rudolf Spitaler and published in *Astronomische Nachrichten*.

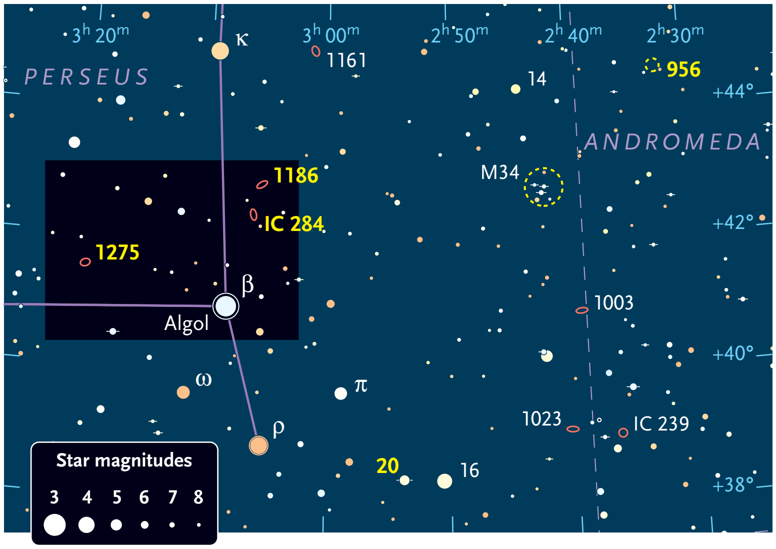
On my way to NGC 1186, I bumped into **IC 284**. This galaxy has lower surface brightness than NGC 1186, but it's still visible through my 130-mm scope at 37×. It's a ghostly glow tilted north-northeast inside a skinny, 26′-tall triangle of three 8th- and 9th-magnitude stars. A close pair of faint stars sits 2½′ northwest. The galaxy shows better at 63×, covering about 1¼′ × ½′ with a small, subtly brighter core.

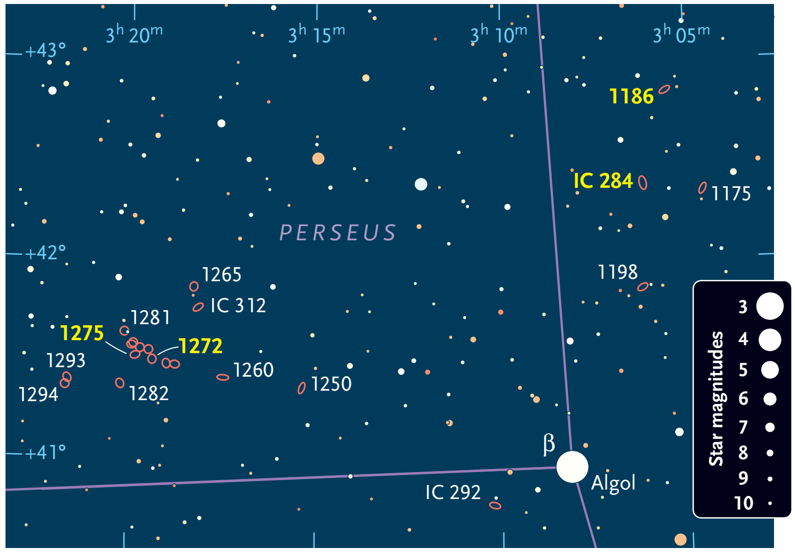
Folks with large telescopes might like to try for tiny PGC 11646, a 15th-magnitude galaxy nestled a mere 45″ west-southwest of IC 284, measured center to center.

Now we'll move on to the Perseus Cluster (Abell 426), a collection of thousands of galaxies centered 230 million light-years away from us and 2.3° east-northeast of Algol on the sky. Its brightest member is NGC 1275, also called Perseus A — a designation that flags its copious emission at radio wavelengths. Powered by a supermassive black hole, the galaxy is also a vigorous X-ray source. Features interpreted as sound waves spread hundreds of thousands of light-years outward from this black hole. The pitch is far below human hearing, a profoundly deep B-flat that's 57 octaves below middle C (*S&T:* March 2013, page 22).

NGC 1275 is a small, round, faint galaxy that grows brighter toward the interior, as viewed with my 105-mm refractor at 87×. **NGC 1272** (magnitude 11.8) is barely visible 5.2′ west-southwest, and a 12th-magnitude star lies between the two galaxies. NGC 1272 is much easier to see at 127×. It appears a little smaller and more uniform in surface brightness than its neighbor. Its broad core is only slightly brighter than its fringe. At 153× **NGC 1278** (mag. 12.4) makes an appearance, yet it's only intermittently visible with averted vision as a small smudge.

Through my 10-inch reflector at 166×, NGC 1275 is oval east-southeast to west-northwest and much brighter in the middle, whereas NGC 1272 is round with a marginally brighter heart. NGC 1278 is smaller but has higher sur-

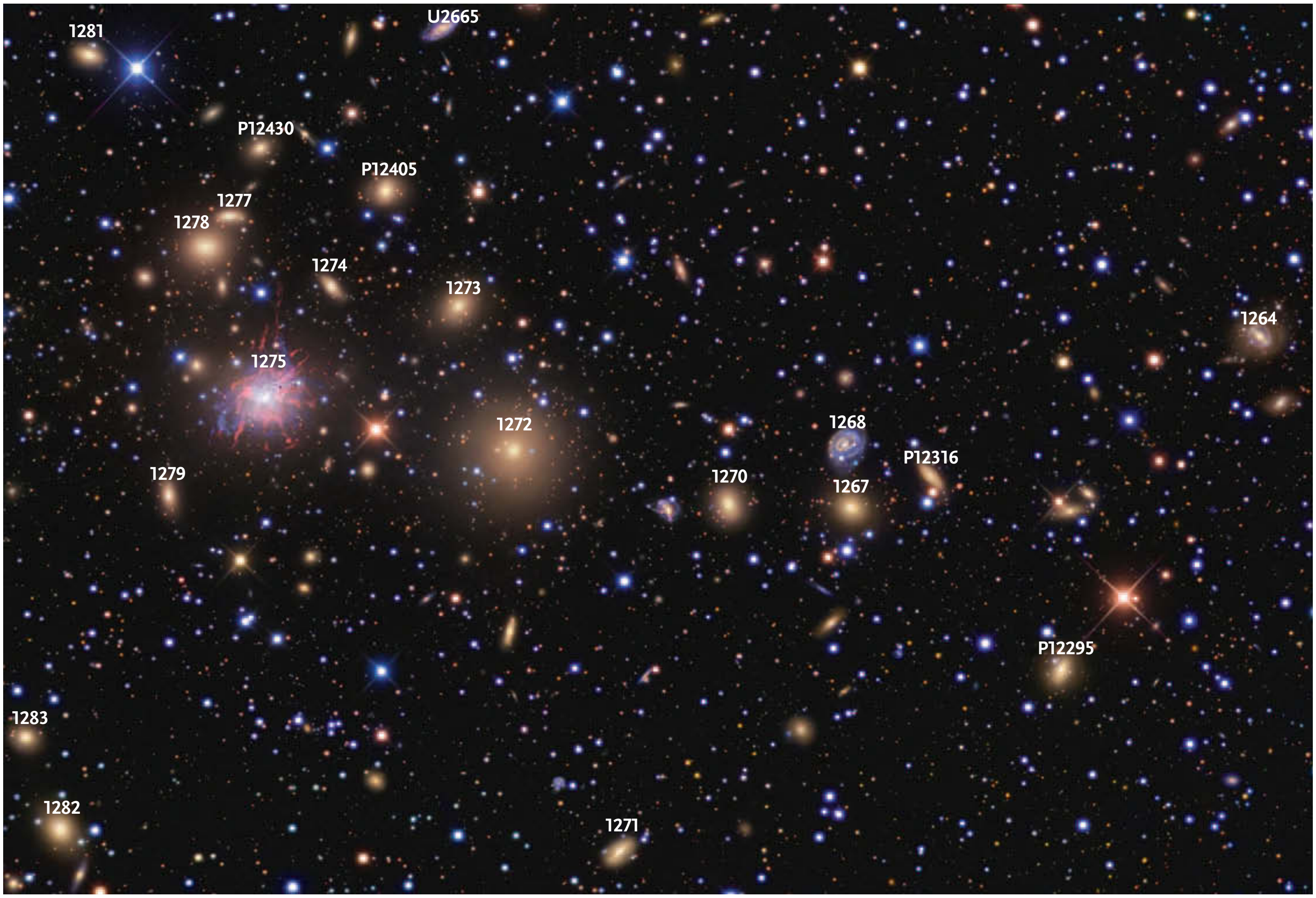




Galaxies, a Double Star, and a Cluster in Perseus and Andromeda

Object	Type	Magnitude	Size/Sep.	RA	Dec.
NGC 956	Asterism	8.9	12.0′	2^h 32.3^m	+44° 34′
NGC 1186	Galaxy	11.4	3.2 × 1.2′	3^h 05.5^m	+42° 50′
IC 284	Galaxy	11.5	4.1′ × 2.1′	3^h 06.2^m	+42° 22′
NGC 1275	Galaxy	11.9	2.2′ × 1.7′	3^h 19.8^m	+41° 31′
20 Persei	Double star	5.0, 9.7	13.9″	2^h 53.7^m	+38° 20′

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



R. JAY GABANY

face brightness than NGC 1272. Its east-west oval intensifies toward a bright core. Several additional galaxies share the field of view. **NGC 1273** (mag. 13.2) is fairly easy and a bit oval, whereas **NGC 1277** (mag. 13.5) is a petite, fuzzy spot just northwest of NGC 1278. **PGC 12405** (mag. 14.2) is quite faint and rests upon a little triangle of very dim stars. This galaxy is sometimes incorrectly identified as IC 1907. With averted vision, **NGC 1274** (mag. 14.0) materializes halfway between NGC 1278 and NGC 1273.

West of NGC 1272, three more galaxies join the tableau. **NGC 1270** (mag. 13.1) is a small oval tipped north-northeast that brightens inward, while to its west, **NGC 1267** (mag. 13.1) is more obvious. NGC 1267 is round and seems to have a considerably brighter center, a perception that's probably enhanced by its superposed star. An incomplete oval of very faint stars, open to the northwest, holds NGC 1267 just within its western side, and NGC 1270 is one of the spots in its eastern side. Only 1.3′ north of NGC 1267, **NGC 1268** (mag. 13.4) is an ashen fuzzspot. At 213× an extremely faint star twinkles at its southern edge.

The brightest galaxies in the densest section of the Perseus Galaxy Cluster are labeled here; not all the labeled galaxies are described in the text. Labels starting with P represent galaxies's designations in the *Principal Galaxy Catalog*, labels starting with U are from the *Uppsala General Catalogue*, and labels with no prefix are from the *New General Catalogue*.

NGC 1268 is the lone spiral galaxy in our quick and localized tour of the Perseus Cluster, although others exist. The main body of the cluster spans more than 3° on the sky and contains dozens of galaxies that are visible through moderate to large backyard telescopes.

We'll bring our journey to a close with a brighter and more colorful object, the lovely double star **20 Persei**. This is a very unequal pair, with the primary star shining at magnitude 5.0 and its companion at 9.7. In my 130-mm refractor at 37×, the bright star glows yellow-white, and its attendant is a little spark of light to its west-southwest. At 63× the stars are widely separated, and the secondary looks reddish orange to me. What colors do you see? ✦

Hot Products for 2014

Our 16th annual roundup of Hot Products highlights the most intriguing new astronomy gear in the worldwide market.

By the Editors of Sky & Telescope

Wow! What a year it's been for product introductions. When we finished compiling our "short list" of candidates for this year's Hot Products, we had the biggest list ever in the history of preparing our annual survey. Furthermore, when the dust settled and we had our final selection, it too comprised the most items ever. While it's been a great year for new products, things need to be more than just "new" to make our list. They need to introduce new technologies, offer solutions to old problems, or deliver unprecedented value. As such, our selection aims to honor the products that help our hobby evolve.

This year's picks range from the elegantly simple (the dual finder bracket on page 68) to the mind-bogglingly complex (the Differential Autoguider System on page 66). The costs are equally varied, ranging from a free smartphone app to telescopes costing $15,000 and more.

As always, we hope you enjoy reading about the new products that intrigued us the most for 2014.

▸ StarSense AutoAlign

Celestron • celestron.com

U.S. price: $329.95

Celestron's SkyProdigy telescopes (reviewed in our March 2013 issue, page 62) introduced the company's StarSense Technology, which uses a dedicated imaging module to provide foolproof initialization of the scopes' computerized Go To pointing. The new StarSense AutoAlign system now brings that technology to the company's full line of Go To telescopes. It's also compatible as a retrofit to almost all of the Celestron Go To scopes made in the past decade.

◀ Filter Slider

Starizona • starizona.com

U.S. price: $129.00

Some astrophotographers don't need (or can't use) a multi-slot filter wheel. Starizona's Filter Slider offers an easy way to add filters to just about every imaging system imaginable (as well as many setups for visual observing). It's also noteworthy for its compatibility with the company's HyperStar imaging systems (reviewed in our February 2010 issue, page 34), which transform selected Schmidt-Cassegrain telescopes into ultra-fast astrographs.

▼ Aspen CCD Cameras

Apogee Imaging Systems • ccd.com

U.S. price: from $3,355

In designing the new Aspen CCD cameras, Apogee Imaging Systems rolled its years of experience serving professional and amateur astronomers into a camera line that can suit every need. In addition to deep cooling, robust shutters rated for 5 million cycles, and USB and Ethernet connectivity, there are subtle features such as mechanical adjustments for precisely squaring the detector to an imaging system's optical axis.

▲ Satellite Safari

Southern Stars
southernstars.com

U.S. price: $4.99

Today there are lots of internet resources for people wanting to observe and identify Earth-orbiting satellites. But we've never see one that surpasses *Satellite Safari* for packing more capability and information into an app for Apple and Android mobile devices. And some of its graphics are worthy of a Hollywood studio.

▲ Advanced VX Computerized Mount

Celestron • celestron.com

U.S. price: $799

High-end, do-everything, super-precise German equatorial mounts grab lots of headlines, but they're also more than what many amateurs need or can afford. So Celestron's engineers set about designing high-end performance into a mount for astrophotographers with more modest needs and budgets. The result is the Advanced VX mount designed for payloads up to 30 pounds (13½ kg).

◀ ALPY 600 Spectroscope

Shelyak Instruments • shelyak.com

U.S. price: from about $950

Spectroscopy is a small but growing field of amateur astronomy thanks, in part, to the continuing efforts of Shelyak Instruments in France. The company's new ALPY system offers high performance in a compact modular design. It can record astronomical spectra from near-ultraviolet to near-infrared wavelengths. It's pictured with optional assemblies for autoguiding and spectral calibration.

▶ Deep-Sky Planner 6

Knightware • knightware.biz

U.S. price: $80.95

Deep-Sky Planner 6 is a major upgrade to one of the most popular Windows programs for scheduling observing sessions. It can now export your custom observing plans to a variety of telescope-control programs, including *Argo Navis, Sky Commander,* and *SkySafari*. It also connects directly to Go To telescopes that use the ASCOM 6 protocol.

▲ Sky Guide

Fifth Star Labs • fifthstarlabs.com

U.S. price: $1.99

Want to know what you're looking at in the sky right now? Then just open the *Sky Guide* app on your Apple mobile device and hold it up to the sky. The view automatically matches the direction you're pointing, and a tap of the screen will identify the brighter objects and provide information about them. Oh, and did we mention that the app has some of the most elegant graphics we've seen?

◀ VSD 100/f3.8 Astrograph

Vixen Optics • vixenoptics.com

U.S. price: not available at press time

This new astrograph from Vixen hits a real sweet spot between high-end camera lenses and small telescopes. Its 380-mm focal length and 100-mm aperture yield an f/3.8 system that offers more than enough field to cover the largest CCD detectors. Its new optical design adds a fifth lens element to eliminate the violet halo around stars that is present in older astrographs in this class with four-element designs.

▼ Baader Classic Q-Turret Eyepiece Set

Baader Planetarium

available in U.S. from alpineastro.com

U.S. price: $395

As our in-depth Test Report in the October 2013 issue (page 60) notes, this eyepiece set is ideal for planetary observers and imagers. It includes four eyepieces (three based on the legendary Zeiss Jena orthoscopic design), a versatile Barlow, and the turret eyepiece holder, all of which can be purchased separately.

▶ NGT-18 Reflector

JMI • jimsmobile.com

U.S. price: $14,995

This portable 18-inch f/4.5 Newtonian reflector on a split-ring equatorial mount has been JMI's flagship telescope for more than a quarter century (it was introduced in early 1989, and we reviewed it in our January 1991 issue, page 35). The design has been tweaked during the intervening years, but now it takes a major leap forward with computerized Go To pointing and a built-in database containing more than 29,000 celestial objects.

◀ **Imaging Power Panel**
Kendrick Astro Instruments
kendrickastro.com
U.S. price: from about $380
Digital imaging brings huge advantages to today's astrophotographers, but it also brings with it lots of USB connections and auxiliary devices needing power. To make life a little less tangled at the telescope, Kendrick's Imaging Power Panels use a single external 12-volt source to supply a variety of outputs from 5 to 18 volts (including an 8-volt output for DSLR cameras). There's also a built-in 7-port USB 2.0 hub.

▶ **1100GTO Equatorial Mount**
Astro-Physics • astro-physics.com
U.S. price: from $8,800
Long a leading manufacturer of transportable German equatorial mounts designed for high-end astrophotography, Astro-Physics has replaced its venerable 900 mount with the new 1100GTO. Its rated payload capacity of approximately 110 pounds (50 kg) is a boost of roughly 60% from its predecessor. It can be fitted with a wide variety of options, including state-of-the-art precision encoders that improve pointing accuracy and eliminate all forms of periodic error in the main drive.

▲ **AstroAlert Weather Monitor**
Foster Systems • fostersystems.com
U.S. price: $455.50
Fully robotic amateur observatories now span the globe. You'll find them in suburban backyards, remote mountaintops, and just about every place in between. But lacking real-time human oversight, these facilities are vulnerable to sudden changes in the weather. That's when AstroAlert can step in and save the day (or night) by letting the observatory's control system know when it's safe to observe.

▶ **Astrocloset**
Astroclosets • astroclosets.com
U.S. price: from $2,995
Backyard observatories come in all shapes and sizes, but Astrocloset will likely win the prize for the most efficient use of a small space. The standard model is roughly 4 feet (1.2 meters) square and 8 feet tall. It can accommodate any telescope that will fit through its 34×84-inch (86×213-cm) door. When rolled away from the scope, the observatory provides a cozy workspace with optional shelving and interior lighting.

▼ SVR102T Raptor APO

Stellarvue • stellarvue.com

U.S. price: $2,395

As our Test Report on page 62 of the September 2013 issue points out, this beautifully made new apo refractor from Stellarvue has a lot going for it. The three-element, 4-inch f/7 objective is among the finest we've ever tested, and the carbon-fiber tube assembly, which tips the scales at a mere 9 pounds (4 kg), breaks down into pieces that will easily fit in airline carry-on luggage. It can be ordered with various focusers to suit visual observers and imagers alike.

▲ Differential Autoguider System

SBIG Astronomical Instruments • sbig.com

U.S. price: not available at press time

This revolutionary new method of guiding a telescope for deep-sky imaging offers the advantages of a separate guidescope while completely eliminating the insidious problem of differential flexure that accompanies them. It also eliminates any guiding errors that arise from flexure of the optics in the imaging telescope. The system uses an artificial-star generator near the main telescope's focal plane and a retroreflector to feed the artificial star's image to the guidescope. It's a challenging concept to think about, but we've seen impressive results from the prototype.

► iOptron ZEQ25GT Mount

iOptron • ioptron.com

U.S. price: from $799

iOptron has built its reputation on a series of computerized Go To mounts, ranging from lightweight alt-azimuth and equatorial models to mid-level German equatorials. The new "Z" mount is a clever design that has its center of mass near the middle of the equatorial head, leading to a greater natural stability than found in traditional German equatorials. This enables the mount to be unusually lightweight for its load capacity, which is a big benefit for portable setups. Watch for our review in the coming months.

▲ ZWO ASI120MM

ZW Optical

available in U.S. from highpointscientific.com

U.S. price: $329.95

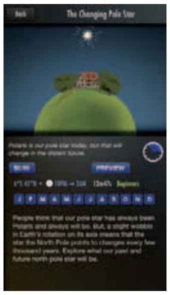
Astrophotographers who concentrate their efforts on the Moon and planets love cameras with small pixels and high frame rates. The ASI120MM from ZW Optical fills both bills with its extremely sensitive CMOS sensor and 3.75-micron pixels. It can record up to 35 full-resolution frames per second (fps) over a USB 2.0 connection, and up to 215 fps with on-chip region of interest (ROI). Our Test Report will appear in an upcoming issue.

◄ Hinode SG Solar Guider

Astro Hutech • hutech.com

U.S. price: $695

There are lots of autoguiders made for tracking faint stars at night, but the Hinode is the only autoguider made for tracking the brightest star of all — our Sun. With many astroimagers interested in capturing time-lapse sequences of solar activity, the Hinode is a product whose time has come. The system works with any equatorial mount having an autoguider input port, but the mount does not have to be accurately polar-aligned. Since it tracks the circumference of the solar disk, Hinode is not suited for solar eclipses. The optional hand controller enables the Hinode SG to work as a stand-alone unit without a separate computer.



◀ **Starmap Media**

Starmap Media • star-map.fr

U.S. price: Free with two stories (additional stories $0.99 each)

The original *Starmap* planetarium app for Apple's iPhone so wowed us that it was one of our Hot Product picks for 2010. Now from the same maker, *Starmap Media* offers more than seven hours of interactive animations and narration to tell the stories of dozens of celestial objects visible in your current sky. It runs as a stand-alone app or in conjunction with the Standard, Pro, or HD versions of the *Starmap* app.

▼ **Skyris CCD Camera**

Celestron • celestron.com

U.S. price: from $499.95

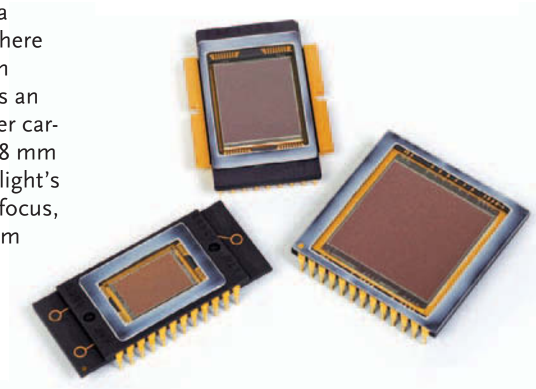
The new line of Skyris video cameras from Celestron is a collaborative effort between the venerable telescope manufacturer in California and The Imaging Source in Germany. They are the first models marketed as astronomical cameras with 12-bit image capture and state-of-the-art, high-speed USB 3.0 connections for exceptionally high frame rates (up to 120 full-resolution frames per second depending on camera model). They usher in a new era for solar, lunar, and planetary imagers.

▶ **SX Mini-USB Filter Wheel**

Starlight Xpress • sxccd.com

U.S. price: $425

Today there are many astrophotography setups having focal reducers or field flatteners with a fixed back focus of only 55 mm (a standard set by the popular T-system that hails from the early days of conventional SLR film cameras). This limited back focus presents a challenge for anyone trying to squeeze an off-axis guider, filter wheel, and camera into an imaging train. That's where the Mini-USB Filter Wheel from Starlight Xpress will help. It has an off-axis guider port and a 5-filter carrousel built into a unit barely 28 mm thick. Coupled with any of Starlight's cameras having a 17-mm back focus, it fits perfectly within the 55-mm limit. Problem solved.



▶ **SX Trius CCD Camera**

Starlight Xpress • sxccd.com

U.S. price: from $1,850

With many astronomical cameras, filter wheels, autoguiders, and focusers requiring a powered USB connection to a computer, there can be a lot of cables hanging around the focal plane of a telescope. But the Trius cameras from Starlight Xpress can help. Each model has an internal powered USB hub with three ports, thus making it possible to operate the camera and up to three USB accessories via a single cable.

▲ **EXview HAD CCD II Sensors**

Sony • sony.net

We've seen this before — a new line of CCDs hits the market and changes the way we think about capturing the night sky. Such is the case with the EXview HAD CCD II chips from Sony. These CCDs offer high sensitivity, low noise, and pixels as small as 3.69 microns square, making them ideal for shooting with short focal lengths. The chips are quickly working their way into astronomical cameras from most of the major manufacturers.

◀ **Dob Dolly**

Orion Telescopes & Binoculars • telescope.com

U.S. price: $129.99

Sometimes the thought of hauling a telescope out of storage (not to mention putting it away afterwards) is all it takes to put a damper on an enjoyable evening under the stars. Enter the Dob Dolly from Orion Telescopes & Binoculars. It offers the most economical way we've seen for easily moving most Dobsonian telescopes up to 10-inch aperture across any smooth surface.

▶ 14-inch CDK Telescope

PlaneWave Instruments • planewave.com

U.S. price: $15,000

Designed from the get-go for high-end digital imaging, the CDK telescopes from PlaneWave have gained a prestigious following among elite astrophotographers. Nevertheless, until now there has been a significant gap in the CDK line between the 12-inch f/8 model (reviewed in our November 2010 issue, page 36) and the 17-inch f/8. That's now been filled by the 14-inch f/8, which, for many, strikes an ideal balance between aperture, focal length, and price.

▼ FLI Imaging Train

Finger Lakes Instrumentation
fli-cam.com

U.S. price: determined by configuration

▼ Tele Vue NP127fli APO

Tele Vue
televue.com

U.S. price: not available at press time

In a rare collaboration between major manufacturers, the folks at Tele Vue Optics and Finger Lakes Instrumentation (FLI) have teamed up to offer a turnkey setup for high-end imaging. The specially configured Tele Vue NP127 (5-inch f/5.3) apo refractor replaces the scope's regular focuser with a rigid adapter that has its optical components perfectly spaced for an imaging train comprising FLI's Atlas focuser, 10-position CenterLine Filter Wheel, and ProLine PL16803 CCD camera. The system produces tack-shape stars across a 4°-wide field. The FLI components are sold separately for those imagers who may already own one or more of them.

▲ Dual Finder Scope Mounting Bracket

Orion Telescopes & Binoculars
telescope.com

U.S. price: $49.99

The name says it all, and it's such a simple concept that we have to wonder why someone hasn't done it before now. This little bracket's foot and dual finder mounts all use the same dovetail fittings that are found on many popular telescopes. This makes it a snap to equip your telescope with red-dot *and* traditional magnifying finders.

◀ RiDK 305 Astrograph

Officina Stellare • officinastellare.com

U.S. price: from $16,595

Officina Stellare has added a new scope to its line of high-performance astrographs. The 100% Italian-made RiDK 305 is a 12-inch f/7.9 modified Dall-Kirkham reflector designed by the company's chief optician, Massimo Riccardi. It promises diffraction-limited imaging performance over a wavelength range from the near-ultraviolet (380 nm) to the near-infrared (2,000 nm). The flat field covers an imaging circle more than 60 mm in diameter, making it suited for the largest CCDs in common use by astrophotographers. As with other astrographs in the Officina Stellare line, the RiDK has a full complement of accessories, including focusers, field rotators, and custom adapters for cameras, filter wheels, and off-axis guiders.

▼ SkyTracker
iOptron • ioptron.com
U.S. price: from $399

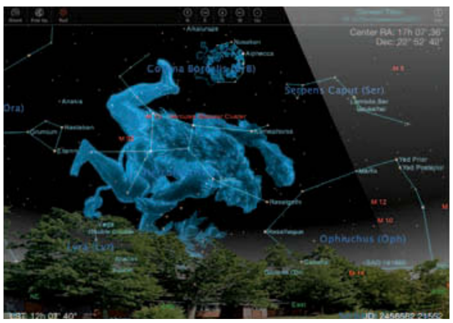
As more photographers discover that their DSLR cameras are capable of capturing great pictures of the starry sky, there's a growing interest in small tracking mounts, which greatly expand upon the astrophotography possible with a camera mounted only on a fixed tripod. The best value we've seen for a tracking mount is iOptron's SkyTracker. As our Test Report noted (May 2013 issue, page 64), the easy-to-use device has an accurate polar-alignment scope, high load capacity, and an excellent motorized drive having precision metal gears that are powered by four internal AA batteries.

▶ Binotron-27 Super System
Denkmeier Optical • denkmeier.com
U.S. price: $1,099

Building on years of experience making binoviewers for telescopes, Denkmeier Optical has created its Binotron-27 Super System. It features 27-mm prisms that allow full illumination of 1¼-inch eyepieces. Each eyepiece holder has adjustable collimation and a built-in helical focuser. The Binotron-27 fits telescopes with 2-inch focusers and it includes the popular Power X Switch that enables users to quickly select three magnification levels for a given set of eyepieces.

▼ TheSky HD
Software Bisque • bisque.com
U.S. price: $4.99

Introduced during the earliest days of personal computers, *TheSky* has become one of the most popular planetarium programs ever developed. It's the standard by which other programs are measured. Now you can carry it with you. After several years of anticipation, Software Bisque has introduced a version for Apple's iPad (with another version for Apple's other mobile devices soon to follow). It requires the iOS 7.0 (or later) operating system.



▶ AWB Dob
Astronomers Without Borders
astronomerswithoutborders.org
U.S. price: $199.99 with free shipping

If you poll a dozen astronomy experts about their picks for ideal beginners' telescopes, you'll likely get a long list of candidates. But this new 5-inch f/5 Dobsonian would certainly be near the top of everyone's list. Imported by Celestron exclusively for sale in the United States by Astronomers Without Borders (AWB), the scope is shipped completely assembled and includes two eyepieces. Tipping the scales at just 14 pounds (6 kg) with a built-in carrying handle and collapsible tube assembly, this little Dob is the perfect instrument for everyone's grab-and-go observing. We'll give you all the details in our Test Report scheduled for the February 2014 issue. But we can tell you now that our reviewer is impressed. Also, all profits from the sale of the scope go to support AWB's global astronomy programs. ✦

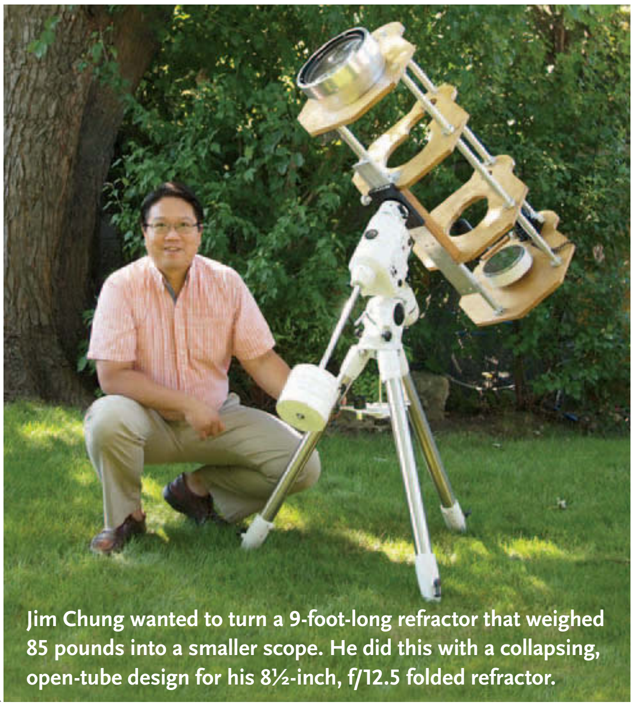
A Retracting Refractor

This folded scope puts portability and performance into a compact package.

There's no question that refractors have many virtues. Like all optical designs, however, traditional achromatic refractors have their tradeoffs. Often the choice comes down to color correction versus portability. Short f/ratio instruments can be quite compact, but usually produce images with noticeable color aberrations. Long-focus lenses can clean up the worst of the color error, but that often means a very long telescope tube.

But when ATM Jim Chung of Toronto, Ontario, decided to make a big refractor, he found a way to have his cake and eat it too. As usual, this telescope-making story begins with a piece of glass. "I was fortunate to acquire an 8½-inch, f/12.5 lens made by D&G Optical," Jim explains. "I wanted to build a refractor that I could easily transport, and that was lightweight enough for a portable mount." But this lens would normally require a tube about 9 feet long, which wouldn't fit into a compact car and would strain the limits of many mounts. Jim decided to match his desires with reality by making a folded refractor.

In spite of its utility, folded refractors are not common among telescope makers. Indeed, the last one we featured in this magazine was a 5-inch f/15 (*S&T:* March 2001, page 120). By folding the light path twice, Jim could reduce the length of his tube assembly to less than 3 feet. Furthermore, by designing a collapsible, strut-style open tube he could trim another foot off the scope's length and reduce its cool-down time and weight. A plan in hand, all Jim had to do was build the scope.



JIM CHUNG (2)

Jim Chung wanted to turn a 9-foot-long refractor that weighed 85 pounds into a smaller scope. He did this with a collapsing, open-tube design for his 8½-inch, f/12.5 folded refractor.

For many ATM projects, it's this moment — when ambition and reality meet — that things come to a halt, especially if someone mistakenly feels that a fully equipped workshop and great mechanical aptitude are prerequisites to success. But as Jim points out, "My workshop is literally my driveway and a collection of rudimentary tools. And most of my knowledge was gleaned from watching too many home-improvement TV shows." He was able to build his telescope in just one week by working just a few hours each day.

Jim's first step was to make a scale drawing so he could figure out the components' dimensions and where they needed to go. This yielded the size and positions of the two flat mirrors and the related baffling system. He obtained high-quality 6- and 3-inch flat mirrors from a seller on eBay, and sourced aluminum tubing from a local firm that sells components for short-wave radio antennas. The main struts are 1-inch diameter and accommodate ⅞-inch-diameter extension tubes that lock into place with quick-release button connectors that he purchased from McMaster Carr (**www.mcmaster.com**).

The scope's bulkheads are cut from high-quality ¾-inch Baltic birch plywood. The truss poles pass through these bulkheads and are locked in position with pairs of shaft collars. Jim fabricated a mounting plate from a 3-foot-long piece of ¾-inch-thick aluminum, which he cut on his table saw. He bolted this plate to a sturdy, solid-oak crossmember attached to the center pair of bulkheads. Finally, he made adjustable cells for the flat mirrors with hardware-store PVC pipe caps and spring-loaded screws.

Aligning a telescope with four optical elements (the objective lens, two flat mirrors, and an eyepiece) is something that must be approached methodically. "I used a laser collimator and paper targets that show the centers of the flats and the objective lens," Jim says. He sets the focuser's

The instrument's optical components include an 8½-inch achromatic objective lens along with 6- and 3-inch flat mirrors that fold the light path. The open-frame tube is made with extendable aluminum tubes and ¾-inch Baltic birch plywood bulkheads.

tilt so that the laser beam strikes the center of the first flat. Then he adjusts the tilt of that mirror until the reflected beam hits the center of the second mirror. Next, he tweaks that flat until the beam strikes the center of the objective lens. Finally, he adjusts the lens's cell until the laser beam's weak reflection from the back of the objective traces its path all the way back to its source.

Did the resulting scope match Jim's expectations? "While not quite the featherweight I envisioned, the complete optical-tube assembly weighs only 50 pounds and collapses down to just 2 feet long," he says. "That's quite an improvement over the original optical tube assembly, which was 9 feet long and weighed 85 pounds! I'm primarily an imager, so it was a revelation to view Saturn on a night of exceptional seeing at 600×. I was so struck by the subtle, pastel-colored bands on Saturn's disk, and a Cassini Division wide enough to fall through, that I'm now looking to expand my eyepiece collection."

Readers wishing to learn more about Jim's folded refractor can e-mail him at jim_chung@sunshine.net. ✦

---

*Contributing editor **Gary Seronik** is an experienced telescope maker. He can be contacted through his website, **www.garyseronik.com**.*

Sketching the King of Planets

Learn to see more detail on Jupiter by drawing at the eyepiece.

Michael Rosolina

Jupiter is consistently one of the most exciting subjects to observe in the solar system. Its large apparent size makes it a prime target for observers with almost any size telescope. But besides the two dusky equatorial bands that are usually visible, the planet's cloud tops are relatively low contrast, making it a challenge to glean the most out of the view.

One way to improve your chances of detecting small-scale features and subtle color variations is to train your eye to see better with lots of practice. The best method to do that is by sketching the planet while observing.

Sketching forces you to carefully examine a feature and then record it on paper. The longer you focus on an area, the easier it becomes to distinguish delicate contrasts between features, or detect small storms in the planet's many belts and zones. This month Jupiter is at its best for the year, so it's a great time to try your hand to become a better observer through sketching.

Preparation: The Key to Success

Before starting, you'll need some drawing supplies. Planetary sketchers often use a pre-printed template that has the planet's oblate shape already in place, as well as lines to record important details of the observation, such as the date, time, conditions, and instrument used. You can download these from planetary observing groups' websites, including those of the Association of Lunar and Planetary Observers (**www.alpo-astronomy.org**), the British Astronomy Association (**http://britastro.org/baa**), and even some internet forums

Above: **When sketching Jupiter, adding details about your observation is important, particularly when sharing your work with observing associations. Your drawings don't have to be pretty, but they should be informative. Indicate the date and time of your observations, as well as which direction is up, what telescope you used, and any other noteworthy descriptions that may not be clear in the drawing.**

such as Cloudy Nights (**www.cloudynights.com**). Using a template enables you to concentrate on your target region of the planet without having to fuss with getting the shape of the planet correct. A template also provides a standardized form that is accepted by each of these observing groups, allowing you to contribute your observations to historical records when complete.

You'll also need some pencils or other form of drawing tool. Graphite pencils come in different degrees of hardness; your standard No. 2 pencil will work fine. Multiple grades of pencil hardness are available through art supply stores. Additionally, you should have an eraser besides the one attached to your pencil. I use a kneaded eraser, which is a type of soft eraser that enables you to mold it quickly into any shape to erase very small areas.

You'll also need a clipboard or a table and a comfortable observing chair: it's easiest to concentrate on your view if you can be seated while observing. Finally, a battery-operated light of some kind is a must. Because Jupiter is so bright, you don't have to preserve your night vision, so a white light is best (it's a requirement if you are drawing in color at the telescope).

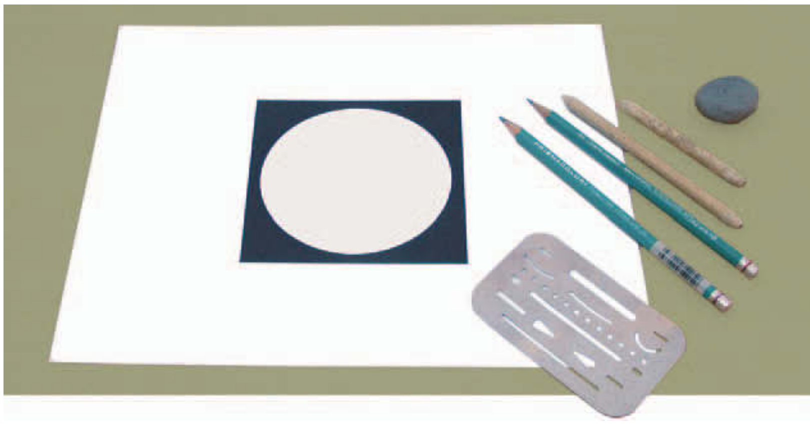
This year, the best part of Jupiter's apparition occurs in the winter for Northern Hemisphere observers, so you'll need to dress warmly. I can't draw with gloves on, so I keep a couple of chemical hand warmers in my pockets. Fingerless gloves or pull-back mittens are also good options to keep your hands warm while drawing.

Author Michael Rosolina describes how to train your eye to see all the subtle details on Jupiter using the time-honored tradition of sketching at the eyepiece. Unless otherwise noted, all photos and sketches are courtesy of the author.

Getting Down to Business

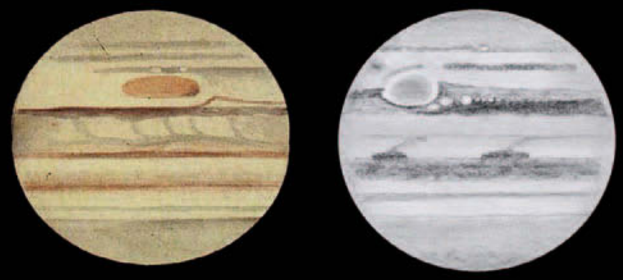
Now that you have everything ready, spend a few minutes soaking in the view before starting your sketch. This gives your eyes time to get used to the subtle contrasts and pastel hues of the planet's belts and zones. There is so much to see on Jupiter that trying to draw the entire planet can be difficult, if not impossible, under excellent seeing. Jupiter's rapid rotation of 9.9 hours to complete a single "day" causes features to move position in just a few minutes, so you'll have to sketch quickly to capture the most detail. A guide to observing Jupiter appears on page 50.

One feature often overlooked on most planets is the slight darkening of the planet's limb. When the planet is near quadrature, one limb will have more pronounced limb darkening than the other.



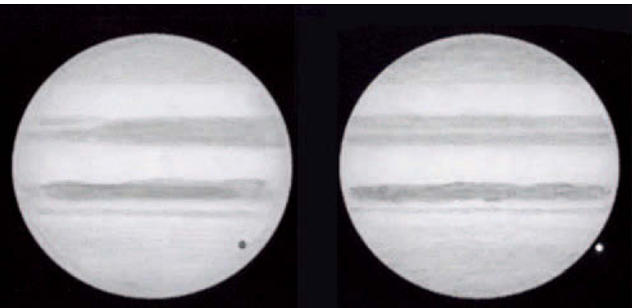
Sketching Tools

Using a pre-printed template of the planet allows you to concentrate on features and their placement. Other supplies include pencils, blending stumps, a soft kneaded eraser, and a metal eraser shield that assists you in limiting where you erase, as well as aligning the belts and zones on your drawing.



LEFT: THOMAS GWYN ELGER

You can compare your completed sketches directly with the many drawings of the planet produced and archived throughout the last 150 years. Note how the Great Red Spot has shrunk dramatically when comparing the author's sketch recorded on November 23, 2012 (right) to one produced in November 1881.



Because of Jupiter's rapid rotation, you might want to execute a series of drawings throughout the night. This pair of drawings captures a rare transit of Callisto, beautifully depicting how the moon appears dark when transiting the planet and bright when seen against the background sky.

After completing your sketch, you can use your notes to create a color version of the observation. Paul Abel produced this wonderful rendition on the evening of November 14, 2012.

Because of the relatively low contrast of Jupiter's cloud tops, it's usually best to resist the temptation to employ high magnification. Depending on seeing conditions, I find a magnification range of roughly 200 to 260× gives the best balance between scale and sharpness in most cases. In poor seeing I rarely go higher than 160×, because above that the image becomes too soft.

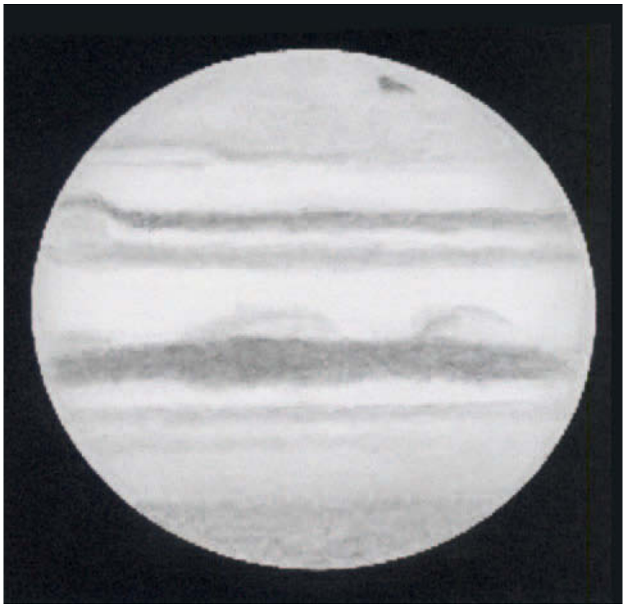
In addition to looking at cloud-top features, check for one or more of the Galilean moons or their shadows transiting the face of the Jovian disk. All of the moons can be seen as they ingress and egress the Jovian limb. An article on observing Galilean moon transits appears on page 54.

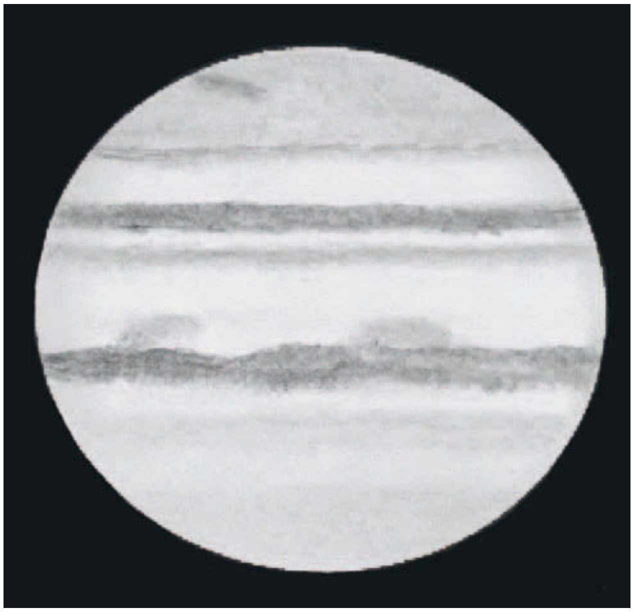
After you've taken time to study Jupiter, it's time to begin your sketch. It's important to work fast because of Jupiter's high rotation rate — 15 to 20 minutes is about all you have before features have moved significantly.

Begin by noting your start time in Universal Time (UT), and then start lightly drawing in the two main equatorial belts with your pencil to anchor your sketch. Add as many of the narrower belts and zones to the north and south as are visible in order to rough out the entire disk. Once this initial sketch is complete, go back to the main belts and shade in darkness along their north and south edges. The kneaded eraser comes in very handy to quickly carve out rifts within the belts, as well as to refine irregularities along their edges. Use your pencil with harder pressure to shade in any dark knots, barges, or other concentrations, and less pressure to lightly shade in any wispy festoons. Do the same thing with the narrower belts and zones, which have their own variations of shading and brightness. Use your kneaded eraser shaped to a point to render any bright ovals you see. There is often less detail near the limbs due to foreshortening and limb shading, so concentrate your efforts on features seen well away from these areas.

You'll have an additional challenge if the Great Red Spot (GRS) is visible during your observing session. Portraying it accurately can be a little tricky. Just like the belts and zones, the longer you look, the more you'll see. There are often subtle gradients within the famous elliptical storm. In addition, the GRS is sometimes surrounded by a white or light-colored "cavity" in the south edge of the South Equatorial Belt (SEB) known as the Red Spot Hollow.

To finish up the sketch, double check the positions and proportions of the various features you have recorded. Use your eraser to remove or lighten features where needed. For more control, you can press or roll the kneaded eraser instead of rubbing on the places you want to lighten. There are mostly no hard edges in the cloud tops of Jupiter, so you may need to soften the boundaries between the belts and zones by lightly blending. You can use your finger to blend adjacent light and dark areas, or use a tightly rolled stick of paper called a blending stump. Blending is also an easy way to depict limb darkening. Note the time you finish the drawing, and you are done.

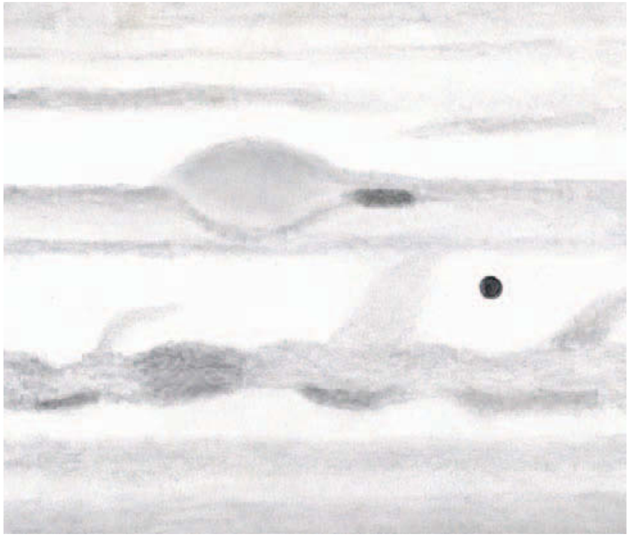




Drawing is also an excellent way to document sporadic events, such as the impact discovered by Anthony Wesley in 2009. The drawing on the left shows the impact "scar" as seen on July 28th; six days later the planet's turbulent atmosphere had caused the feature to spread out and fade. An article about amateur discoveries on Jupiter appears on page 30.

Strip Sketching

An innovative technique that you can employ to sidestep the difficulties of Jupiter's rapid rotation is known as a strip sketch. With the strip sketch, you use a blank sheet of drawing paper instead of the oblate disk template. Start this drawing as close to the preceding limb as you can, and continue from there toward the planet's central meridian (CM). Once you've reached the CM, you can simply add features as they cross the CM successively. Using this method, you let Jupiter's rotation work for you, and you can continue working on the drawing for as long as you observe the planet that evening. Be sure to note the start and end time so you can figure out how many degrees of longitude you have recorded.



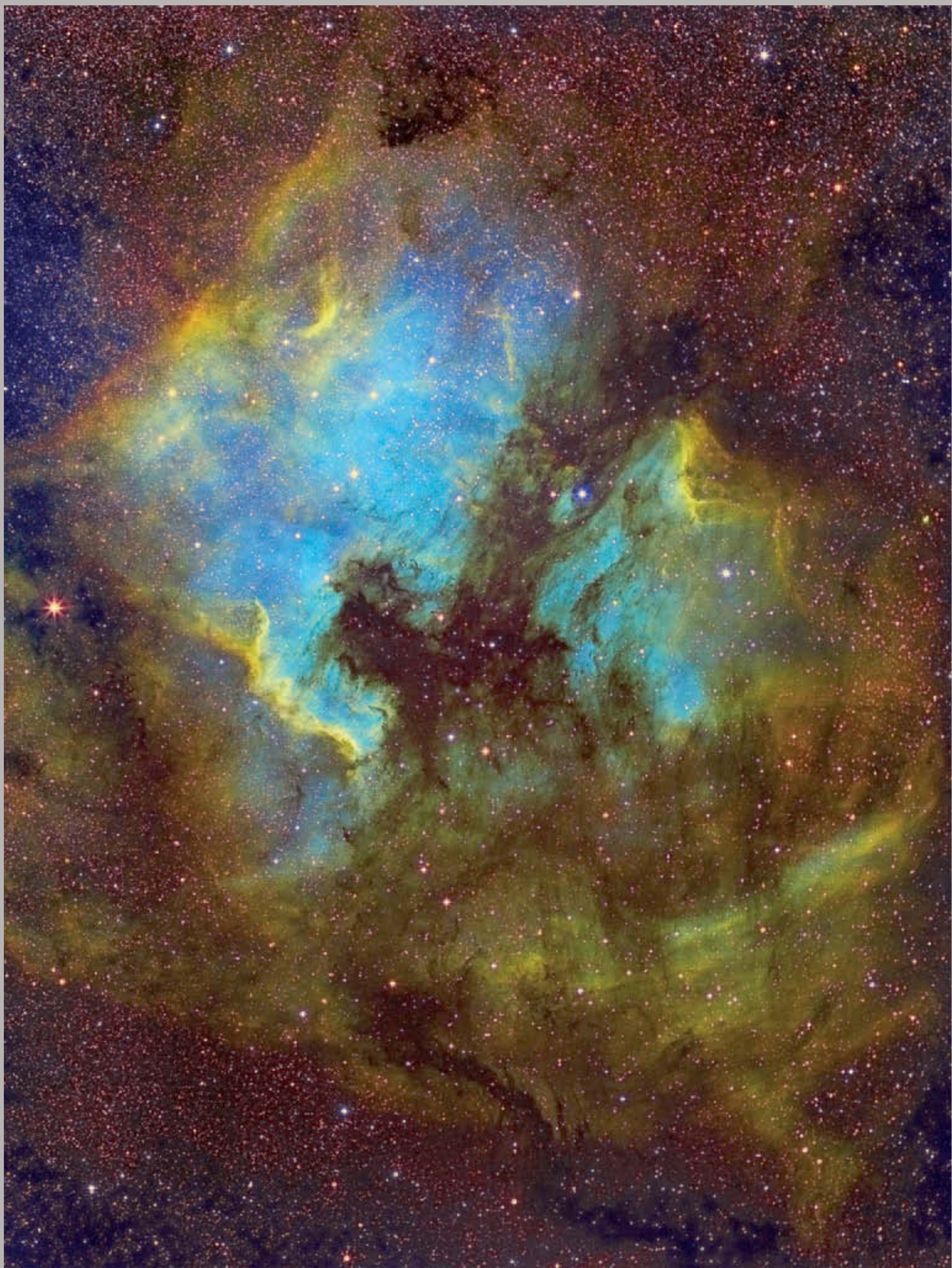
Creating a strip sketch enables you to use Jupiter's rotation to your advantage by drawing features as they cross the central meridian of the planet, making it easier to keep recording for as long as you continue to observe throughout the night.

I often try to include some additional information, such as my observing conditions, unusual colored areas, or interesting occurrences during the session. Additionally, I Indicate the direction of south or north in the drawing, the direction of the planet's rotation, and the magnification used. I always include the System I and System II longitudes in order to track the positions of features I recorded. Depending on your personal preference, you can also add the planet's altitude and diameter at the time of the observation.

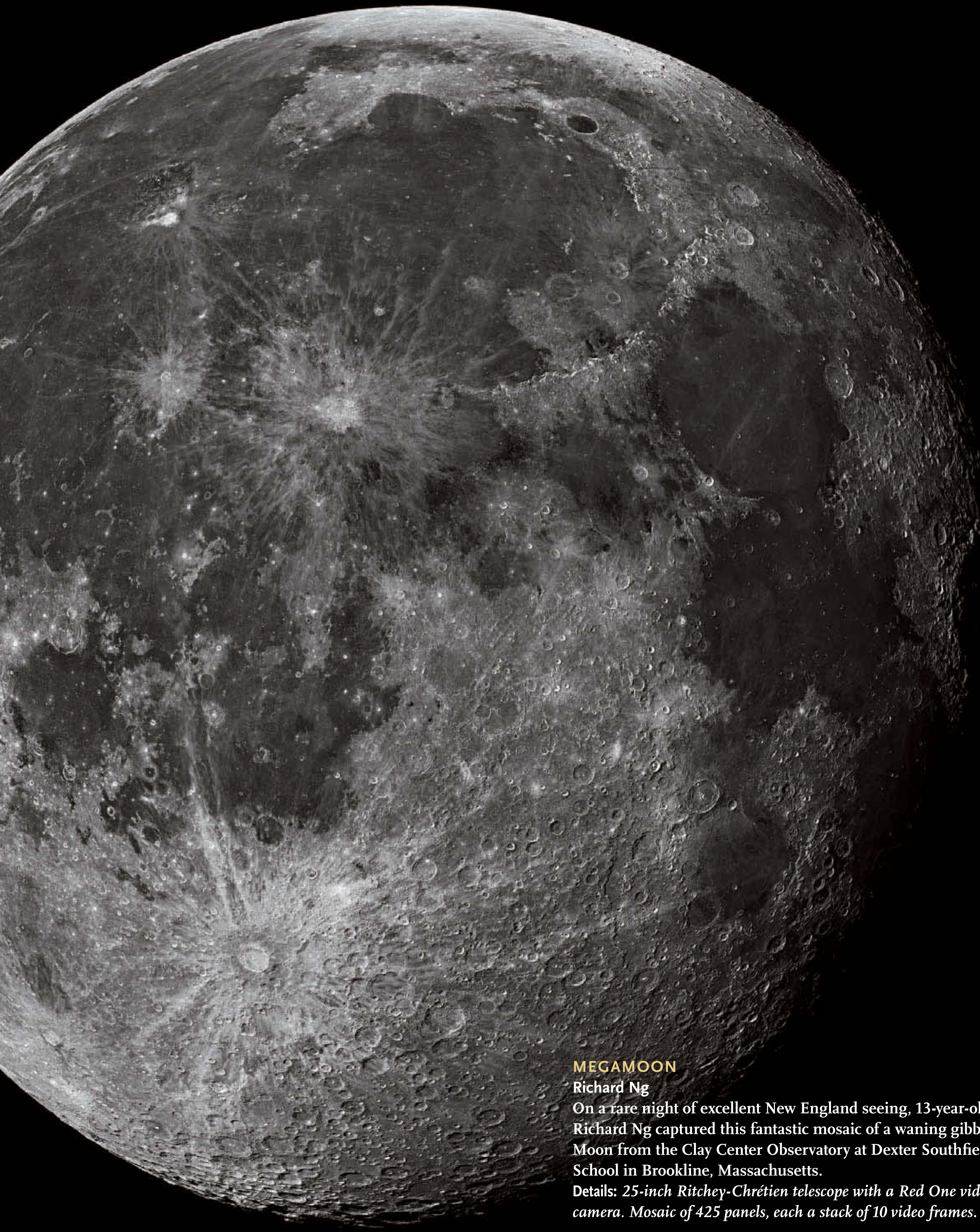
The final step with your drawing, whether it is an extended strip sketch or a full disk sketch, is to preserve and share it. Drawings are usually preserved using spray fixative to keep the media from smudging or rubbing off (hair spray is an alternative). Many sketchers like to scan their work and use image-processing software to adjust the contrast, add color, mirror-reverse, or replace their handwritten notes with clean type. The sketch is then ready to share in online forums or the planetary observers' associations mentioned earlier.

You now have a visual record of your observation and, more importantly, you have taken a huge step in training your eye to bring your observing talents up to a higher level. Good luck with your Jupiter sketch in this and future apparitions! ✦

Michael Rosolina *observes Jupiter with a Celestron C14 from the dark skies of Greenbrier County, West Virginia.*



▲ **NEBULOUS HOLLOW**
Richard S. Wright, Jr.
The North America Nebula, NGC 7000 (left), and the Pelican Nebula, IC 5067/70, appear as the illuminated walls of a single large hollow excavated by bright young stars.
Details: *QSI 583ws CCD camera with Canon 200-mm lens. Total exposure was 12 hours through Astrodon narrowband filters.*



MEGAMOON

Richard Ng

On a rare night of excellent New England seeing, 13-year-old Richard Ng captured this fantastic mosaic of a waning gibbous Moon from the Clay Center Observatory at Dexter Southfield School in Brookline, Massachusetts.

Details: *25-inch Ritchey-Chrétien telescope with a Red One video camera. Mosaic of 425 panels, each a stack of 10 video frames.*

◄ **LICK AND THE BLUE MOON**

Fabio Pettinati

The "Blue Moon" of August 20, 2013 rises beside Lick Observatory on Mount Hamilton as seen from the side of Highway 130 in California.

Details: *Stellarvue SV70ED refractor with Pentax K-5 DSLR. Total exposure was 1/500 second at ISO 400.*

▼ **EAST COAST LAUNCH**

Steve Shilling

A Minotaur rocket carrying the LADEE spacecraft, on its way to study the Moon's tenuous atmosphere, is captured jettisoning its second stage seen from Ship Bottom, New Jersey, on September 6, 2013.

Details: *Canon EOS 5D Mark III DSLR camera with 17-mm lens at f/11. Total exposure was 161 seconds.* ✦

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

Gallery showcases the finest astronomical images submitted to us by our readers. Send your very best shots to gallery@SkyandTelescope.com. We pay $50 for each published photo. See SkyandTelescope.com/aboutsky/guidelines.


Go Ahead
& Take Your
Best Shot
Great Prizes. Stellar Recognition.
Sky & Telescope Comet ISON Photo Contest
Deadline for submissions: Midnight EST December 31, 2013
Finalists posted on our website for voting: January 8, 2014
Voting ends: January 22, 2014
Winners announced: April 2014 Issue
SkyandTelescope.com/photocontest
First Prize
8-inch EdgeHD on Advanced VX Mount; Skyris 274M camera
Second Prize
Cometron 114AZ Telescope
Third Prize
Cometron 12x70 Binoculars
CELESTRON
SKY & TELESCOPE

SKY & TELESCOPE Market Place

Your essential source for astronomical products

ACCESSORIES

BOOKS

CCD EQUIPMENT

COMPUTER SOFTWARE

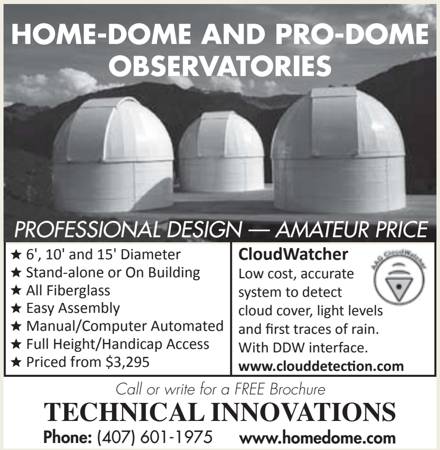
COMPUTER SOFTWARE

DRIVES / MOUNTS

DRIVES / MOUNTS

OBSERVATORIES / DOMES

OBSERVATORIES / DOMES

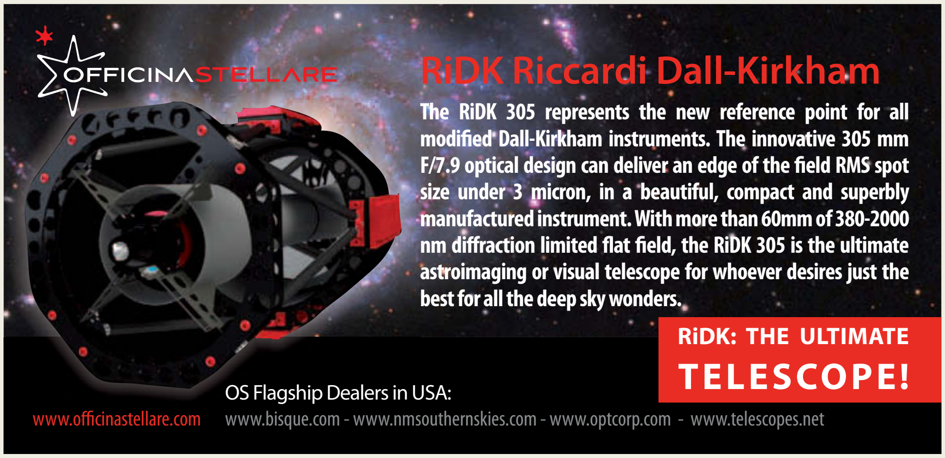


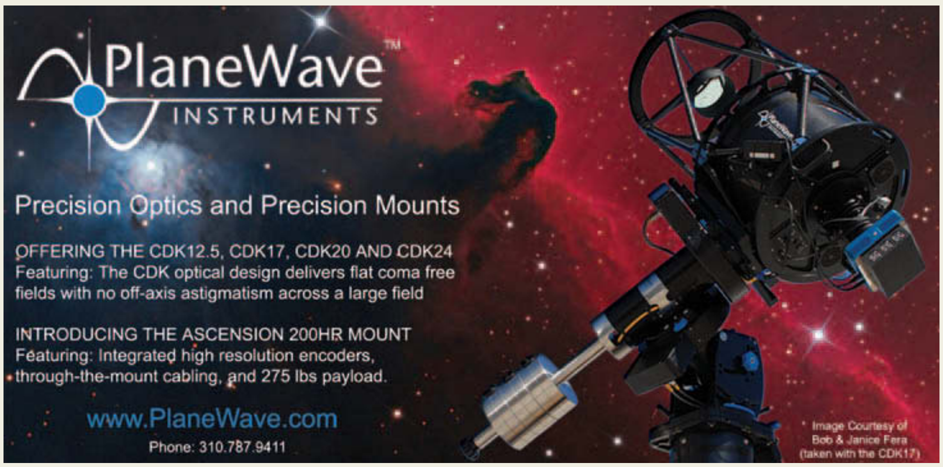
TELESCOPES

ORGANIZATIONS

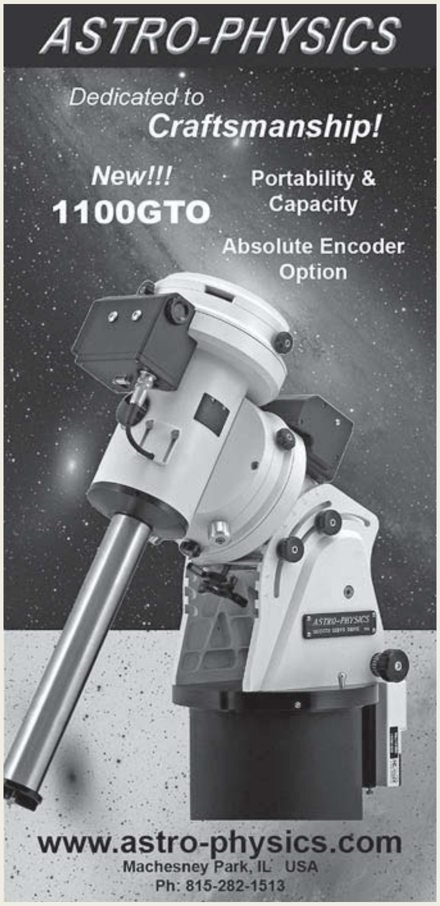
TELESCOPES

TELESCOPES





TELESCOPES



TRAVEL

TRAVEL

CLASSIFIEDS

REAL ESTATE: Land and homes for sale in Southern Utah's high desert – the second darkest place in North America. Noted for deep sky viewing. Properties are located between Bryce Canyon and Capitol Reef National Parks. Small remote communities surrounded by 97% government lands. Electricity, water, internet access and complete comfort while living in the wilderness! Homes on the market now ranging in price from $190,000 to $470,000. Land ranging in size from 2 to 47 acres priced from $48,000 to $350,000, all with exceptional views of the landscape and the sky. For more information, visit www.bouldermountainrealty.com or call Cathy Bagley, Broker, Torrey, Utah, 435-425-3200.

FOR RENT: 3 BR/2BA fully furnished adobe home in ARIZONA SKY VILLAGE in Portal, AZ. Observe and photograph under the darkest, clearest and most transparent skies with astronomers from all over the world. Contact irkitzman@gmail.com 520-203-8500 www.arizona-dreaming.com.

FOR SALE: TAL 200mm Klevtsov-Cassegrain Telescope. TAL200K 8.5 Klevtsov/Cassegrain optical design telescope in excellent condition. 200mm aperture, includes these accessories: 8X50 Finderscope with mounting bracket, 90 degree star diagonal, 2X Barlow lens, 10mm Super Plossl eyepiece, 25mm Super Plossl eyepiece, crosshair reticle for eyepiece.Price: $1,995 plus shipping. Write ads@SkyandTelescope.com

AUTHORS/SOFTWARE DEVELOPERS: is your passion astronomy and would you like to see your work published by Willmann-Bell? If so, let's explore the possibilities. Call 1-800-825-7827 or write PO Box 35025, Richmond, VA 23235.

FOR SALE: Classic A-frame, 2x10 construction, 33 mountaintop acres at 6,200' altitude, dark-sky laws in effect. Fort Davis, TX. 250K; matthewoller@yahoo.com.

FOR SALE: Beautiful 2,000 sq-ft single-story Pueblo-style home, between Las Vegas and Kingman AZ, 12' automated clamshell dome, 4BR, 3BA, 5 car garage, very dark clear skies, $195,000, for pictures and details email: easton6@roadrunner.com . Phone: 702-595-8535.

Classified ads are for the sale and purchase of noncommercial merchandise, unique items, or job offers. The rate is $1.50 per word; minimum charge of $24; payment must accompany order. Closing date is 15th of third month before publication date.

Inside This Issue

Specialty astronomy equipment dealers and manufacturers are an important resource for amateur and professional astronomers alike — patronize our advertising dealers in this issue and enjoy all the benefits of their expertise.

Product Locator

BINOCULARS

Celestron (Page 11)
Celestron.com
310-328-9560

Meade (Page 5, 88)
Meade.com
800-919-4047 | 949-451-1450

CAMERAS

Apogee (Page 9)
CCD.com
916-218-7450

Celestron (Page 11)
Celestron.com
310-328-9560

FLI (Page 57)
FLIcamera.com
585-624-3760

Meade (Page 5, 88)
Meade.com
800-919-4047 | 949-451-1450

Santa Barbara Instrument Group (Page 3)
SBIG.com
805-571-7244

EYEPIECES

Celestron (Page 11)
Celestron.com
310-328-9560

Explore Scientific - Bresser (Page 29)
ExploreScientific.com
888-599-7597

Meade (Page 5, 88)
Meade.com
800-919-4047 | 949-451-1450

Tele Vue (Page 2)
TeleVue.com
845-469-4551

FILTERS

Astrodon (Page 80)
Astrodon.com

Celestron (Page 11)
Celestron.com
310-328-9560

FLI (Page 57)
FLIcamera.com
585-624-3760

Meade (Page 5, 88)
Meade.com
800-919-4047 | 949-451-1450

Tele Vue (Page 2)
TeleVue.com
845-469-4551

FOCUSERS

FLI (Page 57)
FLIcamera.com
585-624-3760

MOUNTS

Celestron (Page 11)
Celestron.com
310-328-9560

iOptron (Page 15)
iOptron.com
866-399-4587

Meade (Page 5, 88)
Meade.com
800-919-4047 | 949-451-1450

Paramount (Page 87)
Bisque.com
303-278-4478

PlaneWave Instruments (Page 82)
PlaneWave.com
310-787-9411

Takahashi (Page 53)
TakahashiAmerica.com
713-529-3551

Tele Vue (Page 2)
TeleVue.com
845-469-4551

OBSERVATORIES

Observa-Dome Laboratories (Page 71)
Observa-dome.com
800-647-5364

SOFTWARE

Celestron (Page 11)
Celestron.com
310-328-9560

Fisch Image Lab (Page 29)
ExploreScientific.com
888-599-7597

Software Bisque (Page 87)
Bisque.com
303-278-4478

Southern Stars (Page 37)
SouthernStars.com
415-671-6254

TELESCOPES

Celestron (Page 11)
Celestron.com
310-328-9560

Explore Scientific - Bresser (Page 29)
ExploreScientific.com
888-599-7597

iOptron (Page 15)
iOptron.com
866-399-4587

Meade (Page 5, 88)
Meade.com
800-919-4047 | 949-451-1450

PlaneWave Instruments (Page 82)
PlaneWave.com
310-787-9411

Sky-Watcher USA (Page 7)
SkyWatcherUSA.com
310-803-5953

Takahashi (Page 53)
TakahashiAmerica.com
713-529-3551

Tele Vue (Page 2)
TeleVue.com
845-469-4551

William Optics (Page 82)
WilliamOptics.com
714-262-9288

Dealer Locator

CALIFORNIA

Oceanside Photo & Telescope (Pages 53)
Optcorp.com
800-483-6287

CALIFORNIA

Woodland Hills (Page 17)
Telescopes.net
818-347-2270

OKLAHOMA

Astronomics (Page 71)
Astronomics.com
800-422-7876

TEXAS

Texas Nautical Repair, Inc. (Page 53)
TakahashiAmerica.com
713-529-3551

To advertise on this page, please contact Lester Stockman at 617-758-0253, or Ads@SkyandTelescope.com

Index to Advertisers

BOTTOM: ROD MOLLISE; TOP: NORTH CAROLINA MUSEUM OF ART, RALEIGH

SKY & TELESCOPE

SkyandTelescope.com

800-253-0245

IN THE NEXT ISSUE

An Impressionist's Sunset

A team of celestial sleuths traveled to the Normandy coast to pin down the exact date and spot of one of Claude Monet's most beautiful paintings.

Kuiper Belt Mysteries

Astronomers are piecing together the puzzle of the realm beyond Neptune.

Easy Photo Targets

Getting started in astrophotography is pretty easy these days. Here's a primer on what to shoot right out of the gate.

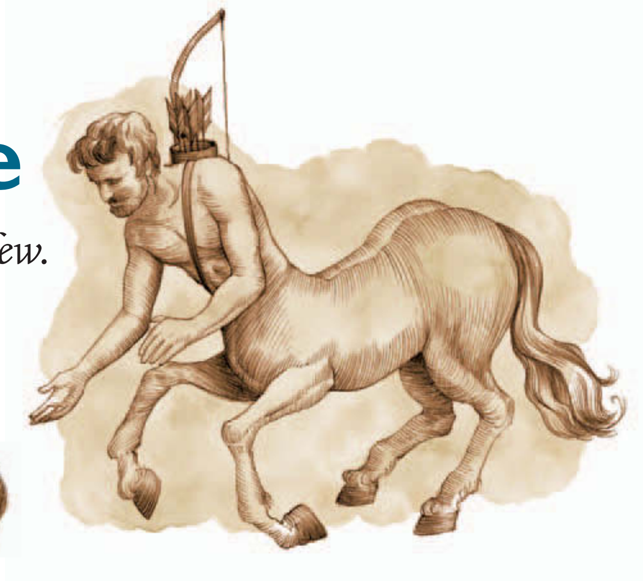
Milky Way, Part 3

Explore the winter Milky Way from Perseus to Puppis and beyond.

On newsstands December 31st!

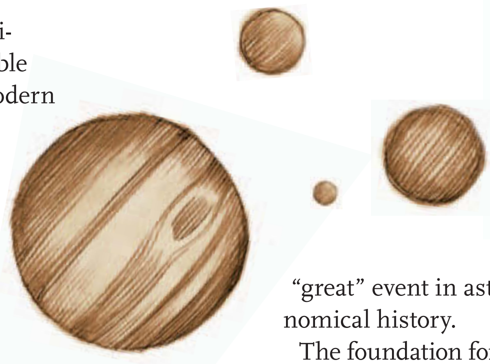
Find us on Facebook & Twitter

Focal Point *Eric M. Fischer*



The Grand Conclave

One of the greatest celestial events was seen by only a few.



January 2014 marks the 30th anniversary of perhaps the most remarkable celestial planetary convergence in modern times. Throughout January 1984 an observer could, in principle, observe all of the planets (including Pluto) within the same naked-eye field of view. But what could have been among the most memorable skygazing events went largely unnoticed, especially by the general public. As such, it seems that only a widely observed event is regarded as a "great" event in astronomical history.

The foundation for the 1984 planetary grouping was laid in the 1970s when Uranus, Neptune, and Pluto convened and awaited the arrival of Jupiter and Saturn in the early 1980s. Of course, the inner planets continued numerous laps around the Sun during that decade, but it took Mars to seal the deal in the fall of 1983 when it moved into the quadrant already shared by the outer planets. Luckily, Earth was situated about 90° (heliocentric longitude) away from its companions in December 1983, thus setting up the grandstand view to come.

Although several fine planetary groupings occurred during this period, none could match the January 1984 "grand conclave," as Robert C. Victor described it in that month's issue of *S&T* (page 58). By January 1st, seven planets had gathered between Virgo and Sagittarius. On January 10th, a Mercury-Neptune-Jupiter conjunction had formed just east of a Venus-Uranus pairing. Mars arrived in Virgo around January 12th, creating an 8-planet array spanning less than 60° of ecliptic longitude. In fact, January 12th through 15th marked the tightest bunching of the planets for the past several centuries.

If this weren't enough, the waning crescent Moon entered the area and pulled to within 1° of Saturn on January 26th. A tight Jupiter-Venus-Neptune conjunction had already formed in Ophiuchus, with Venus and Jupiter separated by less than 1° and Venus-Neptune separated by less than 1 arcminute.

In his book *The Starry Room: Naked-Eye Astronomy In The Intimate Universe*, *S&T* contributing editor Fred Schaaf recalls the bitter cold morning of January 26th, when he stepped out of his New Jersey home to observe the Conclave: "This morning, the ultimate dream of a planet watcher was come true: all of the planets condensed before me into one straightforward, nowhere peripheral view. It struck me like nine-branched lightning, held me still as a (deeply breathing) statue. All the planets at once."

The 1984 Grand Conclave could have drawn an outpouring of public interest and given a major boost to popular astronomy. Alas, for Northern Hemisphere observers the gathering took place in the pre-dawn hours of the coldest winter month, the worst possible time for public outreach. Still, the Conclave deserves membership in astronomy's pantheon of historic events, along with the Crab supernova of 1054, the Leonid Meteor Storm of 1833, this year's Chelyabinsk fireball, and others. What remarkable celestial events are likewise missing from the history books because they were observed by only a few? ✦

S&T: LEAH TISCIONE

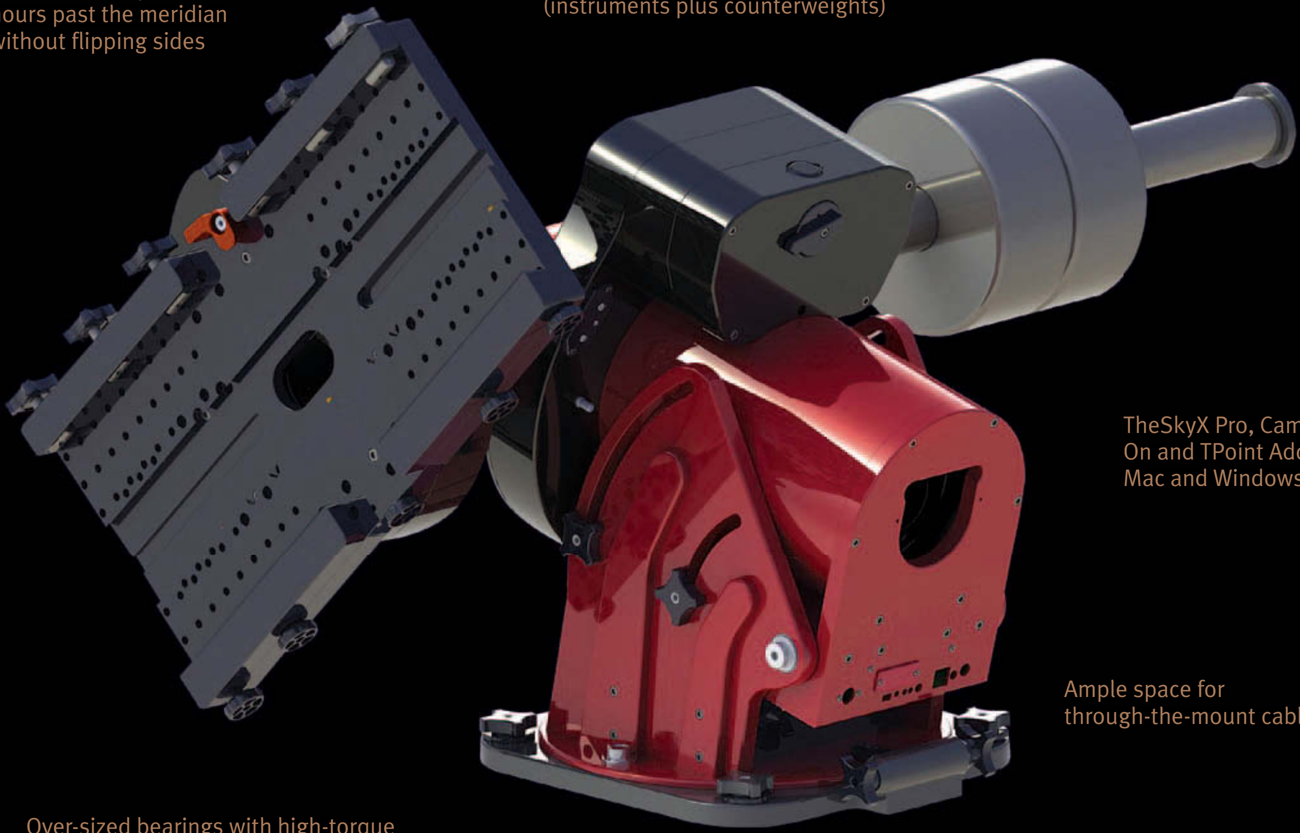
***Eric Fischer** has been an avid backyard observer for 50 years and an active member of the Amateur Astronomers Association of Pittsburgh, serving three terms as president.*

Introducing the Paramount ME II

Track or slew up to three
hours past the meridian
without flipping sides

240 lb (109 kg) instrument capacity,
580 lb (218 kg) maximum payload
(instruments plus counterweights)

Mechanical switch on
each axis simplifies
balancing the payload



TheSkyX Pro, Camera Add
On and TPoint Add On for
Mac and Windows included

Ample space for
through-the-mount cabling

Over-sized bearings with high-torque
servomotors ensure 'to specification
performance' at maximum payloads

$13,500

PARAMOUNT MEII

The Robotic Telescope Mount Engineered for Productivity

FIND YOUR SPACE BISQUE.COM

SOFTWARE BISQUE

Software Bisque, Inc. 862 Brickyard Circle, Golden, Colorado 80403