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JANUARY 2024

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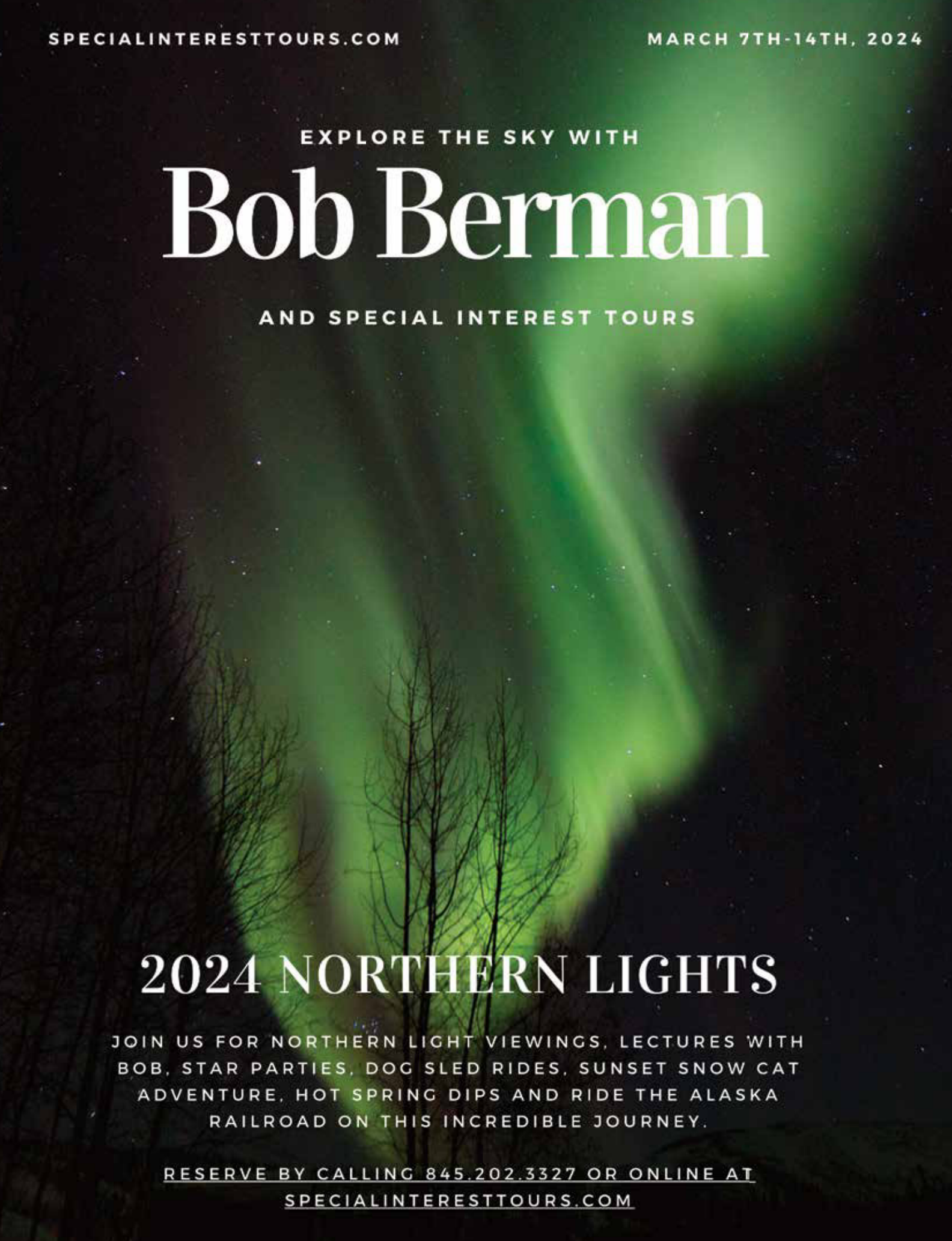
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IN EVERY ISSUE

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Weird = good

The Vela Supernova Remnant is one of 101 exotic objects you can observe and image with a moderate-sized telescope. HAREL BOREN/WIKIMEDIA COMMONS

When I excitedly unboxed my first telescope, a Celestron 8, in 1976, I couldn't wait to get it under the stars. Those were exciting times, not really knowing what anything would look like "live" in the eyepiece.

I was a little discouraged reading about some objects in various books before the scope arrived, though. The Veil Nebula was one example that stood out as a serious challenge in an 8-inch scope. But when the C-8 arrived I had a clear sky on the first night, and so I took it out. Lo and behold, there was the Veil Nebula, one half at a time, visible in the scope, plain as day. This taught me right off the bat that some of the folks writing about observational astronomy were not always 100% correct.

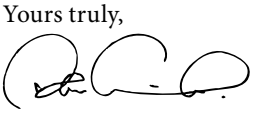
Over the years, observers gained access to larger telescopes, and the information became far better and more reliable. I tried to do my part by publishing *Deep Sky* magazine, at first a homegrown journal and later a venture that brought me to *Astronomy* magazine. The information revolution, coupled with better and larger telescopes, opened the universe to amateur astronomers.

Suddenly, it seemed, an observer or imager armed with an 8-inch or 12-inch scope could see not hundreds but thousands of interesting objects. Yes, there are the bright ones — the Andromeda Galaxy, Orion Nebula, Pleiades. But in this special issue, we have taken you to more exotic locales. Why not take some time and make an effort to get to know some of them?

Weird nebulae are tucked into the Milky Way's spiral arms. Have you checked out Gyulbudaghian's Nebula? What about Jones-Emberson 1? Or perhaps Simeis 147? Unusual galaxies lie scattered all across the sky. Perhaps you've stumbled on Maffei 1, or Hoag's Object, or maybe the Cartwheel Galaxy?

I invite you to use this issue to explore the 101 most bizarre, unusual, and oddball sky objects that came to mind when I contemplated such a list. I hope it will lead you to some moments of discovery and wonder.

Yours truly,



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101 WEIRDEST COSMIC OBJECTS

A strange brew of astronomical oddities awaits you and your telescope.

TWO YEARS AGO, our special January issue brought forth a popular package, 101 Must-See Cosmic Objects. Now we follow it up in a very different direction. My thought this time was to produce something covering not the brightest, but some of the strangest celestial objects you can see or image with amateur telescopes.

Some of the present 101 objects have strange names — Gyulbudaghian's Nebula, Purgathofer-Weinberger 1, or Gomez's Hamburger. Some are weird stars — Tabby's Star, Eta Carinae, or FU Orionis. Some are strange regions of the sky filled with color and apparently exotic behaviors — Rho Ophiuchi, the Red Spider Nebula, or the Jewel Box.

Most of these 101 objects, however, are really compelling and odd ducks that can be explored from a dark-sky site. Want an astrophotographic challenge? Try shooting the nearby galaxies Maffei 1 and 2, which are so heavily obscured by the Milky Way that they weren't discovered until 1967. How about spying really odd planetary nebulae? Take a shot at the Saturn Nebula, the Lemon Slice Nebula, or Jones 1.

With the right scope, you can see a quasar, 3C 273, from your backyard, or the galaxy with a quasar near it, NGC 4319 and Markarian 205, that caused a years-long controversy over redshifts as distance indicators. The sky is loaded with mysterious galaxies. Take a peek at Zwicky's Triplet, Seyfert's Sextet, or the Hercules Galaxy Cluster.

In short, you'll find many hours of cosmic exploration in this issue, whether you spy some of these creatures with your own eyes, capture them with a camera, or merely enjoy reading about them on these pages.

Have fun with the journey. I'll be taking it right beside you. — DAVID J. EICHER

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Michael E. Bakich *is a contributing editor of* Astronomy *who has spent countless hours observing fascinating deep-sky objects.*

Alan Goldstein's *50-year-long interest in astronomy aligns with the founding of the magazine. He has been contributing since 1981.*

Phil Harrington *received the Walter Scott Houston Award at Stellafane 2018 for his lifelong work promoting and teaching astronomy.*

Stephen James O'Meara *is a globetrotting observer who is always looking for the next great celestial event.*

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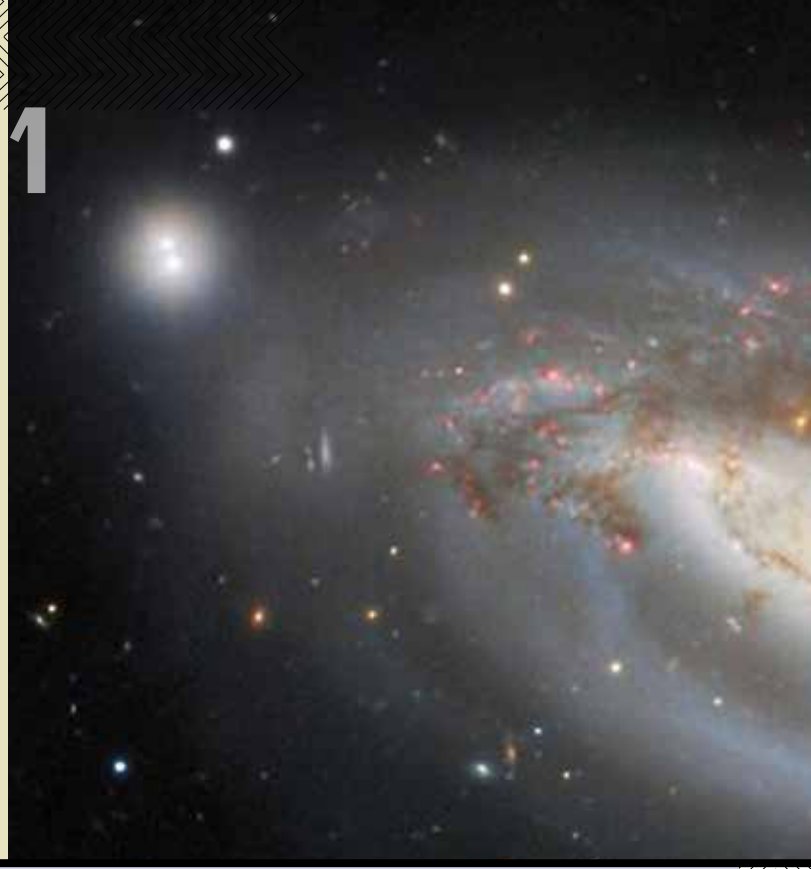
UGC 12914 AND UGC 12915



A long time ago, two spiral galaxies far, far away were slowly drawing closer to each other, until, about 25 million to 30 million years before the image here was taken, they collided head-on.

Found 180 million light-years away in the constellation Pegasus, both UGC 12914 and UGC 12915 managed to pull away from each other but were left badly warped and stretched from this violent event. The aftermath shows a bridge of hydrogen gas connecting the two. In radio images, it makes the galaxies look like warm taffy candy being pulled apart. That, plus their twisted appearances, led to the nickname the Taffy Galaxies.

There was so much momentum that each galaxy kept moving despite the crash — a case of a galactic hit-and-run. Such collisions often trigger rapid bursts of star formation, but for this pair the opposite happened. The cosmic dust and glowing red clouds of ionized hydrogen between the galaxies have all the necessary materials for new stars to be born. However, due to the head-on nature of the collision, the impact between galactic disks and gases injected a massive amount of energy, creating fierce turbulence. This chaos hindered the collection and compression of gas necessary for new star formation. – P.H.

ALPHA PERSEI CLUSTER

MARTIN GEMBEC (ASTROFOTKYCZ/~MAG)

Also known as Melotte 20, Collinder 39, and the Perseus Moving Group, this open cluster is a loosely bound association of predominantly blue and blue-white type O and B stars spanning 6° of the northern autumn sky. Many of the cluster members are visible to the unaided eye and through binoculars.

The brightest of the bunch is 2nd-magnitude Mirfak (Alpha [α] Persei), a type F white/yellow supergiant. Other prominent naked-eye members include Delta (δ), Sigma (σ), and Psi (ψ) Persei. About 50 stars belong to the cluster, although some sources cite 10 times as many. These stars are only about 60 million years old. They are referred to as "moving" because they share a similar, albeit very slow, proper motion against more distant stars.

Although the brighter stars in the α-Persei Cluster had been known since our ancient ancestors looked skyward, Italian astronomer Giovanni Hodierna is credited as the first person to catalog it as a nebulous object in 1654. However, Sir Arthur Eddington was the first to recognize the Perseus Moving Group was a stellar grouping. This prompted British astronomer Philibert Melotte to include it in his 1915 catalog of star clusters. But it wasn't until 1938 that American astronomer Robert Trumpler proved it to be a true cluster.

Two independent techniques to determine a star's distance showed that the stars in the Perseus Moving Cluster lie between 557 and 650 light-years away. – P.H.

NGC 4151

NGC 4151 is an intriguing spiral galaxy, discovered by William Herschel in 1787. Modern images show an intense central core surrounded by an oval ring of stars, dust, and gas. Red splotches throughout the spiral arms display an array of emission nebulae, while blue regions mark concentrations of newly formed stars. Studying its spiral structure gives hints of a central bar, which has led astronomers to classify it as an SAB intermediate spiral, between barred and unbarred spirals.

American astronomer Carl Seyfert was the first to realize that NGC 4151's center was unusual. His landmark research led to this galaxy and others like it being known as Seyfert galaxies. Seyfert galaxies contain actively growing supermassive black holes buried in their cores. In a sense, they are the missing link between quasars and relatively dormant galactic black holes, like our Milky Way's.

At roughly 52 million light-years away, NGC 4151 is one of the closest galaxies with an active galactic nucleus, allowing it to be studied in greater detail. In 1970, the Uhuru X-ray observatory satellite detected X-ray emissions originating from NGC 4151, evidence of a central black hole. Four decades later, the Chandra X-ray Observatory obtained data suggesting that these emissions are likely caused by an outburst fueled by the supermassive black hole, while material swirls around it in an accretion disk.

ADAM BLOCK/MOUNT LEMMON SKYCENTER/UNIVERSITY OF ARIZONA

Combining images of its core taken at visible, radio, and X-ray wavelengths gives NGC 4151 a supernatural appearance, and the nickname Eye of Sauron (from *The Lord of the Rings*). – P.H.

NOIRLAB

NGC 1023

NGC 1023 is the largest member of a small group of galaxies in Perseus. After extensive study, NGC 1023 has been classified as a barred lenticular galaxy, which have protruding central bulges that taper toward their edges. In many ways, they look like elliptical galaxies, but also share some common traits of spiral galaxies — except for one: They do not have spiral arms. In the case of NGC 1023, the disk shows no discernible structure, but there is a hint of a central bar, leading to the SB0 classification.

Detailed images of NGC 1023 show a lump on the eastern side of the galaxy, which was thought to be a lopsided spiral arm and led Halton Arp to add it to his atlas as Arp 135. As imaging improved, it became clear that the lump was actually a small irregular galaxy that is likely tidally locked to the larger NGC 1023. That companion galaxy is now referred to as NGC 1023A.

Hubble Space Telescope studies unveiled a supermassive black hole at the center of NGC 1023. Its mass is between 40 million and 60 million times greater than our Sun's. Hubble also shows that many stars closest to the black hole orbit in a small, flattened disk rather than at random angles as other stars in the central bulge do. And even though some are orbiting as fast as 1.3 million mph (2.1 million km/h), they still cannot break the powerful grip of the black hole. – P.H.

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JONES-EMBERSON 1

The saga of the planetary nebula Jones-Emberson 1 began 148 years before Harvard Observatory astronomers Rebecca Jones and Richard Emberson discovered it in the faint constellation Lynx. In 1790, William Herschel discovered a small, nebulous glow about 2½° northwest of 27 Lyncis. He moved on without noticing a second, fainter glow nearby. That object was discovered 66 years later by William Parsons, Earl of Rosse, through his 72-inch "Leviathan" reflector. Both were later added to John Dreyer's *New General Catalogue* as NGC 2474 and NGC 2475 and classified as dim elliptical galaxies separated by just 25".

Then, in 1939, Jones and Emberson published a paper in that year's *Harvard College Observatory Bulletin* August issue, announcing that "a recent photographic plate [revealed] a faint nebular ring has been detected joining two condensations, NGC 2474 ... and NGC 2475."

Their error did not become apparent for more than 40 years, until Nancy and Ronald Buta of McDonald Observatory realized that Jones and Emberson had not photographed NGC 2474 and 2475 at all. Instead, they had discovered an unusual planetary nebula half a degree to the north, about 1,600 light-years away, that had never been seen before.

In addition to its unconventional discovery story, Jones-Emberson 1 looks weird as far as planetary nebulae go. Images show a familiar ring structure. But what makes it strange are two brighter lobes connected by opposing faint arcs of nebulosity. This unusual cloud structure has given rise to the nickname of the Headphone Nebula. – P.H.

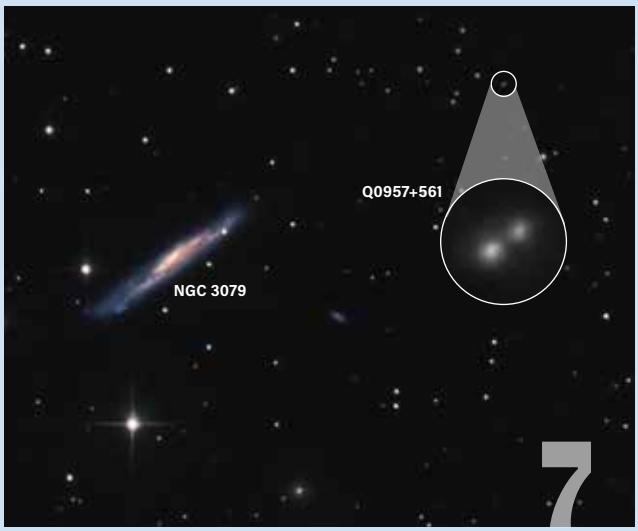
DWINGELOO 1

Like Maffei 1 and 2 (see #16), Dwingeloo 1 is located in the constellation Cassiopeia, obscured from direct view by opaque clouds of dust within the Milky Way's zone of avoidance. It was first spotted in 1994 by the Dwingeloo Obscured Galaxy Survey using the 82-foot (25 meters) dish at Dwingeloo Radio Observatory in the Netherlands.

Thanks to infrared techniques that can pierce dust clouds, Dwingeloo 1 is now recognized as a member of the nearby IC 342-Maffei 1 Group. Like the other galaxies in the collection, Dwingeloo 1 is estimated to be about 10 million light-years away. It is thought to contain more than 100 billion stars — making it about the same size and mass as the Triangulum Spiral (M33). Infrared images clearly show that Dwingeloo 1 has two spiral arms curving away from the ends of a central bar — with at least 15 HII emission regions in both arms.

Dwingeloo 1 is accompanied by two smaller satellite galaxies. The first, known as Dwingeloo 2, is an irregular galaxy discovered in 1996. Dwingeloo 2's irregular structure is likely due to gravitational interplay with the more massive Dwingeloo 1. The second satellite galaxy, known as MB 3, was discovered by the team of Marshall McCall and Ronald Buta in 1996 using the Burrell Schmidt Telescope at Kitt Peak Observatory. MB 3 is a dwarf spheroidal galaxy characterized by a highly flattened disk. –P.H.

DAVID RATLEDGE



ROBERT EDER

NGC 3079 AND Q0957+561

In 1790, William Herschel discovered NGC 3079, a nearly edge-on barred spiral galaxy in Ursa Major about 50 million light-years away.

Hubble images reveal its spiral disk is peppered with many HII regions that appear strikingly red. Hubble also uncovered how the galactic nucleus is emitting a lumpy bubble of hot gas surrounded by glowing fingers of interstellar matter. The bubble is more than 3,000 light-years wide and towers 3,500 light-years above the galaxy's spiral disk. Research suggests that the bubble is caused by a stream of high-speed particles that were released during a surge of star formation.

There's another oddity nearby. Though not physically related, Q0957+561 lies just 14' northwest of NGC 3079. This object contains not one, but two quasars separated by 6". Do quasars form in pairs too, like some stars? That was undoubtedly one of the first questions asked when Q0957+561 (nicknamed the Twin Quasar) was discovered in 1979. Further studies revealed that it's actually a single quasar; it only appears double due to gravitational lensing.

A galaxy cataloged as YGKOW G1 happens to sit exactly between us and the distant quasar. Its gravity warps the space around it, bending the path of light that passes nearby, like a lens. In fact, Q0957+561 was the first known example of a gravitational lens, proving that Einstein got it right when he said that gravity can bend the fabric of space and time. –P.H.

JONES 1

Planetary nebula Jones 1 is named after American astronomer Rebecca Jones, who discovered this weird object in 1941 on photographic plates taken at Harvard Observatory. She was well known for her galaxy studies, and at the time of the discovery, she was an assistant to Harlow Shapley.

Jones 1 is located in Pegasus just north of the Great Square. Although it measures 5' across, Jones 1 is an extremely faint planetary at 15th magnitude. The white dwarf central star is even fainter at 16th magnitude. (Don't confuse Jones 1 for Jones-Emberson 1 in Lynx [see #5]; she and Richard Emberson discovered that planetary nebula two years earlier.)

If you compare the appearances of both of Jones' discovered planetary nebulae, there is definitely a familial similarity. Each shows a wispy face-on ring structure that is highlighted by a pair of brighter lobes of nebulosity that appear opposite of each other. Jones-Emberson 1 is nicknamed the Headphone Nebula after its appearance, but Jones 1 could just as easily carry the same handle.

Jones 1 is also named PK 104–29.1 in *The Perek-Kohoutek Catalogue of Planetary Nebulae*, compiled by Czech astronomers Luboš Perek and Luboš Kohoutek and published in 1967. Estimates place the planetary nebula at about 2,300 to 2,700 light-years from Earth.

Planetary nebulae are classified based on their shape and structure. Jones 1 is in Class IIIb, meaning it displays an irregular disk of varying brightness and an annular structure. For comparison, Jones-Emberson 1 is a Class IV annular planetary. –P.H.

T.A. RECTOR/UNI. OF ALASKA ANCHORAGE, H. SCHWEIKER/WIYN, AND NOIRLAB/NSF/AURA

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HOAG'S OBJECT

In the October 1950 issue of *The Astronomical Journal*, American astronomer Arthur Hoag states that the object "appears to be a perfectly symmetrical planetary nebula." However, he acknowledged that some of its characteristics did not match those of other planetary nebulae, so he also suggested that instead it might be "a new species among the 'pathological' galaxies."

Today, Hoag's Object is one of the finest, most perfect examples of a rare galaxy type: a ring galaxy. It's over 600 million light-years away in the constellation Serpens and spans over 120,000 light-years. At the center, there's a sphere of older reddish stars, looking very much like an elliptical galaxy. Moving outward, there's a seemingly empty gap until arriving at the ring. The ring is made up of young blue stars highlighted by spokes that appear curved, signs of rotation. Astronomers have been asking how the galaxy evolved since 1950.

Ring galaxies can result when a smaller galaxy collides with a larger, disk-shaped galaxy. This collision generates a density wave within the disk, resulting in a distinct ringlike structure. But there seems to be no evidence of a past collision in the case of Hoag's Object. Besides, the core of Hoag's Object is spheroidal, while the nucleus of a barred spiral is typically disk-shaped.

Look again at the gap between the ring and central core. Notice anything? It's another ring galaxy that's much farther away. What are the extraordinary odds that a rare ring galaxy is seen in the gap of another ring galaxy? – P.H.

NGC 147 AND NGC 185

The Andromeda Galaxy (M31) is known for sharing a nearby space with two smaller satellite galaxies, M32 and NGC 205. But fewer people are aware that it also has many more distant satellite galaxies, including two across the border in Cassiopeia. William Herschel found NGC 185 in November 1787. And fainter NGC 147 evaded detection until his son John discovered it in September 1829.

NGC 185 and NGC 147 are only one degree apart in the sky, and just over 7° north of the Andromeda Galaxy. Both are dwarf ellipticals found in M31's outer halo, but farther out than M32 and NGC 205. Past studies concluded that because of the close proximity of NGC 185 and NGC 147, they must form a gravitationally bound pair — a binary galaxy, if you will.

A 2020 study led by Sangmo Tony Sohn of the Space Telescope Science Institute published in *The Astrophysical Journal*, found otherwise. Those measurements showed that NGC 147 has a distance of 2.36 million light-years, while NGC 185 is 2.07 million light-years away, placing them both on the near side of Andromeda. Due to Andromeda's overwhelming gravity, the study concluded that both galaxies "may be a chance alignment rather than a physical pair."

Like the Andromeda Galaxy, both NGC 147 and NGC 185 are on trajectories to merge with the Milky Way. The latter is the faster of the two, drawing closer at a rate of 472,000 mph (760,000 km/h). NGC 147 is advancing at a more leisurely rate of 365,000 mph (587,000 km/h). – P.H.

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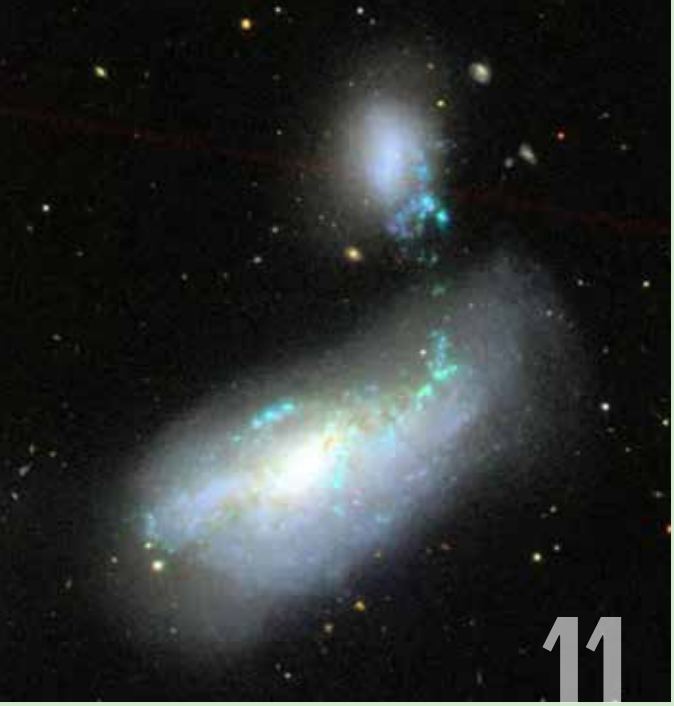
DAN BARTLETT



2MASS

NGC 4485 AND THE COCOON GALAXY

Located just 40' northwest of 4th-magnitude Chara (Beta [β] Canum Venaticorum), the Cocoon Galaxy (NGC 4490) forms an intriguing pair with neighboring NGC 4485. Both were discovered by William Herschel in 1788 and are listed together as Arp 269.

Studies reveal that sometime in the distant past, NGC 4485 and NGC 4490 collided with each other. We now see the aftermath of the cosmic crash, which totaled both galaxies and left them nearly unrecognizable. NGC 4490 was once a barred spiral, but the clash with NGC 4485 stretched its arms into a chrysalis shape, leading to its nickname the Cocoon Galaxy.

NGC 4485 was also a spiral once, but was so warped by the interaction that nearly any trace of its former self has been erased, and it now lags behind as the two galaxies slowly separate. Hubble images reveal a trail of bright stars and HII extending 24,000 light-years back toward NGC 4490.

The stirred-up, entangled clouds of gas and dust in both galaxies sparked bursts of star formation. The striking red and pink blotches seen here are huge ionized clouds, energized into fluorescence by the ultraviolet energy from hot, newly formed stars that lie nearby.

In 2020, a team of astronomers analyzing infrared images discovered that NGC 4490 has two central cores. The second core was not apparent in visible light due to intervening dust clouds. The team concluded that NGC 4490 is likely a remnant of an even earlier merger with a now-absorbed galaxy. –P.H.

THE INTERGALACTIC WANDERER

Globular cluster NGC 2419 is an enigma hiding in the dim constellation Lynx, way off the beaten path. While most Milky Way globulars surround the galactic core in Sagittarius, NGC 2419 lies halfway across the sky. On New Year's Eve 1788, William Herschel first spotted a faint blur of light in Lynx that he described as "considerably bright, round, very gradually much brighter in the middle." Then, in 1918, American astronomer Harlow Shapley determined that NGC 2419 was 99,000 light-years away, much farther than other known globulars at the time.

NGC 2419 then earned the nickname the Intergalactic Wanderer. Recent estimates nearly triple the distance to 275,000 light-years from Earth and 300,000 light-years from the galactic center. However, technically, it's not wandering aimlessly in space. Just like the other 150 or so globulars in our galaxy's collection, NGC 2419 is gravitationally bound to the Milky Way and orbits the galactic core — but with a much higher eccentricity, taking an estimated 3 billion years to complete one trip.

NGC 2419 is unlike many other globulars, whose ancient red stars are all largely the same chemically. Those in NGC 2419 can be divided into two groups based on their composition. One set of stars is much richer in helium than the second set, and is largely gathered in the center of the cluster. The groups vary in abundance of other elements as well, notably nitrogen. These inconsistencies seem to show that NGC 2419 was formed in not one, but two distinct stages that remain a mystery. –P.H.

RADEK CHROMIK

ZWICKY'S TRIPLET

Halton Arp's 1966 *Atlas of Peculiar Galaxies* was the first comprehensive effort to study and photograph unusual galaxies and galaxy groups that showed strange behavior. Arp raised fundamental questions about the nature of galaxies themselves. While our understanding of galaxies has improved since Arp's time, many of these questions still perplex astronomers.

SDSS

One of the weirdest entries in Arp's atlas is Arp 103, also known as Zwicky's Triplet. Arp 103's nickname refers to Swiss astronomer Fritz Zwicky, whom Arp acknowledged as one of the colleagues who discovered some of the peculiar galaxies that he included in his study.

Zwicky's Triplet is situated approximately 425 million light-years away, near the star 52 Herculis. None of the three galaxies in this system are listed as a group in the *New General Catalogue* or *Index Catalogue*. Instead, they have individual entries in the *Catalogue of Principal Galaxies* (PGC) published in 1989.

Arp 103's brightest galaxy is PGC 59061, at 15th magnitude. Its southwestern flank is overlapped by PGC 59062, a smaller, fainter galaxy. A luminous tidal arm of intergalactic matter stretches in the opposite direction from PGC 59062 toward the group's third galaxy, 16th-magnitude lenticular PGC 59065, 2' to the north.

Initially, Arp believed that PGC 59061/2 was a spiral galaxy connected to elliptical galaxy PGC 59065 through a tidal arm of intergalactic matter. However, further analysis revealed that all three galaxies in Arp 103 are spirals. PGC 59062/5 are now tagged as S0 spirals, or lenticulars. –P.H.

NATIONAL RADIO ASTRONOMY OBSERVATORY

THE INTEGRAL SIGN GALAXY

While examining photo plates of the Palomar Observatory Sky Survey in 1967, British astrophysicist Geoffrey Burbidge noticed something peculiar in the constellation Camelopardalis. A galaxy? If so, it was nothing like any he, or anyone, had ever seen. Burbidge's weird find is now nicknamed the Integral Sign Galaxy for its warped profile, and is cataloged in the *Uppsala General Catalogue of Galaxies* as UGC 3697.

The Integral Sign Galaxy is an unusual super-thin Type Sd spiral galaxy seen edge-on from our perspective. Although "super-thin" may sound like a subjective term, it has a measurable definition. Super-thin spirals display little or no central bulge and have a 10-to-1 or higher diameter-to-thickness ratio. They almost always have a low surface brightness, which makes them difficult to spot.

But UGC 3697 is even more unique. Rather than having a flat disk like other super-thin spirals, the two ends of UGC 3697's galactic plane curl slightly in opposite directions, like an integral sign (∫) or a wavy potato chip. What's causing that, and how would this galaxy appear if we could view it from a steeper angle?

No one knows the answer to how it would look from 45° or 90°, but there's a theory for the undulating ends. The odd appearance is likely caused by the galaxy's relatively small mass being twisted and contorted by the peculiar neighboring galaxy UGC 3714 and several dwarf galaxies that lie nearby. Another theory comes from a study published in 2004. It speculates that the appearance may have been caused by an infalling satellite galaxy. – P.H.

STEPHAN'S QUINTET

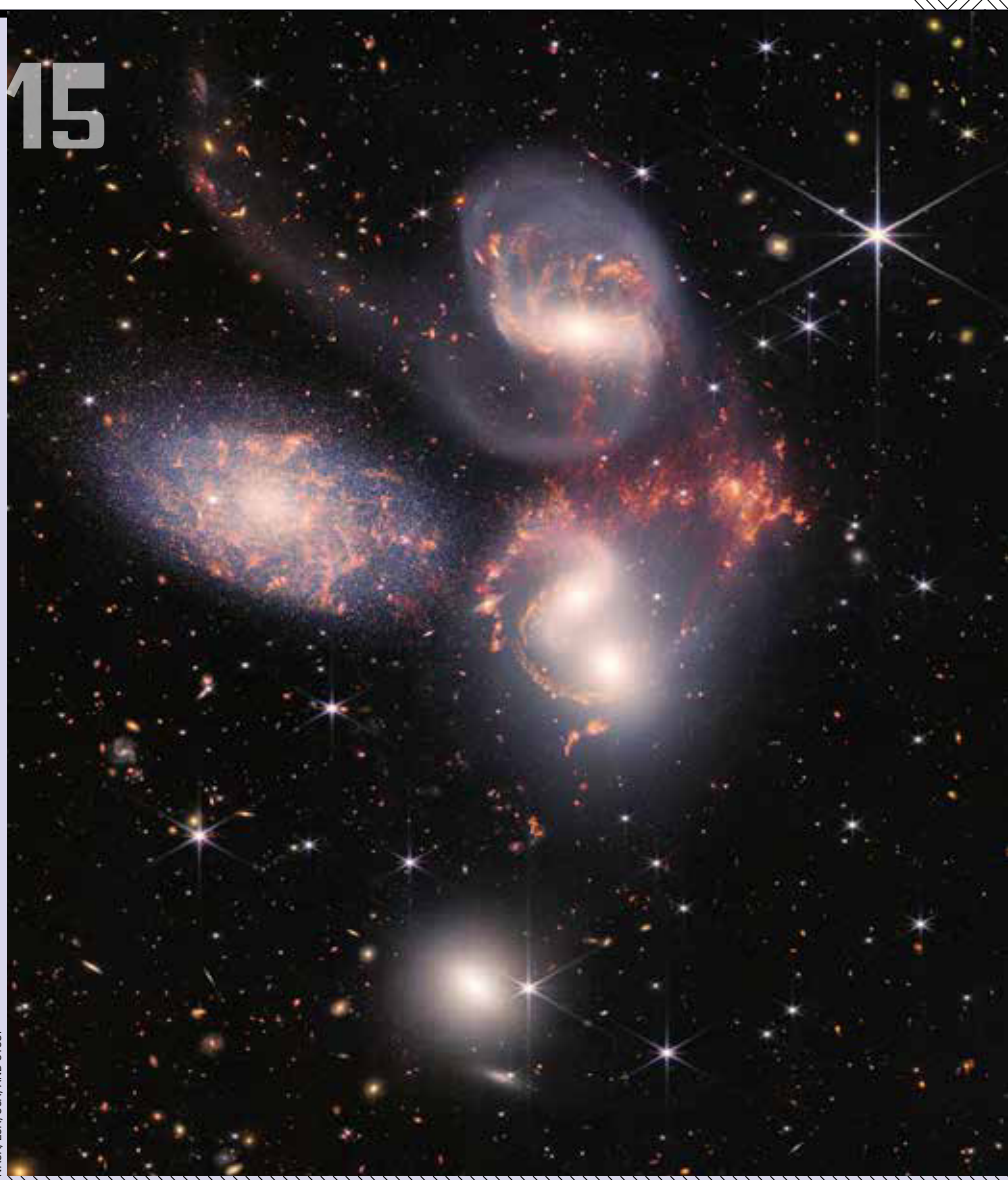
In 1929, Edwin Hubble made a discovery that changed our view of the universe forever. After examining a multitude of spectra from other galaxies, he concluded that the farther away a galaxy was, the faster it was receding. This revelation, now called Hubble's Law, showed that the universe was expanding.

But there were exceptions. One of the best-known enigmas, Stephan's Quintet, was discovered in 1877 by Édouard Stephan, former director of Marseille Observatory in France. It lies less than ½° south of the bright, unbarred spiral galaxy NGC 7331 in Pegasus.

The five galaxies that make up Stephan's Quintet are: elliptical NGC 7317; elliptical NGC 7318A, colliding with barred spiral NGC 7318B; distorted barred spiral NGC 7319; and barred spiral NGC 7320. All are crammed into a tight 20' area.

Early images of the quintet — such as that used in the 1946 classic film ***It's a Wonderful Life*** to represent talking angels — were low resolution, making it appear as if all five galaxies formed a single, compact group. But spectral data showed otherwise. NGC 7320 is 40 million light-years from Earth, while the other four galaxies are about 290 million light-years away.

Two years ago, NASA released an image of the group taken by the James Webb Space Telescope (JWST). It showed all five in unprecedented detail. The image reveals dazzling clusters of young stars and regions where new stars are being born in a burst of activity. Long, curved tails of star material are being pulled away from the galaxies due to interacting tidal forces. The JWST image also reveals immense shockwaves created as NGC 7318B collides with NGC 7318A. – P.H.



NASA, ESA, CSA, AND STSCI

MAFFEI 1 AND MAFFEI 2

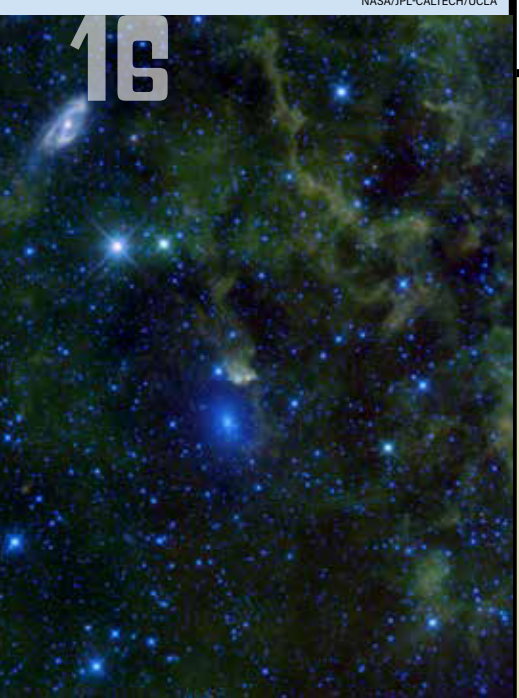
In 1967, the Italian astrophysicist Paolo Maffei, one of the pioneers of infrared astronomy, made an amazing discovery. While scanning images of IC 1805 (the Heart Nebula) in Cassiopeia, he spotted two galaxies that had never been seen before. These two galaxies had evaded detection due to their position within what is referred to as the zone of avoidance. That's the region of the sky that is obscured visually by gas and dust along the plane of the Milky Way. Infrared wavelengths, however, can pierce those clouds.

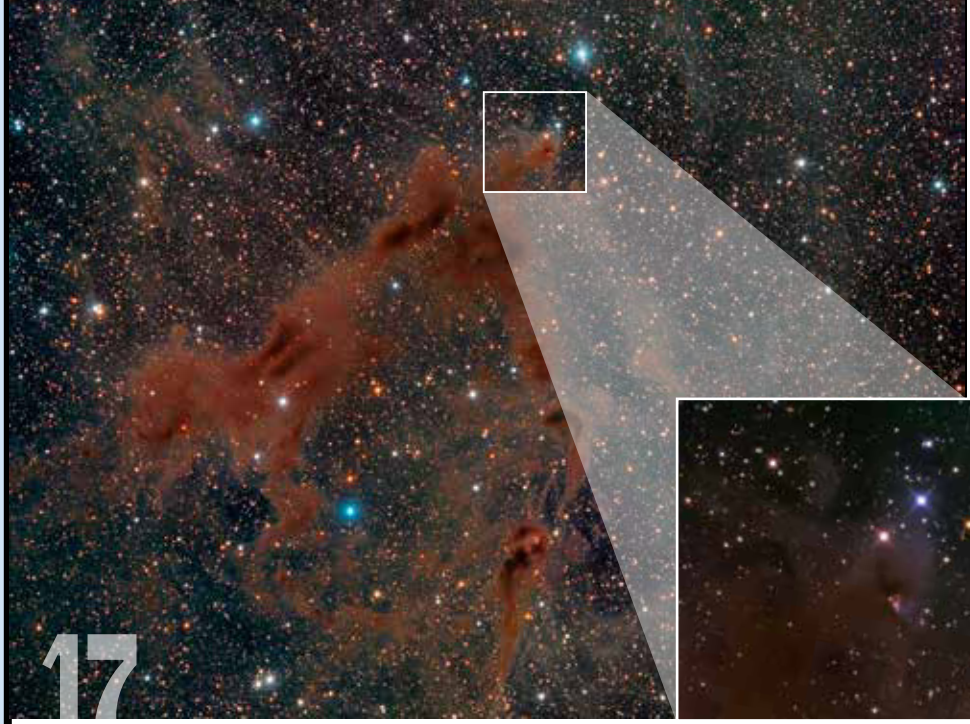
As a result of Maffei's breakthrough discovery, these two galaxies are now known as Maffei 1 and Maffei 2. Maffei 1 is a giant type E3 elliptical galaxy. Its stars are mostly old, around 10 billion years in age. If the view was clear, it would likely be one of the brightest galaxies in the northern sky and span about two-thirds of the Moon's diameter. Despite Maffei 1's size and mass, the presence of a giant black hole in its center has never been detected.

Maffei 2 is a barred spiral that features two asymmetrical spiral arms. Its prominent central bar and lopsided arms show that the galaxy is undergoing a burst of star formation in its core. This occurs when large quantities of gas and dust are forced into the center of a galaxy by gravitational interactions.

The two galaxies, along with 16 other galaxies, form the IC 342-Maffei 1 Group. All lie an average of 10 million light-years away. —P.H.

NASA/JPL-CALTECH/UCLA





JERRY MACON; INSET: ADAM BLOCK

GYULBUDAGHIAN'S NEBULA

This cosmic object is named after Armenian astronomer Armen Gyulbudaghian (pronounced gyool-boo-DAH-ghee-an), who discovered it in 1977. Gyulbudaghian's Nebula is one of only a few interstellar clouds that change in appearance in a matter of a few months or years, so-called variable nebulae.

Gyulbudaghian's Nebula is classified as HH 215, a Herbig-Haro object. Herbig-Haro objects are patches of nebulosity around newborn stars. In the case of Gyulbudaghian's Nebula, that star is known as PV Cephei. PV Cep is a young, pre-main sequence star surrounded by a rotating accretion disk of material. As the star spins, it ejects two high-speed jets of partially ionized gas along its rotational axis. These beams slam into surrounding clouds of gas and dust.

PV Cep's rotational axis is tilted slightly toward Earth, which means that the varying fan-shaped nebula that we see is due to a partial clearing in the surrounding dust clouds by the energy beam on the north side of the star. The south jet is obscured by dark nebulosity.

The discovery images taken in 1977 showed that PV Cep had brightened to illuminate the fan-shaped reflection nebula just to its northeast. Later observations show that both the star and nebula may dim or even disappear entirely due to variations in the star as well as intervening dust. At other times, the nebula has been glimpsed in amateur telescopes as small as 10 inches in aperture. —P.H.

MAYALL'S OBJECT

Mayall's Object — found by American astronomer Nicholas Mayall at Lick Observatory in March 1940 — is a strange-looking sight indeed. Cataloged more formally in the *Morphological Galaxy Catalog* as MCG +7–23–19 and in the *Atlas of Peculiar Galaxies* as Arp 148, the object resembles a question mark. That shape likely epitomized Mayall's confusion as well. Was it a nebula within the Milky Way, or did it lie beyond? That question remained unanswered for decades.

Technological improvements finally allowed later studies to prove that Mayall's Object was actually the carnage left over after two galaxies collided 450 million light-years away in Ursa Major. As one pierced the other, the aftershock was so intense that both progenitors were structurally disrupted beyond recognition. Stars and interstellar matter were first pulled into the center of the pierced galaxy. But then in an action/reaction effect, everything expanded away to form a ring.

The centralized extension protruding on one side is the remains of the galaxy that did the piercing — almost like a game of space darts. The gas and dust in the target galaxy have been pushed outward in surges to form the outer rim, triggering new star formation along the way. The result is the slow formation of a rarely seen ring galaxy.

Look closer and you will see a small yellow feature inside the ring to the lower right of the tail end of the "dart" galaxy, probably the only remains of the target's nucleus. —P.H.

NASA, ESA, THE HUBBLE HERITAGE TEAM (STSCI/AURA)-ESA/HUBBLE COLLABORATION AND A. EVANS, K. NOLL, AND J. WESTPHAL

JOE NAVARA, GLENN CLOUDER, AND RUSSELL DISCOMBE

CRESCENT NEBULA

One of the most striking summertime objects is the oddly shaped Crescent Nebula (NGC 6888) in Cygnus. William Herschel was first to spot it, back in September 1792. He described the sight as "a double star of the 8th magnitude with a faint ... milky ray joining to it."

Telescopes equipped with contrast-enhancing filters showed that Herschel's "milky ray" curves around both sides of that star. That unique appearance — reminiscent of our Moon a few days before or after the New phase — led to its nickname, the Crescent Nebula.

However, more sensitive digital images show the complete picture. Rather than a crescent, they record a distinctly oval form. In fact, the details in today's images are so extensive, they make it difficult to identify the simpler crescent shape.

At first glance, some might conclude that we are looking at a planetary nebula or possibly a supernova remnant. In reality, the Crescent Nebula is an unusual class of emission nebulae that are byproducts of Wolf-Rayet stars — the hottest known stars, named after astronomers Charles Wolf and Georges Rayet, who discovered the first three.

The Wolf-Rayet star at the center of the Crescent Nebula, designated WR 136 (also known as HD 192163), has a surface temperature of nearly 100,000 degrees Fahrenheit (54,800 degrees Celsius). That's nearly 10 times hotter than our Sun.

The nebula we see formed when the star's fast-moving stellar wind collided with a stream of slower-moving particles ejected from WR 136 several hundred thousand years ago. The collision produced a glowing nebulous shell and two shock waves traveling in opposite directions. —P.H.

NGC 1275 ET AL.

At approximately 240 million light-years away, the central portion of the Perseus Galaxy Cluster holds an estimated 190 individual galaxies — just a part of the Pisces-Perseus supercluster, which includes over 1,000 additional galaxies. The Perseus Cluster is centered around NGC 1275, a dominating goliath among galaxies. Classified as a supermassive elliptical galaxy, NGC 1275 spans more than 100,000 light-years.

Our understanding of this weird galaxy began in 1943, when Carl Seyfert included it in his list of galaxies with active nuclei. It is often referred to as Perseus A, indicating it is a strong source of radio emissions. In fact, NGC 1275 is one of the strongest radio galaxies in the entire sky.

NGC 1275 is also a powerful emitter of X-rays. At the core of its active nucleus is a supermassive black hole. Estimated to be equivalent to 800 million solar masses, the black hole is feasting on gas and dust at a furious rate. As interstellar matter swirls around in the accretion disk as it heads toward the event horizon and its ultimate fate, it heats up due to friction and emits X-rays. Filaments of red glowing gas — appearing like roots from a strange galactic plant — spread out from the core to the outer edges of the galaxy. Some extend up to 20,000 light-years. These eerie tendrils are forced outward by the central black hole and bound together by magnetic fields. —P.H.

NASA, ESA, HUBBLE HERITAGE, A. FABIAN

EGG NEBULA

NASA, ESA, WFPC2 SCIENCE TEAM

After stars use up all the fusible hydrogen in their cores, the ones that are up to around three times the mass of our Sun evolve off the main sequence and undergo two red giant phases. During the second phase, the star expels its outer layer as a shell of expanding gas, known as a planetary nebula. Catching a planetary nebula in the act of birth is difficult to do, since it is so short lived. The phase lasts perhaps only 2,000 years, the blink of an eye, astronomically speaking. Nonetheless, we have captured this moment.

The aptly named Egg Nebula, lying 3,000 light-years away in the constellation Cygnus, vibrantly shows us the tremendous forces at work while a protoplanetary nebula transitions to a planetary nebula. Concentric ripples — like those in a still pond after a pebble has been tossed in — expand away from the central star. The star itself is hidden from our direct view by a perpendicular belt of thick dust, shown to be composed largely of carbon, a byproduct of the nuclear fusion inside the core of the star.

Analysis of the starlight scattered by the dust shows that the central star is a yellow-white type F (these stars are about 1.0 to 1.4 times the Sun's mass). Its surface temperature is likely to be around 1,620 degrees Fahrenheit (900 degrees Celsius) hotter than our Sun, but not hot enough to ionize the gas clouds that have been expelled. However, eventually the star's temperature will increase enough to trigger the formation of a planetary nebula. –P.H.

NASA AND THE HUBBLE HERITAGE TEAM (STSCI/AURA) AND R. KNACKE

NGC 4319 AND MARKARIAN 205

Located in the constellation Draco, NGC 4319 is a barred spiral galaxy seen nearly face-on from Earth. It is characterized by an inner ring structure and moderately tight spiral arms. What is perhaps most unusual about NGC 4319 is how close it appears to quasar Markarian 205.

After studying the pair in 1971, American astronomer Halton Arp concluded that the quasar was not a distant background object at all. He believed it may have been blasted away from the nucleus of NGC 4319 as sort of a cosmic cannonball.

Arp's strange idea derived from his skepticism of both the Big Bang theory and the notion that the universe was expanding. He thought that quasars were caused by other events. To support his theory, he pointed to what looked like a luminous stream of material bridging the gap between NGC 4319 and Mrk 205. Arp's claim created a furor that lasted for more than two decades.

To resolve the matter, astronomers used two methods to find the distances to these objects. First, they examined the objects' spectra to determine their redshifts caused by the expansion of the universe — the greater the redshift, the greater the object's distance. This revealed that the quasar's redshift far exceeds the galaxy's redshift.

Next, they measured how much of Mrk 205's ultraviolet energy dimmed as it passed through NGC 4319's outer halo of interstellar gas. Each technique gave the same answer: NGC 4319 is 80 million light-years from Earth, whereas Mrk 205 is 1 billion light-years away, separated by both space and time. –P.H.

SEYFERT'S SEXTET

When you first hear of a galaxy group referred to as a sextet, you'd expect to find six close-set galaxies fighting a gravitational tug-of-war. Well, in this case, you'd be wrong. Seyfert's Sextet is actually a quartet, since it contains only four interacting galaxies — plus one photobomber.

In 1882, Édouard Stephan discovered the primary galaxy, a bright spiral in the head portion of the split constellation Serpens. It became known as NGC 6027. Another seven decades passed before Carl Seyfert uncovered a horde of fainter galaxies huddled nearby. He wrote of his find in the April 1951 issue of *Publications of the Astronomical Society of the Pacific*. As was the custom, the newly found galaxies were assigned new NGC annex numbers. Seyfert's article listed them as NGCs 6027A through E.

Seyfert acknowledged in the article that the group was not physically made up of six galaxies. Nonetheless, the name stuck. Today, we recognize that spiral galaxy NGC 6027A, lenticular galaxy 6027B, and barred spiral 6027C are all coming together with NGC 6027, the most massive of the quartet.

All are about 190 million light-years away. Eventually they will meld into a single giant elliptical galaxy, but this is billions of years into the future. However, we already see evidence of tidal distortions in all four systems. In fact, NGC 6027E is not a separate galaxy at all, but rather a tidal tail of stars and interstellar matter dragging behind NGC 6027. The sixth member of the sextet, NGC 6027D, is a face-on barred spiral galaxy seen lying comfortably about five times farther away than the rest — 877 million light-years to be exact. –P.H.

NASA, J. ENGLISH (U. MANITOBA); S. HUNSBERGER, S. ZONAK, J. CHARLTON, S. GALLAGHER (PSU), AND L. FRATTARE (STSCI)

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NGC 6826

As we peer through our telescopes, many of us have momentarily blinked while trying to view a challenging object. We don't expect them to blink back at us. But 9th-magnitude NGC 6826 in Cygnus does — hence its popular nickname, the Blinking Planetary.

Of course, it's not actually blinking at us. The human eye is responsible for that effect. The center of the eye's retina is made up of bright-light receptors, called cones, as well as some low-light sensors called rods. Together, they allow us to look directly at stars. To see faint, diffuse objects, we need to look for them out of the corner of our eyes using averted vision. Doing so directs a target's feeble light onto the peripheral area of the retina, which is rich in rods.

NGC 6826 is a classic example of a double-shell planetary nebula. Its fainter outer shell surrounds a brighter inner shell that is directly surrounding the 10th-magnitude central star. When we look directly at it, we are seeing the progenitor and some of the brighter nebulosity in the planetary's inner shell. But when we use averted vision, we can also make out the fainter outer shell. Glance back directly and it disappears, giving the illusion that the oval, eye-shaped planetary is blinking.

The Blinking Planetary appears to have two weird knots of condensed red gas that seem to have blasted away from the hot central star at a faster rate than the surrounding nebula. These features have been dubbed FLIERS (Fast Low-Ionization Emission Regions). –P.H.

NASA/ESA AND BALICK ET AL.

KEENAN'S SYSTEM

Also known as Arp 104 in Halton Arp's *Atlas of Peculiar Galaxies*, this target is the pairing of an elliptical NGC 5216 and barred spiral galaxy NGC 5218. Both were discovered by William Herschel in 1790. A pair of galaxies hardly qualifies as "weird," but what lies between them makes it a worthy contender.

It wasn't until 145 years after Herschel's discovery that Philip Keenan noticed on a photo taken through the Yerkes 24-inch reflector that "these two apparently well-separated galaxies are connected by a faint but definite band of nebulosity." Even then, Keenan's discovery went largely unnoticed until 1958 when the filament stretching between the two galaxies was rediscovered by astronomers at Lick and Palomar observatories. Both galaxies lie 17 million light-years away in the constellation Ursa Major.

The filament that joins them, along with the warped spiral arms in NGC 5218 and an odd comma-shaped extension seen in NGC 5216, are all the result of a near miss between the two galaxies that occurred about 200 million years ago. The slight interaction formed new hot, massive stars within the filament, making it appear blue. The filament passes through NGC 5218 and extends beyond it in a plume almost 46,000 light-years long. From the blue color, the plume may also be the site of continuing star formation.

This passage also triggered major starburst activity in NGC 5216, shown by the blue color as well. The galaxy's red center suggests that it holds large quantities of cosmic dust.

Eventually, the two galaxies will circle back toward each other and continue to make ever closer passes until one day, they will merge into a single system. –P.H.

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ADAM BLOCK/MOUNT LEMMON SKYCENTER/UNIVERSITY OF ARIZONA

NGC 520

Although this deep-sky object is cataloged as NGC 520, it's actually a pair of interacting spiral galaxies in the constellation Pisces the Fish. German-born English astronomer William Herschel discovered it in 1784.

Even a small scope will show its odd shape, which has led amateur astronomers to christen it the Flying Ghost. It measures 4.6' by 1.9' and glows at magnitude 11.4. It lies roughly 100 million light-years away.

To find it, look about 2½° south-southwest of the magnitude 4.8 star Mu (μ) Piscium. Through a 6-inch telescope at low power, you'll think you're looking at an edge-on spiral. Crank the magnification up to 150x, however, and the sharp northwest edge will pop into view. Through larger instruments, the dark lane of dust that divides the two galaxies becomes visible.

Computer simulations have shown that this pair of galaxies began colliding some 300 million years ago. During such interactions, few stars collide with other stars — on the order of single digits. But the gravitational interaction of the two systems creates lots of new star-forming activity. It also expels much of the dust and gas that lies between the stars into intergalactic space. And, indeed, astronomers have located two small tails (called tidal tails because they're created via the tidal forces exerted by the galaxies) composed of such material.

Interestingly, the larger galaxy is edge-on to our line of sight, which makes it fainter than its smaller, less massive companion. And the whole system is also not as bright as expected in X-ray wavelengths. Researchers think this is because the smaller galaxy didn't have much gas prior to the collision. —M.E.B.

3C 273

ESA/HUBBLE & NASA

Observing 3C 273 is a lot like observing Pluto. In both cases, you'll only see a faint point of light, but the observations are meaningful because of what the objects are. In the case of 3C 273, you're looking at the first quasar ever discovered, receiving photons emitted a couple of billion years ago from the maw of a supermassive black hole. You can find it 3½° northeast of Zaniah (Eta [η] Virginis). It's also the brightest quasar in the sky, glowing softly at magnitude 12.9.

But that's just its apparent magnitude. Because it lies some 2.4 billion light-years away, its absolute magnitude (the brightness it would have if seen from a distance of 32.6 light-years) is –26.7, the same as the Sun's apparent brightness. A bit of math, then, shows that 3C 273 is 4 trillion times as bright as the Sun.

The designation 3C 273 comes from the fact that it was the 273rd object cataloged in the *Third Cambridge Catalogue of Radio Sources*, which was published in 1959. The quasar lies at the center of a giant elliptical galaxy, which has a mass estimated at 200 billion times that of the Sun. And while amateurs using large scopes have a chance to spot 3C 273, there's no hope of seeing the galaxy, which, at magnitude 16, is a lot fainter.

This object is an example of an active galactic nucleus. At the center of such objects, a supermassive black hole accelerates gas and dust to speeds near that of light before they disappear to become part of the black hole. 3C 273's supermassive black hole is some 900 million times as massive as the Sun. The process of accretion also produces a jet of tremendous energy. This quasar's jet is approximately 200,000 light-years long. On images taken through large telescopes, its angular size is 23". —M.E.B.

PURGATHOFER-WEINBERGER 1

In May 1980, Austrian astronomers Alois Purgathofer and Ronald Weinberger discovered a large, faint planetary nebula while searching Palomar Observatory Sky Survey prints for possible flare stars. As their first co-discovery of a planetary, it was designated Purgathofer-Weinberger 1. This is usually abbreviated PuWe 1, but also carries the catalog designation PN G158.9+17.8.

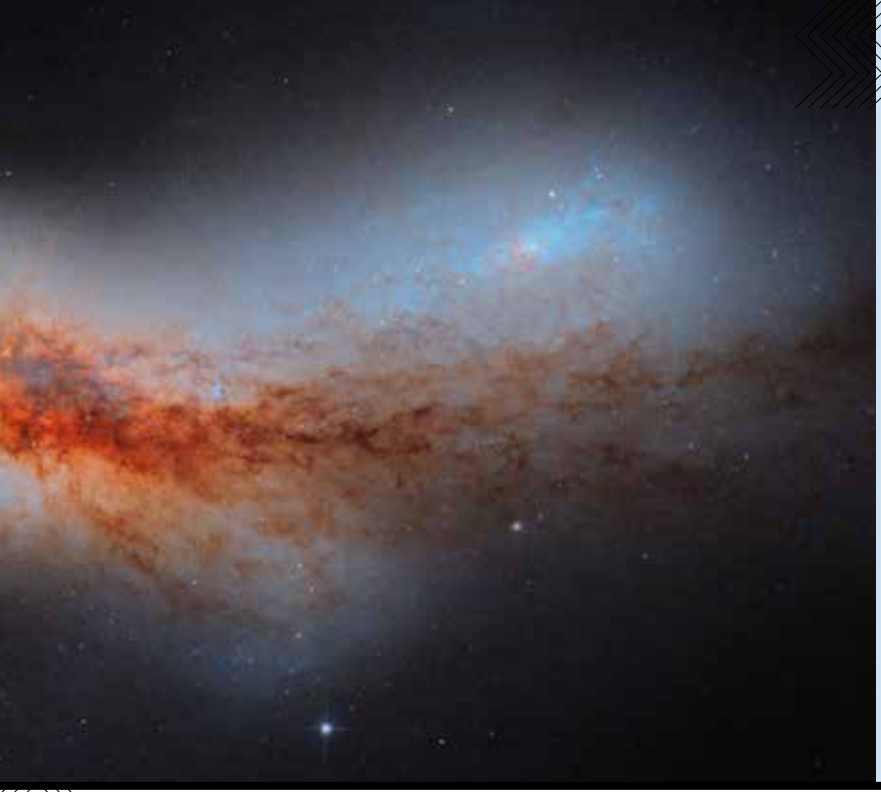
This object lies at the far western edge of the constellation Lynx, near that star pattern's borders with Camelopardalis and Auriga. With an apparent diameter of 20', it is the second-largest planetary nebula visible from Earth, surpassed only by the Helix Nebula (NGC 7293) in Aquarius. As a demonstration of its size, it covers 41 percent as much area as the Full Moon.

Researchers have measured its brightness in two wavelengths, those of Hydrogen-alpha (Hα) and Oxygen-III (OIII). In Hα, the magnitude of PuWe 1 is 8.6; in OIII, it falls to 11.2. These magnitudes may seem relatively bright, but remember that they're the total integrated magnitudes of a sphere two-thirds the apparent diameter of the Moon. The central star, a white dwarf, is also quite faint. The best estimates peg its visual magnitude at 15.5.

DON GOLDMAN

Although the nebula's low surface brightness makes it nearly impossible to detect visually through amateur instruments, it's not difficult to photograph. Excellent images of it have been obtained through telescopes with apertures as small as 5 inches.

PuWe 1 lies some 1,300 light-years away, making it one of the nearest of the approximately 1,500 planetary nebulae in the Milky Way. It has a true diameter of about 4 light-years. Astronomers think that while the cloud of gas will continue to expand, its outer edge has pretty much reached the limit at which the radiation from the central star can still excite the atoms and cause them to glow. —M.E.B.



NASA, ESA, HUBBLE; PROCESSING: WILLIAM OSTLING

29 NGC 3190 GALAXY GROUP

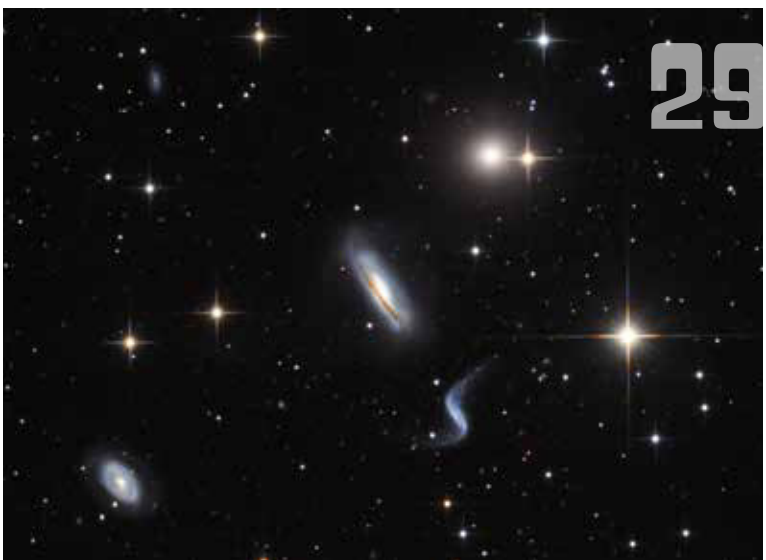
You'll find this grouping of galaxies 2° north-northwest of the 2nd-magnitude star Algieba (Gamma [γ] Leonis). It carries a couple of common names. One is the Gamma Leonis Group because of its nearness to Algieba. The other is Hickson 44, the brightest group in Canadian astronomer Paul Hickson's catalog of 100 compact galaxy groups. Hickson 44 lies approximately 100 million light-years away.

Spiral NGC 3190, the largest galaxy in Hickson 44, appears more than twice as long as it is wide (4.1' by 1.6') and glows at magnitude 11.2. Its central region is bright and long. Through a 12-inch telescope at 250x, you'll see a dust lane south of the nucleus. The lane is least apparent near the nucleus. It broadens in both directions as you look away from the center. With a diameter of 75,000 light-years, NGC 3190 is slightly smaller than the Milky Way.

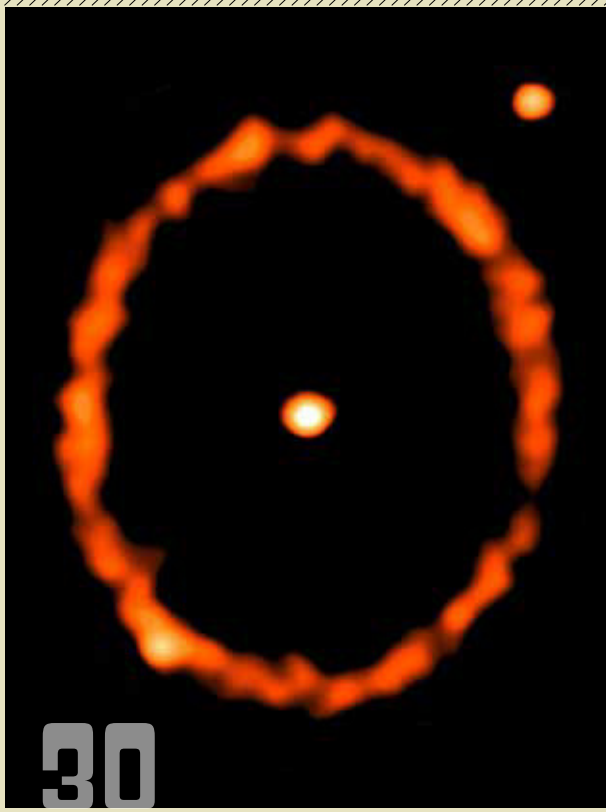
The brightest galaxy in Hickson 44 is the elliptical NGC 3193, which glows at magnitude 10.8 and has a diameter of 2'. An 8-inch telescope will reveal a wide, evenly illuminated core surrounded by a thin halo.

The final two objects in this quartet are the magnitude 12.0 barred spiral NGC 3185 (11' to the southwest of NGC 3190) and the magnitude 12.9 spiral NGC 3187 (5' to the northwest).

Galactic astronomers theorize that compact galaxy groups like Hickson 44 eventually merge into a single object, probably a giant elliptical galaxy. Computer simulations show that this will happen in about a billion years. – M.E.B.



SERGEY TRUDOLYUBOV



ALMA (ESO/NAOJ/NRAO)/MARK BOOTH

30 EPSILON ERIDANI

Humanity's story of Epsilon (ε) Eridani (Ran) is a case of life imitating art. Shining at 4th magnitude, Epsilon Eridani lies only 10.5 light-years distant, making it the third closest naked-eye star. At 800 million years young, this Sun-like star is almost the same age as our solar system was when life first took root on Earth. Knowledge of this fact likely inspired science-fiction writers ever since the 1960s to imagine the star hosting habitable worlds.

Such imaginings started to enter the realm of reality in 1998, when astronomers revealed that the star is surrounded by a young belt of comets — similar to our solar system's Kuiper Belt — whose more jagged appearance may be caused by a possible planet at its edge. These findings were followed by the discovery of a near-Jupiter-sized body (Epsilon Eridani b, orbiting with a period of 7.4 years at a distance 3.5 times that of Earth from the Sun) and two asteroid belts (one interior to the planet and one much farther out). The inner belt is at about the same location as the asteroid belt in our solar system, while the second lies around where Uranus orbits our Sun. The data also infer that an unconfirmed second planet may lie near the outer asteroid belt.

Epsilon Eridani, then, holds the distinction of being the closest planetary system around a star similar to the young Sun and is a prime location to research how planets form around Sun-like stars. And while its Jupiter-sized world may not have the conditions for life, any satellites orbiting it might.

It appears the science-fiction fever over Epsilon Eridani has not waned, as the star has been the target of SETI Institute searches, while some dreamers have suggested the star as a possible destination for future space travelers. – S.J.O.

LALANDE 21185

French astronomer Jérôme Lalande, working at the Paris Observatory, first cataloged the star that would be known as Lalande 21185 in 1801, in *Histoire céleste française*. The name/number association came about in 1847 when English astronomer Francis Baily (of Baily's beads fame) listed the catalog's stars in numerical order.

To find it, point your binoculars or telescope 4½° northwest of Alula Borealis (Nu [ν] Ursae Majoris). Don't expect to see more than a magnitude 7.5 point of light with a slight orange hue. That said, Lalande 21185 is the brightest red dwarf in the northern half of the sky.

Its current distance of 8.3 light-years ranks it as the fourth-closest star system to our own. Due to its motion through space combined with our Sun's, it will be closest to us in 20,000 years. At that time, Lalande 21185 will lie only 4.65 light-years away.

As you'd expect for a red dwarf, Lalande 21185 is a tiny star. Its diameter and mass are only 39 percent that of our Sun's. Most of its energy is emitted as infrared radiation (heat), so its brightness is only 1/200 that of the Sun. And as a spectral type M red dwarf, its surface temperature — 5,930 degrees Fahrenheit (3,280 degrees Celsius) — is much less than the Sun's 9,930 F (5,500 C).

In 2017, a team of astronomers at the Keck Observatory in Hawaii announced the discovery of an exoplanet with a period just under 10 days. That number has since been upgraded to 12.95 days and was confirmed by observations from the Calar Alto Observatory in Spain in 2020. Further study showed the planet has a mass equal to about three Earths.

A second exoplanet in the system was confirmed in 2021 with a period of around eight years. – M.E.B.

ANTHONY AYIOMAMITIS

ESA/HUBBLE & NASA

M15 AND PEASE 1

Globular cluster M15 in Pegasus is the "hey, let me show you this one" autumn object for amateur astronomers north of the equator. It's also known as NGC 7078.

M15 lies some 34,000 light-years from Earth and appears 18' across. It has a true diameter of 175 light-years and contains more than 100,000 stars. Among them are two X-ray sources, designated Messier 15 X-1 and X-2. This cluster outshines our Sun by more than 320,000 times.

From a dark site, sharp-eyed observers can spot this magnitude 6.3 globular with their naked eyes. If you try to find it this way, don't be confused by the magnitude 6.1 star only ¼° to the east. A telescope will confirm your sighting because even the smallest will show that M15 looks fuzzy. Its relatively large apparent size means the cluster covers nearly one-third as much sky as the Full Moon.

Finding M15 is easy if you use Theta (θ) and Epsilon (ε) Pegasi as pointers. Just draw a line from Theta through Epsilon and continue another 4°.

At magnifications around 100x, even a 4-inch scope will resolve dozens of stars around M15's strikingly bright core. Look for the chains of stars that wind out from its central region. Through this size telescope, these star patterns cause some observers to describe M15 as slightly oval.

If you have an 11-inch or larger telescope at your disposal, you can try for the challenge object inside M15: Pease 1 (circled). In 1928, American astronomer Francis Gladheim Pease discovered this object — the first planetary nebula to be found inside a globular cluster — on a photographic plate taken with the 100-inch Hooker Telescope at Mount Wilson Observatory. Use an eyepiece that yields 200x or more and a nebula filter at a dark site with good seeing. Don't forget the finder chart. – M.E.B.

HIND'S VARIABLE NEBULA

This emission nebula in the constellation Taurus the Bull, cataloged as NGC 1554/55, combines two objects in one. At least, it used to. Observers call NGC 1555 Hind's Variable Nebula. They call NGC 1554 Struve's Lost Nebula, a name that pretty much says it all.

Both common names refer to the 19th-century astronomers who discovered the respective objects. British astronomer John Russell Hind discovered NGC 1555 in 1852. It remained visible for a few years, but then faded from view. Russian astronomer Otto Wilhelm von Struve subsequently observed the nebula, but it had again disappeared by 1868. When examining the region early that year, Struve found another small nebula. He gave its position as 4' to the west-southwest of T Tauri, the variable star whose outflow interacting with the interstellar medium created the nebula. Subsequent observations showed no object.

In 1890, American astronomer Edward Emerson Barnard found a position error for the star T Tauri and suggested that other astronomers had been looking in the wrong place for NGC 1554. In March of that year, using the 36-inch refractor at Lick Observatory, he glimpsed a faint nebula at the position he had calculated, along with NGC 1555. No observer has seen NGC 1554 since.

To start your search for Hind's Variable Nebula, head 1.7° west-northwest of magnitude 3.5 Epsilon (ε) Tauri. Use a finder chart to identify the star SAO 93887, which glows at magnitude 8.4. From there, move 5' to the northeast where you'll find T Tauri. Although it's a variable star, it usually shines at magnitude 9.6. NGC 1555 appears as a faint wisp of nebulosity only 1' across near T Tauri. Use the largest telescope you have access to, a high-power eyepiece, and a nebula filter, which will dim the star a bit. – M.E.B.

ADAM BLOCK/MOUNT LEMMON SKYCENTER/UNIVERSITY OF ARIZONA

THE HERCULES GALAXY CLUSTER

If your observing site is dark and you have access to at least a 14-inch telescope, do yourself a favor and target the Hercules Galaxy Cluster. Its main official designation is Abell 2151, a member of a catalog of 2,712 rich northern clusters of galaxies originally published by American astronomer George O. Abell. Later inclusions of southern clusters brought the total to 4,073. A true deep-sky object, Abell 2151 lies 500 million light-years away.

One of the coolest aspects of this cluster is that nearly half of its 200-plus members are spirals. And several of those are interacting with other members of the cluster.

If your scope has a go-to drive, target the brightest member, elliptical galaxy NGC 6047. Without go-to, locate the 5th-magnitude star Kappa (κ) Herculis. Then move 1° northwest, and your field of view should capture several dozen visible galaxies.

A finder chart is a must if you want to identify the faint patches of light. Seven of the galaxies in Abell 2151 are brighter than 14th magnitude: NGC 6047 (magnitude 13.5), NGC 6061 (13.6), IC 1194A (13.6), NGC 6055 (13.7), IC 1185 (13.9), NGC 6045 (13.9), and NGC 6056 (13.9).

The one amateur astronomers enjoy viewing the most is NGC 6045. If you look carefully at its eastern tip, you'll find the magnitude 15.5 lenticular galaxy PGC 84720. To most observers, this combo looks like a hockey stick or the letter L, which may be normal, flipped, or reversed depending on your scope's optics.

In addition to a large telescope, to successfully view this galaxy cluster you'll need to use eyepieces that give magnifications of 250x and more. High powers will increase the contrast between the galaxies and the background sky. Also remember that the diameter of Abell 2151 is more than 1°. So move your field of view around to see every galaxy visible.

– M.E.B.

DOUGLAS J. STRUBLE

SIMEIS 147

Take one look at supernova remnant Simeis 147 and you'll immediately know why it's called the Spaghetti Nebula. It lies in Taurus the Bull, near that constellation's northern border with Auriga. In fact, its position is about 6° north of an even more famous supernova remnant, the Crab Nebula (M1).

A team of Russian astronomers led by G.A. Shajn and V.E. Hase, working at the Crimean Astrophysical Observatory, discovered Simeis 147 in 1952. The camera they used had a field of view of nearly 3°, and the nebula filled all of it. That would make its apparent diameter six times greater than that of the Full Moon. Because it is so huge, it's not possible to see the entire nebula visually. Amateur astronomers with access to a 20-inch or larger telescope, a dark site with terrific seeing (atmospheric steadiness), and an Oxygen-III filter might glimpse some brighter regions at its southern edge. Astroimagers with wide-field camera setups, however, can capture striking pictures of it with relative ease.

Another catalog identifier you might encounter is Sharpless 2–240. American astronomer Steward Sharpless found it on photographic plates of the Palomar Observatory Sky Survey. He published his second catalog, which contained 313 such objects, in 1959. Simeis 147 was the 240th entry.

Current estimates place the supernova remnant at a distance of some 3,000 light-years. If that's correct, the diameter of the Spaghetti Nebula would be about 160 light-years.

Researchers think the explosion of the supergiant star that created this object happened approximately 40,000 years ago. The core of that star is now a pulsar (a rapidly rotating neutron star) designated PSR J0538+2817. Radio astronomers have detected the large amount of radio radiation that the object produces. – M.E.B.

YANN SAINTY

ESO; ACKNOWLEDGEMENT: VST/OMEGACAM LOCAL GROUP SURVEY

WLM

The barred irregular galaxy Wolf-Lundmark-Melotte (WLM) is a member of the Local Group of galaxies. This collection of more than 100 stellar systems includes the Milky Way and the Andromeda Galaxy (M31). German astronomer Max Wolf discovered WLM in 1909. In 1926, Swedish astronomer Knut Lundmark and British astronomer Philibert Melotte determined its nature. It lies some 3.2 million light-years away and is considered a low-mass galaxy. Of course, that's relative. Its total mass is on the order of 430 million solar masses.

WLM lies in the constellation Cetus the Whale. It has an apparent size of 11.5' by 4.2' and glows at magnitude 11.2, so you can see it from a dark site through an 8-inch telescope. To find it, use an eyepiece that will give a ½° field of view, and point it a bit more than 10° west-northwest of Diphda (Beta [β] Ceti). Keep in mind that WLM has a low surface brightness. A good strategy for revealing it against the surrounding darkness is to center it (or the position you think it's at) and tap the telescope's tube ever so slightly.

Because telescopes sensitive to ultraviolet radiation have revealed clumps of hot new stars, astronomers think WLM is still in the star-formation stage. These regions, mainly in the southern half of the galaxy, range from 20 to 100 light-years across.

In 1994, American astronomer Andrew Dolphin, now at the University of Arizona, used the Hubble Space Telescope to show that around half of all the star formation in this galaxy occurred roughly 13 billion years ago. Because it's at the edge of the Local Group, WLM has avoided encounters with other galaxies. That makes it valuable to researchers to compare with other nearby galaxies. –M.E.B.

NGC 404

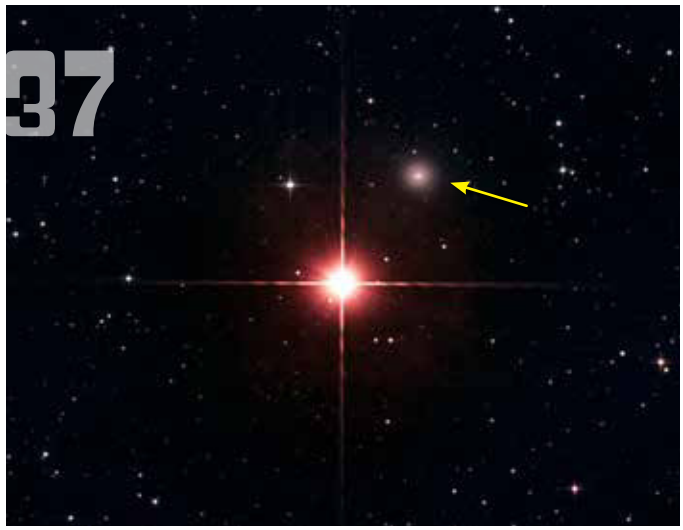
Elliptical galaxy NGC 404 lies in the constellation Andromeda, glowing at magnitude 10.3 with a diameter of 6.1'. It carries two other names: Mirach's Ghost and the Lost Pearl Galaxy. And though the galaxy is well placed for viewing on Halloween night, that's not how it got the first moniker.

Amateur astronomers call it Mirach's Ghost because it lies only 6.8' from 2nd-magnitude Mirach (Beta [β] Andromedae). That makes it easy to locate but, as you can imagine, a 10th-magnitude galaxy next to a star that bright is pretty difficult to see.

Astronomers classify NGC 404 as a lenticular galaxy (or S0 galaxy). This type has the disk shape of a spiral galaxy but no spiral arms. Several teams of researchers have pegged its distance at 10 million light-years from Earth, just outside the Local Group of galaxies.

In 2016, while examining images he took in 2010 and 2013, Italian amateur astronomer Giuseppe Donatiello discovered a dwarf spheroidal galaxy that may be a satellite of NGC 404 (dubbed Mirach's Goblin). The uncertainty lies in its distance measurements, which stand between 8.1 million and 11.4 million light-years.

To observe Mirach's Ghost, use high magnification to increase the contrast (and the apparent separation) between the galaxy and the star. NGC 404 is round with a brighter center. The glare from Mirach is troublesome, but there's really no detail to be seen in the galaxy.



JOHN CHUMACK

As to NGC 404's second common name, *Astronomy* Contributing Editor Stephen James O'Meara christened it the Lost Pearl Galaxy. "Lost" is because some star atlases don't plot this object, because the printed image of Mirach overlaps it. As for "pearl," he says it looks like a loose pearl rolling across the deck of a pirate ship. –M.E.B.

BARNARD'S E

ALAN DYER

If you're an amateur astronomer who enjoys binocular observing, Barnard's E has to be one of your favorite objects. These two dark nebulae are recorded in American astronomer Edward Emerson Barnard's famous catalog of such objects as numbers 142 and 143.

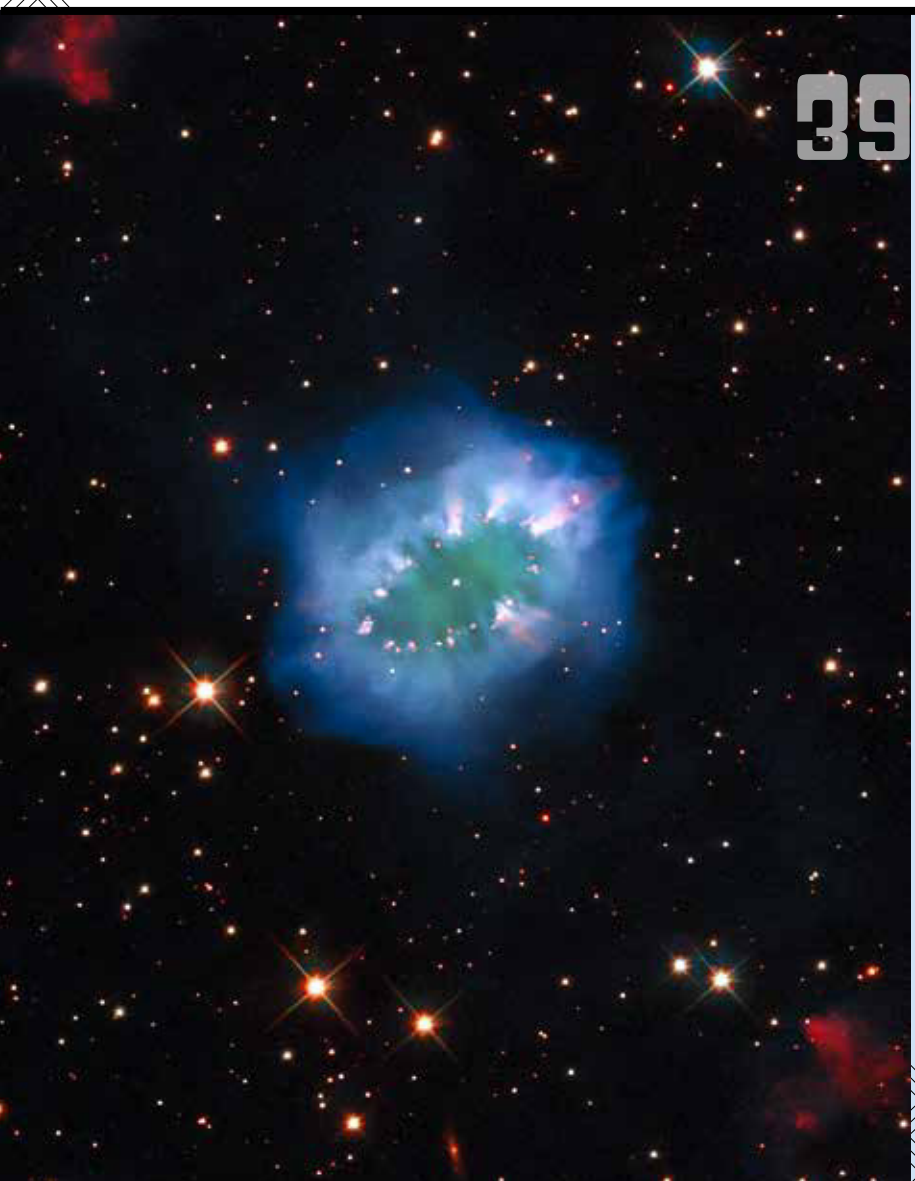
It's easy to find the E in the northern summer constellation Aquila the Eagle. Just center 3rd-magnitude Tarazed (Gamma [γ] Aquilae) in your binoculars. Barnard's E lies 1.6° west-northwest of the star.

Barnard 143 (B143) is the darker of the two nebulae. Its most visible part is a narrow bar about ¼° long, which stretches east to west. A second bar of the same length connects at its east end and heads northward. At the end of that bar is a third, which parallels the first one. The combination of these three bars forms a C-shape whose open end points west.

Barnard 142 (B142) lies just south of B143. This bar isn't as dark as B143, so it's harder to see.

Astronomers classify the components of Barnard's E as dark nebulae — objects that emit no light and reflect no starlight. We see them only because they lie in front of more distant, bright backgrounds along the same line of sight from Earth. If you view Barnard's E from a dark site, you'll see it silhouetted before many tens of thousands of unresolvable stars.

Dark nebulae actually consist of a combination of dust and really cold gas — material that can one day form stars. To do so, the temperature of the hydrogen in dark nebulae must be just 18 degrees Fahrenheit (10 degrees Celsius) above absolute zero or less. If it's warmer, the atoms in the cloud will be moving too fast to merge when they collide, and stars won't form. —M.E.B.



ESA/HUBBLE & NASA, K. NOLL

THE NECKLACE NEBULA

The object below is a planetary nebula in the small northern constellation Sagitta the Arrow. Cataloged as either IPHASX J194359.5+170901 or PN G054.2–03.4, it's a lot easier to refer to it by its common name, the Necklace Nebula. Although you won't see it visually even through the largest amateur telescopes, you can find its position by looking 1° east-southeast of magnitude 4.4 Beta (β) Sagittae.

Researchers in the Canary Islands, Spain, discovered it in 2005 in data acquired by the Isaac Newton Telescope Photometric H-alpha Survey. The Necklace Nebula lies about 15,000 light-years away and has a diameter of about 2 light-years.

This planetary nebula formed thanks to a pair of Sun-like stars in a close binary system at the center. One of the stars evolved a bit faster than the other, becoming a giant. About 10,000 years ago, the giant star expanded to a point where it completely engulfed its companion, called a "common envelope." But it didn't consume it. Because the outer layers of the giant were composed of such thin gas, the Sun-like star continued to revolve around the center of its captor. This dramatically increased the giant's rotational speed. Eventually, the larger star spun so fast that a large percentage of its outer atmosphere expanded into space, producing the planetary nebula.

In this case, most of the gas flew outward along the giant star's equator, producing the ring we now see. The bright spots along the ring are regions of denser gas.

The Sun-like star continues to orbit the core of the giant about every 27 hours. And the two stars are close, separated by only about 2 million miles (3.2 million km). —M.E.B.

WILD'S TRIPLET

Here we have what was once thought to be a trio of interacting spiral galaxies located in the constellation Virgo the Maiden. The three galaxies are PGC 36733, which glows at magnitude 13.6, PGC 36723 (magnitude 14.1), and PGC 36742 (magnitude 14.8). (The designations come from the *Catalogue of Principal Galaxies*, published in 1989.)

Commonly known as Wild's Triplet, this group is named for Paul Wild, the British-born Australian astronomer who discovered them in the 1950s. It later was cataloged as the 248th object in American astronomer Halton C. Arp's *Atlas of Peculiar Galaxies*, published in 1966.

Originally, Wild, Arp, and other astronomers assumed that all three galaxies were interacting gravitationally. But recent studies have shown that only the brightest two galaxies are interacting, connected by a 200,000-light-year-long bridge of material.

The bridge is composed of gas, dust, and stars, and is usually referred to as a tidal tail. Such features form when the gravity and tidal forces of two or more galaxies pull material from the outer regions of the objects. The tail is most impressive when two spiral galaxies merge because these contain lots of gas and dust.

The pair lies some 200 million light-years away. The smaller spiral below the central bridge is much farther than that. Astronomers estimate that in about a billion years, the two interacting galaxies will combine to form a single spiral.

If you'd like to try to observe Wild's Triplet, point the largest scope you can use 5¾° due south of Zavijava (Beta [β] Virginis). Don't use any filter; galaxies are full-spectrum objects, and a filter will simply cut the overall brightness. –M.E.B.

MIKE SELBY/WARREN KELLER

DESI LEGACY IMAGING SURVEYS/LBNL/DOE & KPNO/CTIO/NOIRLAB/NSF/AURA

COPELAND'S SEPTET

In 1874, Scottish astronomer Ralph Copeland was an assistant to William Parsons, Earl of Rosse. In April, while scanning the constellation Leo with Parsons' 72-inch speculum-mirror reflector — the Leviathan of Parsonstown — Copeland was the first to spot this compact galaxy group. When he wrote a description for the *New General Catalogue*, he described five of the galaxies as "pretty bright." Well, he was using a 72-inch scope. And although you don't need such an optical behemoth to view these objects, you will need at least a 14-inch instrument, perfect seeing (atmospheric stability), and a dark site.

Also known as Hickson 57, this group lies 5.7° east-northeast of magnitude 2.6 Zosma (Delta [δ] Leonis). It spans an area 5' by 2'. The seven galaxies that make up the Septet are magnitude 15.2 NGC 3745, magnitude 14.0 NGC 3746, magnitude 14.8 NGC 3748, magnitude 15.0 NGC 3750, magnitude 15.0 NGC 3751, magnitude 14.5 NGC 3753, and magnitude 14.3 NGC 3754. Note that the magnitudes for these galaxies vary somewhat depending on the source you reference.

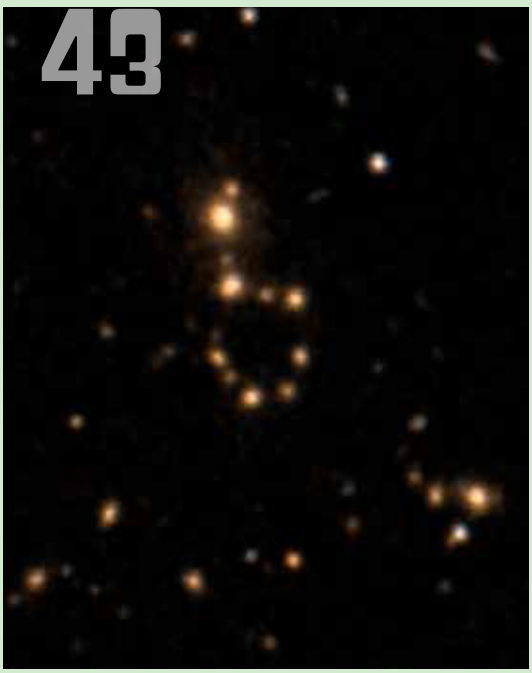
One key to successfully observing Copeland's Septet is patience, especially through telescopes smaller than 18 inches in aperture. Spotting all seven can take a while, but identifying them is easy if you've first printed out a finder chart. Another key is letting the group climb to its highest point in the sky. A third depends on your site's seeing. If the stars overhead are twinkling, move on to your next target and try for the Septet another night. –M.E.B.

ZWICKY'S NECKLACE

This distant ring of galaxies is the 388th entry in volume 8 of the *Catalogue of Galaxies and of Clusters of Galaxies* compiled by Swiss astronomer Fritz Zwicky. As such, it's referred to as VIII ZW 388. But astronomers (especially amateurs) often refer to it as Zwicky's Necklace.

The brightest member of this group (the galaxy in the "handle" of the necklace) is LEDA 3110345. It glows at magnitude 14.9. The next brightest galaxy, just below LEDA 3110345 in this image, is LEDA 1142006, which glows slightly fainter at magnitude 15.9. The faintest member of the Necklace visible in this image, LEDA 4540064, scrapes the bottom of the scale at magnitude 19.1. That's nearly 175,000 times fainter than the average human eye can see at night. Perhaps an amateur telescope with a 40-inch mirror could reveal the faintest one. If you have such an instrument, you'll find Zwicky's Necklace a bit more than 3½° southeast of magnitude 4.3 Tau (τ) Virginis.

This object was discovered more than four decades ago, but little is known about it. It contains at least 10 galaxies arranged in a ring (or necklace). The oldest image of it was taken in 1955 by the first Palomar Observatory Sky Survey. The NASA/IPAC Extragalactic Database, normally a font of valuable information, contains almost nothing about it.



DIGITIZED SKY SURVEY - STSCI/NASA, COLORED & HEALPIXED BY CDS

Zwicky's description, published in a 1975 paper he wrote with Wallace L. W. Sargent and Charles T. Kowal, reads: "Four red spherical (stellar or fluffy) compacts surrounded by seven additional compacts within circle of 7 minutes of arc. Individual magnitudes from 16.8 to 19.3."

Based on the redshift of the group, Zwicky's Necklace probably lies some 2 billion light-years away. – M.E.B.

ALBERTO PISABARRO

THE COMA STAR CLUSTER

The Coma Star Cluster, also known as Melotte 111 and Collinder 256, is an open star cluster that lies in Coma Berenices, a faint northern constellation with only three stars brighter than magnitude 4.5. Look toward the constellation's northwest corner for the yellow star Gamma (γ) Comae Berenices. When you find it, you've found the Coma Star Cluster. Gamma isn't part of it, however, but rather a foreground star some 170 light-years away. The cluster is about 100 light-years more distant.

British astronomer Philibert Jacques Melotte made it the 111th entry in a catalog of star clusters published in 1915. It wasn't until 1938, however, that astronomers confirmed that it is a true physical grouping.

The Coma Star Cluster glows at a relatively bright magnitude 1.8. It contains roughly 40 stars between magnitudes 5 and 10. About a dozen rise above naked-eye visibility. Because this object spans more than 4°, you'll need optics with a wide field of view to see all the stars simultaneously. Start by using binoculars with apertures of 50mm or larger, and then switch to your telescope and select your lowest-power eyepiece.

This cluster's two common names — Ariadne's Hair and Thisbe's Veil — are rooted in antiquity. The Greek mathematician Eratosthenes wrote that the stars represented the hair of the mythological figure Ariadne, daughter of King Minos of Crete. At the time, however, this cluster was part of Leo. Ptolemy III renamed it for his wife Berenice II, who once sacrificed her hair as a votive offering.

Thisbe's Veil is a reference to Ovid's *Metamorphoses*. It recounts the myth of Pyramus and Thisbe, two lovers who committed suicide due to a misunderstanding. In honor of their mutual devotion, Jupiter placed Thisbe's veil in the sky. – M.E.B.

NASA, ESA, CSA, STSCI, WEBB ERO PRODUCTION TEAM

MERRILL'S STAR NEBULA

Merrill's Star is a high-velocity Wolf-Rayet star discovered in the constellation Sagitta the Arrow in 1938 by American astronomer Paul W. Merrill. As a Wolf-Rayet star — a kind of massive star with powerful winds — it carries the designation WR 124. Of stars in the Milky Way, it has one of the highest known radial velocities: about 450,000 mph (720,000 km/h). The star is ever-so-slightly variable (its brightness changes by only 0.08 magnitude), so it's also called QR Sagittae.

Around the star is a planetary nebula cataloged as M1–67 and Sharpless 2–80. The extreme stellar wind of Merrill's Star propels the gas outward into space at a speed of 93,000 mph (150,000 km/h). Astronomers estimate that the star is losing about $1/10{,}000$ the mass of the Sun each year. Currently, the diameter of the nebula is 6 light-years. Astronomers think that the planetary nebula formed about 20,000 years ago.

In 2020, the Gaia Early Data Release 3 put the distance to Merrill's Star at around 21,000 light-years. That would mean that the star is about 500,000 times brighter than the Sun.

The nebula stands out well because WR 124 has a surface temperature of 80,000 degrees Fahrenheit (44,400 degrees Celsius). That means most of its energy is emitted as ultraviolet light, which excites the atoms in the expanding gas cloud. Astronomers think WR 124's diameter is about 12 times that of the Sun and that it contains a mass equal to roughly 20 Suns.

Spectroscopic study reveals WR 124's composition is only 15 percent hydrogen. Compare that to our Sun (and, indeed, most of the stars in space), which is made up of 75 percent hydrogen. – M.E.B.

LEO 1

KFIR SIMON

As you might guess, Leo I lies in the constellation Leo the Lion. This deep-sky target is also known as UGC 5470, PGC 29488, and the Regulus Dwarf. It's an example of a dwarf spheroidal galaxy. Such objects are faint, have little dust, and are not forming new stars. The vast majority are satellites orbiting larger galaxies. More than 30 of the 59 satellites (any galaxy within 1.4 million light-years) of the Milky Way are dwarf spheroidal galaxies.

Leo I lies some 830,000 light-years away, which makes it the Milky Way's fourth most distant satellite. It has a diameter on the order of 2,000 light-years and a mass of roughly 25 million Suns. American astronomer Albert George Wilson discovered it in 1950 while examining a photographic plate taken by the 48-inch Schmidt camera at Palomar Observatory.

Astronomers think Leo I may be the youngest of the Milky Way's dwarf spheroidals. Most of its stars seem to have formed between 2 billion and 6 billion years ago. And no stars have formed in the past billion years because around that time, Leo I made a close approach to the Milky Way, which may have stripped away all the remaining gas available for star formation.

Leo I is easy to find but difficult to observe. It lies 20' north of Regulus (Alpha [α] Leonis). Unfortunately, the glare from that magnitude 1.3 star can hide Leo I, whose magnitude is 11.2. And it appears even dimmer because its light is spread over an area measuring 10' by 7'. To increase your chances of spotting it, place Regulus just outside of your eyepiece's field of view to the south. Try a variety of magnifications and tap the scope's tube gently. Look for a faint glow moving slightly back and forth. –M.E.B.

ESO/DIGITIZED SKY SESO/DIGITIZED SKY SURVEY 2; ACKNOWLEDGEMENT: DAVIDE DE MARTIN

BARNARD'S STAR

Barnard's Star is a magnitude 9.5 star moving almost due north against the stars of Ophiuchus at a rate of 1° every 351 years. This, the highest proper motion known of any star, is due to a combination of factors: The star lies less than 6 light-years away (the next closest star to our Sun after the Alpha Centauri system) and it is moving toward us at 68 miles per second (110 km/s), indicating a total velocity of about 89 miles per second (143 km/s).

Edward Emerson Barnard discovered the star in 1916, while comparing images he had taken in 1894 and 1916 with a blink comparator. This apparatus allows two photographic plates of the same part of the sky to be compared quickly in succession.

For decades, astronomers have been scratching their heads over a wobble that Barnard's Star exhibits as it moves across the sky. Some astronomers claimed the wobble is due to a gravitational tug-of-war between the star and planetary companions. But to date, observations have failed to reveal any large Jupiter- or brown-dwarf-sized objects, down to a limit of about 0.4 Jupiter mass. One 2018 study claimed that an object three times the mass of Earth was found; however, this was considered a false positive. Although the idea of planets orbiting Barnard's Star is fading from view, a final verdict in this case has not been reached.

Like Proxima Centauri, Barnard's Star is a red dwarf, possibly an old disk star that formed before our galaxy became enriched with heavy elements. Barnard's Star shines brightly enough to be spied through the smallest of telescopes. It will pass closest to Earth (3.9 light-years) in just under 10,000 years. By that time, the star's proper motion will have increased, and its brightness will have grown significantly. –S.J.O.

THE MEDUSA NEBULA

Observers of the Northern Hemisphere's winter sky can point their telescopes toward the not-so-frightening visage of the Medusa Nebula, also cataloged as Abell 21 and Sharpless 2–274. This object's common name comes from the braided filaments of glowing hydrogen that, in astroimages, resemble the Gorgon Medusa's snakelike hair.

Originally thought to be a supernova remnant for more than a decade after its discovery, this object is now known to be a planetary nebula. American astronomer George O. Abell found it in 1955 while conducting a survey for such objects. Abell 21 lies in the constellation Gemini the Twins near the border with Canis Minor. In fact, one good way to find it is to look 5° due north of Gomeisa (Beta [β] Canis Minoris).

The Medusa Nebula glows at magnitude 10.3, but that brightness is a bit misleading. Its diameter is 10', which makes its surface brightness low.

Indeed, it's tough to spot through an 8-inch telescope unless sky conditions are ideal. Observers describe a fat arc of nebulous material with numerous dark gaps. A triangular region at its northern end and a circular region due south are the brightest areas. Step up to a 16-inch telescope to get a really good look. An Oxygen-III filter will help.

Astronomers classify the central star of the planetary nebula as a predegenerate star or a PG 1159 star. The latter designation comes from the Palomar-Green survey of ultraviolet-excess stellar objects. PG 1159–035 in Virgo was the first of these stars to be discovered. Such an object is changing from being a planetary's central star, actively shedding material, into a white dwarf. –M.E.B.

DOUGLAS J. STRUBLE

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MARTIN BRACKEN

IC 443

The supernova remnant cataloged as IC 443 and Sharpless 2–248 is more commonly known as the Jellyfish Nebula. It lies in the constellation Gemini the Twins. IC 443 isn't small. It has a diameter of 50', which means it covers 2.8 times as much area as the Full Moon. Because it is so large and diffuse, it's a much better target for imagers than for visual observers.

Although astronomers know that this object was once a massive star that exploded as a supernova, it's been tough to pin down when that happened. Estimates range between 3,000 and 30,000 years ago. It lies some 5,000 light-years from Earth, which would make its actual diameter approximately 70 light-years.

In 2015, data from the Chandra X-ray Observatory revealed what may be the remnant of the supernova that created IC 443: On the nebula's southern edge, it found a pulsar (a rotating neutron star) with the imposing designation J061705.3+222127.

However, researchers have also discovered that IC 443 is a weak X-ray source whose light is produced as electrons in the surrounding gas are released by heat generated from a central neutron star's infrared emission. This differs from many supernova remnants whose X-ray emission comes from the wind generated by a pulsar, rather than its heat. But it's difficult to see what's really going on because a giant molecular cloud between us and IC 443 is absorbing lots of the X-rays and visible light the object is producing.

The structure of IC 443 has been heavily influenced by its surroundings. In the southeast part of the nebula, the supernova's blast wave is interacting with a dense molecular cloud. The cloud has slowed down the wave so that it's now moving between 67,000 and 89,000 mph (108,000 and 144,000 km/h).

Toward the northeast part of the nebula, however, the blast wave is hitting a cloud of hydrogen that is much less dense. There, it's moving at between 180,000 and 220,000 mph (290,000 and 360,000 km/h). – M.E.B.

SKY THIS MONTH

Visible to the naked eye
Visible with binoculars
Visible with a telescope

THE SOLAR SYSTEM'S CHANGING LANDSCAPE AS IT APPEARS IN EARTH'S SKY.
BY MARTIN RATCLIFFE AND ALISTER LING

The rocky planets congregate in the predawn sky to kick off the first month of 2024. Here, Venus lies highest (above the star Regulus), while Mars and brighter Mercury are below the Moon. ALAN DYER

JANUARY 2024
Starting strong

The new year begins with Jupiter and Saturn visible most of the evening. Uranus and Neptune are on show as well, requiring optical aid to spot. Meanwhile Mercury, Venus, and Mars congregate in the morning sky, with Mercury and Mars reaching a close conjunction. Also don't miss the occultation of Antares, visible from portions of the mountain states and southern California. Add the potential for some binocular comets, and 2024 is off to a great start.

You'll find **Saturn** glowing 30° high in the southwestern sky an hour after sunset. It lies in the constellation Aquarius, shining at magnitude 0.9. The bright star Fomalhaut — slightly fainter at magnitude 1.2 — lies 19° to its south-southeast. A beautiful thin crescent Moon stands 8° west and then 7° east of Saturn on the 13th and 14th, respectively.

Catch Saturn through your telescope early in the evening before it gets too low. It sets by 9 P.M. local time on Jan. 1 and is gone before 7:30 P.M. on Jan. 31. Your best view of the narrowing rings will be as soon as you pick the planet up out of the darkening twilight. After an hour you will quickly lose Saturn in the haze.

Your scope will reveal the planet's disk, spanning nearly 16" on Jan. 1. It shaves off almost 1" by Jan. 31, as the distance to Saturn increases. The rings are tilted by 9° to our line of sight, providing a stunning view.

Get your last views of Titan before the planet moves into conjunction with the Sun. You'll find Saturn's brightest moon shining at magnitude 8.8. It stands roughly north of the planet Jan. 13 and 29 and roughly south Jan. 5 and 21. Three more moons, easily spotted in small telescopes, flit around the planet inside the orbit of Titan. Tethys, Dione, and Rhea shine at magnitude 10. Their constantly changing locations are fascinating to follow from night to night.

Early on the evening of Jan. 10, observers might spot tiny Tethys transiting the disk of Saturn shortly after 7:20 P.M. CST. Its shadow follows about 15 minutes after the moon begins its transit. This transit is best observed from the Midwest to Pacific Coast. For the eastern half of the country, a second Tethys transit is visible early in the evening on Jan. 12, beginning just before 5:40 P.M. EST.

Iapetus reaches its fainter (near 12th magnitude) eastern elongation Jan. 6, when its darker hemisphere faces earthward. Its orbit carries it closer to Saturn until Jan. 26, when it reaches inferior conjunction 27" north of the disk. It's a great time to spot this enigmatic moon, which should be glowing near 11th magnitude.

Neptune stands about 20° east of Saturn along the ecliptic and sets soon after 8 P.M. local time at the end of January. It's located in Pisces the Fish, just south of the Circlet asterism. It's 5° due south of 4th-magnitude

Worlds meet

Capture Mars and Mercury in the same telescopic field of view in late January.
ALL ILLUSTRATIONS: *ASTRONOMY*: ROEN KELLY

OBSERVING HIGHLIGHT

MARS and **MERCURY** come within 15' of each other on the morning of Jan. 27.

Lambda (λ) Piscium on Jan. 1. Binoculars will reveal the distant planet glowing at magnitude 7.8.

As an aid to finding Neptune, look for three 5th- and 6th-magnitude stars spanning nearly 3° in a line due east of Neptune's location. As January progresses, Neptune wanders to within 1° of the easternmost star of the trio, 20 Psc. Another 7th-magnitude star lies 20' south of Neptune.

The ice giant is some 30.6 astronomical units (2.8 billion miles; 1 astronomical unit, or AU, is the average Earth-Sun distance) from Earth in late January, and its tiny bluish disk spans 2". Neptune's retrograde motion ended in early December and the planet barely moves against the background stars all month.

Jupiter is a stunning object all evening. After sunset, it stands high in the southern sky in Aries the Ram. It shines at magnitude –2.6 on Jan. 1 and dims to –2.4 by the 31st. Jupiter remains visible until after midnight, offering hours of viewing its delicate cloud belts and wandering moons. Its path through Aries is now directly eastward after reaching its stationary point at the end of December.

At the start of the month, Jupiter displays a magnificent disk spanning

— *Continued on page 34*

RISING MOON | Impacts disturb Tranquillity

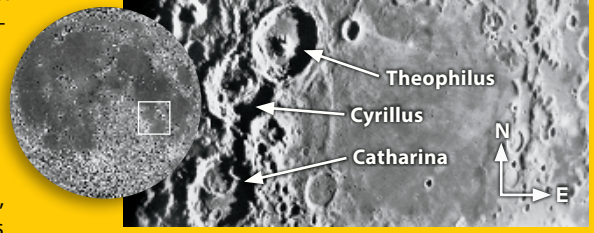
IF THERE'S A BEST FACE to the Moon, the thick crescent phase is it. Then, its smooth seas seemingly sport large waves — big craters take your breath away and small impacts stand out by casting long shadows. On the evening of the 16th, the Serpentine Ridge is an attention-grabbing couplet of light and darkness snaking across the Sea of Serenity just north of the equator. Geologically it's a compression feature, not a frozen wave rippling through the lava.

Scanning southward, you will run into Theophilus, a large 60-mile-wide, sharp-edged crater. Its complex jumble of peaks and multiple slumped terraces will have shorter shadows than in the scene pictured here. Cyrillus just to its south is about the same size but, being older, has softer edges. Catharina, offset more to the south, is older still, its lower and rounded rims evidence of a longer history of pummeling. The impact that created Theophilus spread such a rugged apron of debris northward onto the Sea of Tranquillity that the region is named Sinus Asperitatis, the Bay of Roughness.

Look closely at Torricelli, the unusual double crater north of Theophilus. Astronomers are confident that its weird shape comes from a single glancing blow instead of two unrelated events. A fraction of a second after impact, what was left of the projectile blasted through the back wall as the initial crater was in the process of forming. Torricelli itself sits off-center in a low-profile, ages-old battered bowl filled to the brim with lava.

Before inventing the mercury barometer, Evangelista Torricelli was an assistant to Galileo during the astronomer's last months of life.

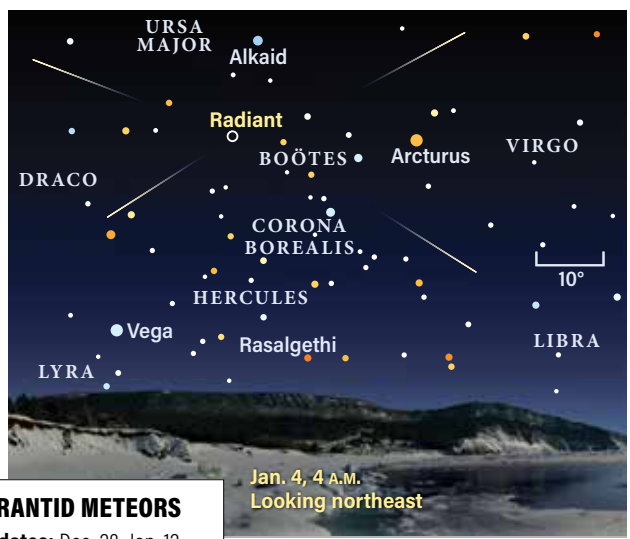
Theophilus, Torricelli, and more



The rugged Bay of Roughness spreads northeast from the lunar crater Theophilus. *CONSOLIDATED LUNAR ATLAS/* UA/LPL. INSET: NASA/GSFC/ASU

METEOR WATCH | An early start

Quadrantid meteor shower



The Quadrantids have a narrow peak the morning of Jan. 4, so observing early increases your chances of a good show.

THE QUADRANTID METEOR SHOWER peaks the morning of Jan. 4 and is best viewed in the hours before dawn. The crescent Moon won't affect observations much. The shower is active from Dec. 28 to Jan. 12; it is named after a defunct constellation that lies in the northern regions of Boötes.

The narrow peak of activity is expected to occur around 4 A.M. EST, favoring locations across the U.S. The radiant rises soon after 9 P.M. local time and by 4 A.M. is about 45° high. Expect about 25 to 30 meteors per hour, corresponding to a zenithal hourly rate of 80 meteors per hour (though this can vary quite a bit). Look also for the occasional fireball known to occur with this shower.

The Quadrantids result from 2003 EH_1, discovered in 2003 by Brian Skiff at Lowell Observatory.

QUADRANTID METEORS

Active dates: Dec. 28–Jan. 12
Peak: Jan. 4
Moon at peak: Waning crescent
Maximum rate at peak: 80 meteors/hour

STAR DOME

HOW TO USE THIS MAP

This map portrays the sky as seen near 35° north latitude. Located inside the border are the cardinal directions and their intermediate points. To find stars, hold the map overhead and orient it so one of the labels matches the direction you're facing. The stars above the map's horizon now match what's in the sky.

The all-sky map shows how the sky looks at:

9 P.M. January 1
8 P.M. January 15
7 P.M. January 31

Planets are shown at midmonth

MAP SYMBOLS

- Open cluster
- Globular cluster
- Diffuse nebula
- Planetary nebula
- Galaxy

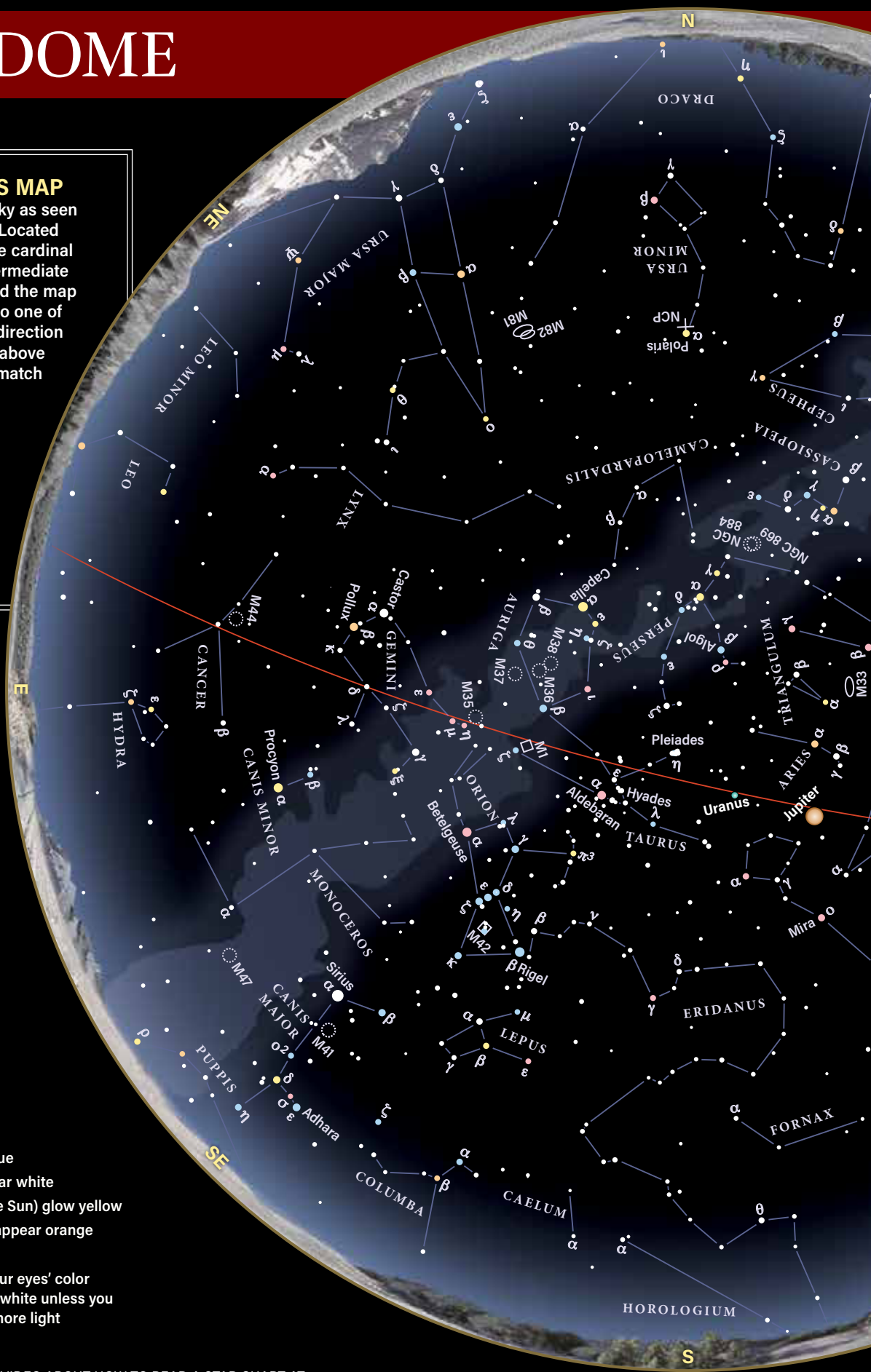
STAR MAGNITUDES

- Sirius
- 0.0
- 1.0
- 2.0
- 3.0
- 4.0
- 5.0

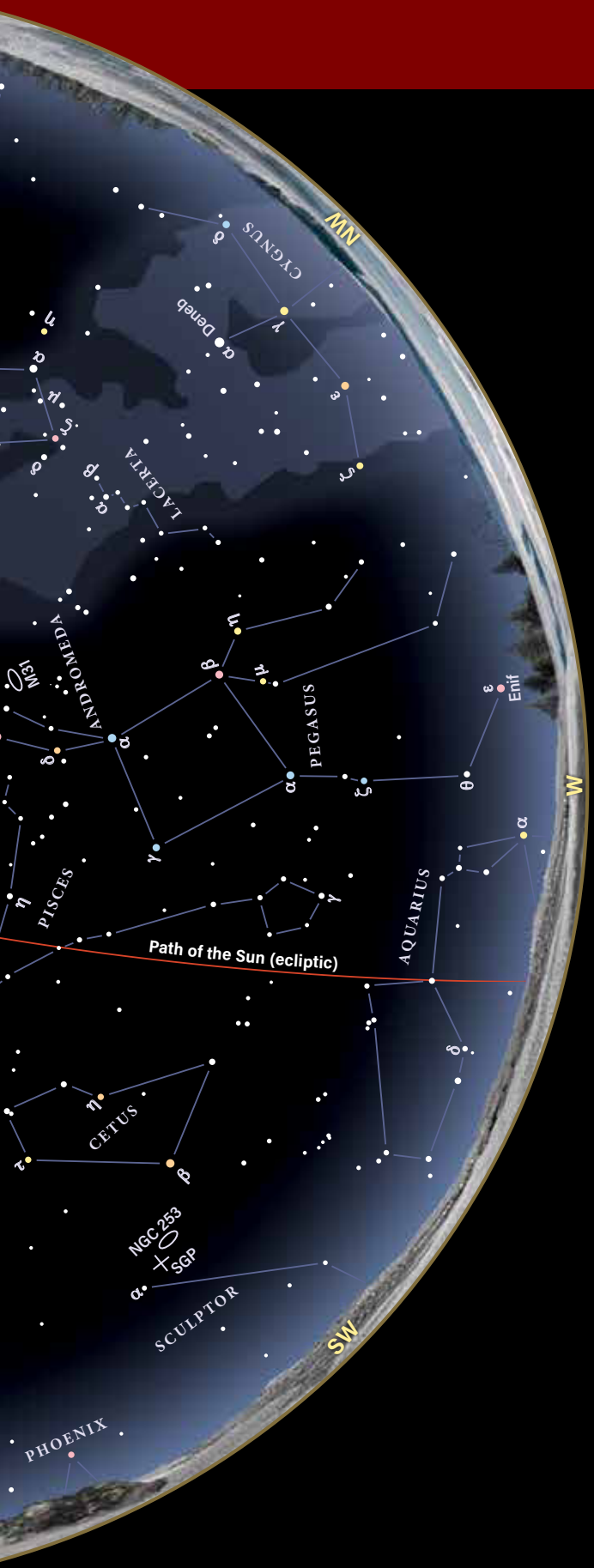
STAR COLORS

A star's color depends on its surface temperature.

- The hottest stars shine blue
- Slightly cooler stars appear white
- Intermediate stars (like the Sun) glow yellow
- Lower-temperature stars appear orange
- The coolest stars glow red
- Fainter stars can't excite our eyes' color receptors, so they appear white unless you use optical aid to gather more light



BEGINNERS: WATCH A VIDEO ABOUT HOW TO READ A STAR CHART AT **www.Astronomy.com/starchart.**



JANUARY 2024

SUN.	MON.	TUES.	WED.	THURS.	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			

ILLUSTRATIONS BY *ASTRONOMY*: ROEN KELLY

Note: Moon phases in the calendar vary in size due to the distance from Earth and are shown at 0h Universal Time.

CALENDAR OF EVENTS

1 The Moon is at apogee (251,599 miles from Earth), 10:28 A.M. EST

Mercury is stationary, 11 P.M. EST

2 Earth is at perihelion (91.4 million miles from the Sun), 8 P.M. EST

3 Last Quarter Moon occurs at 10:30 P.M. EST

4 Quadrantid meteor shower peaks

6 Venus passes 6° north of Antares, 3 A.M. EST

8 The Moon passes 0.8° north of Antares, 10 A.M. EST

The Moon passes 6° south of Venus, 3 P.M. EST

9 The Moon passes 7° south of Mercury, 2 P.M. EST

10 The Moon passes 4° south of Mars, 4 A.M. EST

11 New Moon occurs at 6:57 A.M. EST

12 Mercury is at greatest western elongation (24°), 10 A.M. EST

13 The Moon is at perigee (225,102 miles from Earth), 5:36 A.M. EST

14 The Moon passes 2° south of Saturn, 5 A.M. EST

15 Asteroid Juno is stationary, 6 A.M. EST

The Moon passes 0.9° south of Neptune, 3 P.M. EST

17 First Quarter Moon occurs at 10:53 P.M. EST

18 The Moon passes 3° north of Jupiter, 4 P.M. EST

19 The Moon passes 3° north of Uranus, 3 P.M. EST

20 Pluto is in conjunction with the Sun, 9 A.M. EST

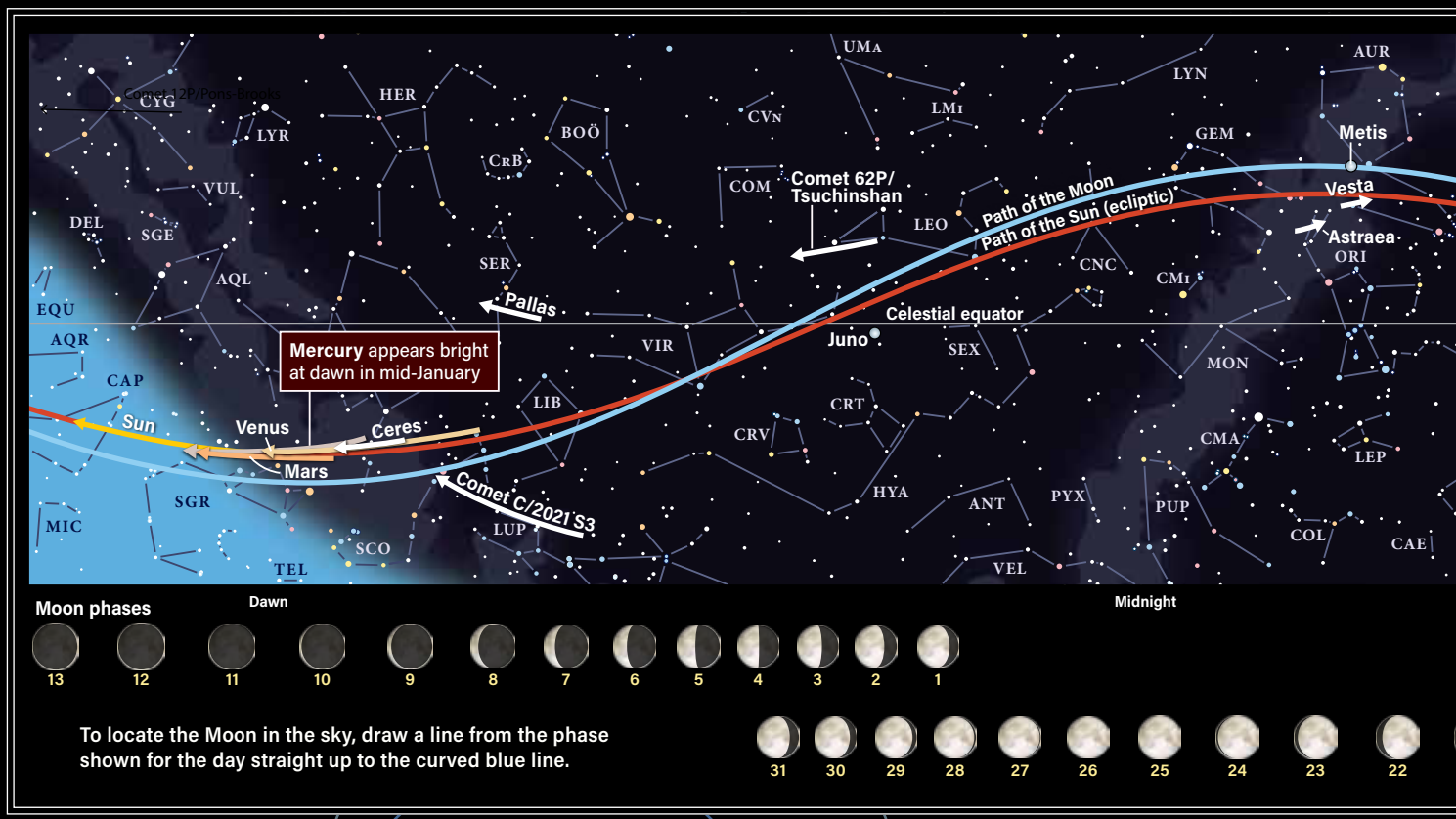
25 Full Moon occurs at 12:54 P.M. EST

27 Uranus is stationary, 6 A.M. EST

Mercury passes 0.2° north of Mars, 11 A.M. EST

29 The Moon is at apogee (252,138 miles from Earth), 3:14 A.M. EST

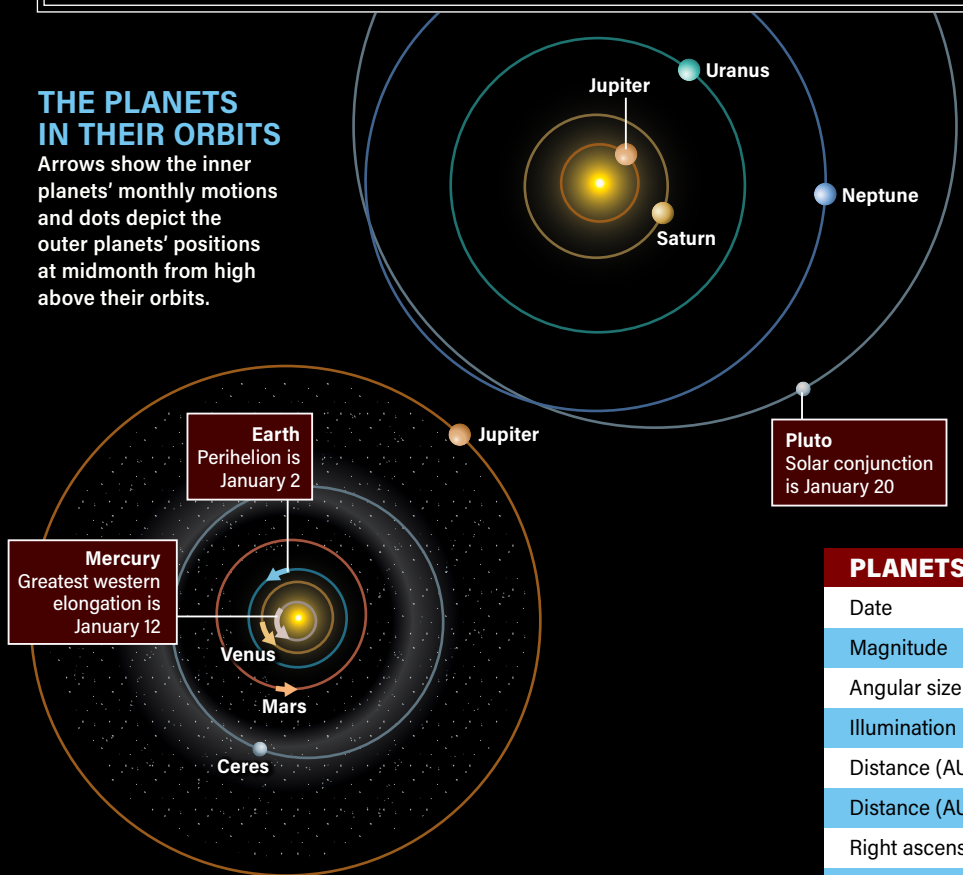
PATHS OF THE PLANETS



To locate the Moon in the sky, draw a line from the phase shown for the day straight up to the curved blue line.

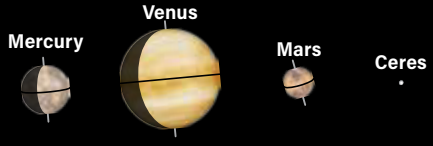
THE PLANETS IN THEIR ORBITS

Arrows show the inner planets' monthly motions and dots depict the outer planets' positions at midmonth from high above their orbits.



THE PLANETS IN THE SKY

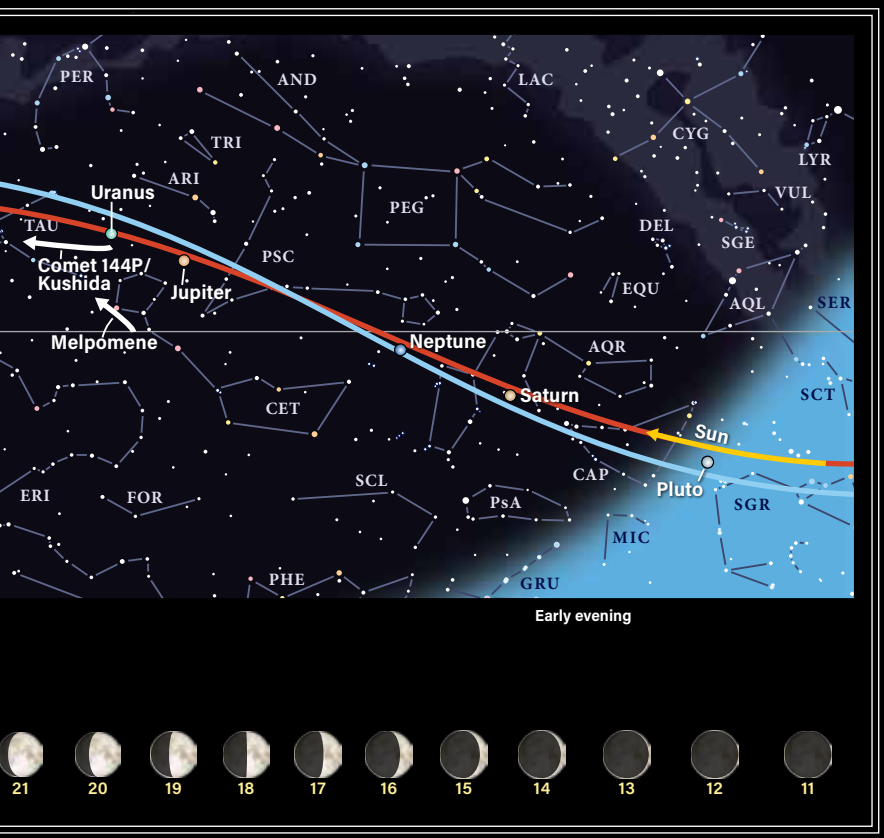
These illustrations show the size, phase, and orientation of each planet and the two brightest dwarf planets at 0h UT for the dates in the data table at bottom. South is at the top to match the view through a telescope.



PLANETS	MERCURY	VENUS
Date	Jan. 15	Jan. 15
Magnitude	–0.2	–4.0
Angular size	6.4"	13.2"
Illumination	68%	82%
Distance (AU) from Earth	1.058	1.267
Distance (AU) from Sun	0.420	0.722
Right ascension (2000.0)	18h02.8m	17h14.3m
Declination (2000.0)	–22°13'	–21°35'

This map unfolds the entire night sky from sunset (at right) until sunrise (at left). Arrows and colored dots show motions and locations of solar system objects during the month.

JANUARY 2024




Callisto

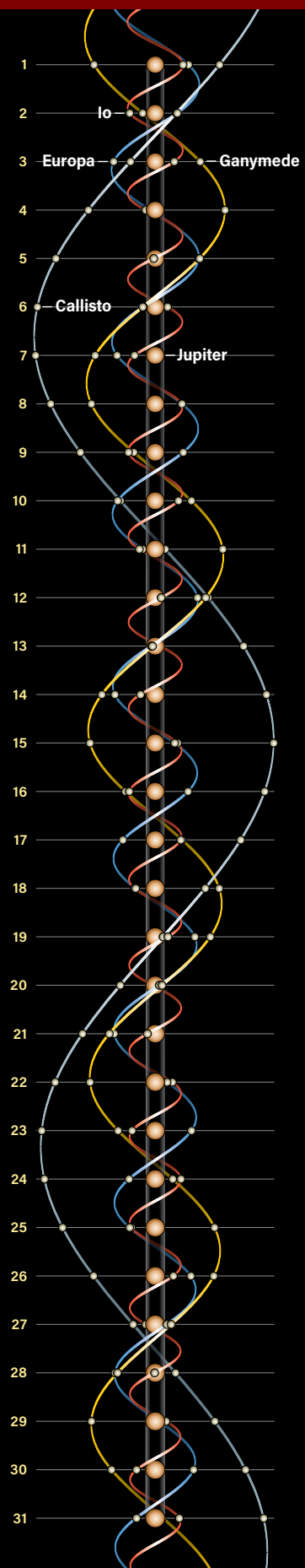

Europa

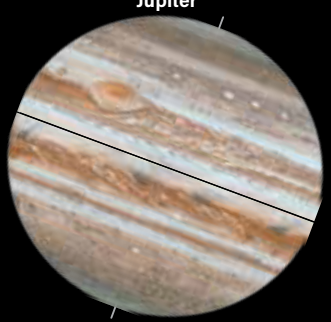

Io


Ganymede

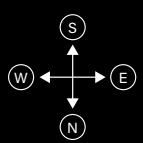
JUPITER'S MOONS

Dots display positions of Galilean satellites at 10 P.M. EST on the date shown. South is at the top to match the view through a telescope.




Jupiter


Saturn



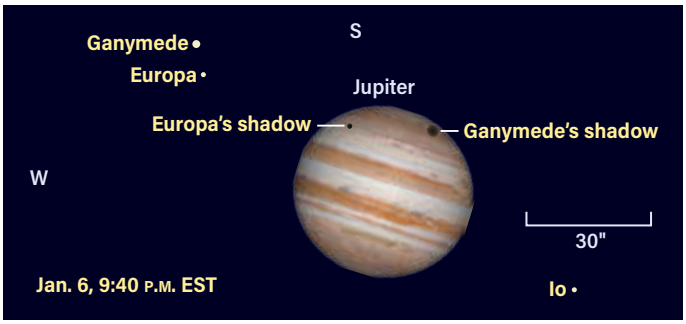
10"

Uranus Neptune Pluto

MARS	CERES	JUPITER	SATURN	URANUS	NEPTUNE	PLUTO
Jan. 31	Jan. 15	Jan. 15	Jan. 15	Jan. 15	Jan. 15	Jan. 15
1.3	9.1	–2.5	0.9	5.7	7.8	15.2
4.0"	0.4"	42.0"	15.9"	3.7"	2.2"	0.1"
99%	99%	99%	100%	100%	100%	100%
2.323	3.541	4.695	10.463	19.178	30.368	35.910
1.444	2.772	4.988	9.734	19.611	29.903	34.932
19h25.1m	17h20.2m	2h14.8m	22h26.9m	3h05.8m	23h43.6m	20h09.1m
–22°50'	–21°34'	12°21'	–11°27'	17°08'	–3°07'	–22°59'

 — Continued from page 29

The buddy system



Europa and Ganymede transit Jupiter together with their shadows several times this month. The first such event occurs on the 6th. Callisto lies far east, outside the field of view shown here.

4" through a telescope. Immediately noticeable are two dark bands straddling the equator. Occasionally the Great Red Spot appears adjacent to the southern band. By the end of January, Jupiter's distance from Earth has increased to 4.97 AU (462 million miles) and its disk spans 40".

The four bright Galilean moons — Io, Europa, Ganymede, and Callisto — undergo transits and occultations. You'll see moons transit first followed by their shadows, and as the month progresses, the separation between moon and shadow increases due to our changing perspective. Currently due to the relative tilt of its orbit to our line of sight, Callisto misses the disk.

On Jan. 6, Ganymede and Europa are transiting the disk at sunset in the Midwest. Their two shadows move across the planet next, starting with Europa's around 7:40 P.M. EST. As it approaches the western limb of the planet, notice the giant black shadow of Ganymede begin to transit soon after 9:20 P.M. EST. It takes more than 10 minutes to fully appear. When do you first notice it? It slips onto the southern polar region of Jupiter and takes nearly two hours to cross the disk. Notice the two moons involved are now far west of the disk itself.

Europa and Ganymede repeat this event Jan. 13/14. By 8 P.M. EST, both moons are transiting. They leave the disk within about 15 minutes of each other starting at 9:45 P.M. EST.

Later, both shadows appear to transit one after the other. They pair up again Jan. 20.

Overnight on Jan. 19/20, Callisto appears south of Jupiter at the same time that Io and its shadow are transiting the disk. For observers in the Midwest, Jupiter sets during the event — but the western half of the U.S. will see Callisto move due south of the planet.

Uranus shines at magnitude 5.7 and is located in eastern Aries, roughly halfway between Jupiter and the Pleiades star cluster (M45). It is an easy target to find with binoculars and technically visible to the naked eye under ideal conditions.

On Jan. 1, the ice giant stands 45' south of 53 Arietis. It moves west during the month, extending this distance to 53' by the time it reaches its stationary point Jan. 27. You can find this region about 12° southwest of M45, or roughly two field diameters in 7x50 binoculars. Uranus stands 19.5 AU (1.8 billion miles) from Earth by the end of the month and through a telescope shows off a 4"-wide disk.

WHEN TO VIEW THE PLANETS

EVENING SKY
Jupiter (south)
Saturn (southwest)
Uranus (southeast)
Neptune (southwest)

MIDNIGHT
Jupiter (west)
Uranus (west)

MORNING SKY
Mercury (southeast)
Venus (southeast)
Mars (southeast)

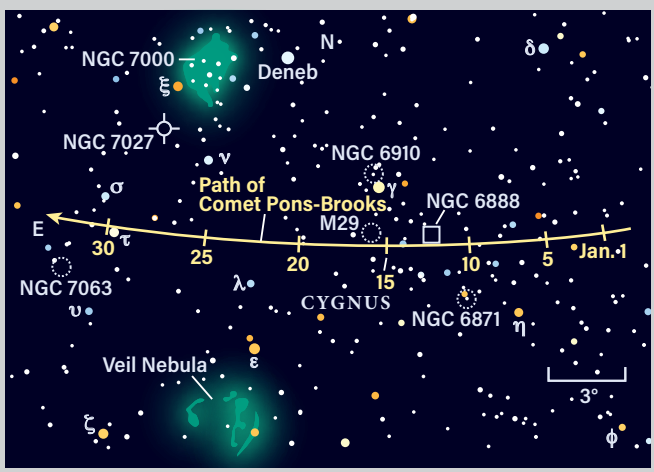
COMET SEARCH | Climbing as the stars sink

NORTHWEST, STEADY AS SHE COMES! By luck, the comet predicted to just crack the naked-eye barrier in April combines with Earth's motion to remain between the evening ecliptic and the Milky Way. Comet 12P/Pons-Brooks only returns every 71 years, so few people alive will have seen it.

First discovered in 1812 by Jean-Louis Pons, it reached a respectable 4th magnitude. But its recorded positions were too poor to calculate its 1883 return, when it was accidentally recovered by William Brooks.

On the 12th, the 10th-magnitude fuzzball passes ½° from the Crescent Nebula (NGC 6888) in the picturesque heart of Cygnus. Set up in early twilight so you're ready to observe before it drops below 10° in altitude. Put any city light dome to the southeast if you can.

Comet 12P/Pons-Brooks

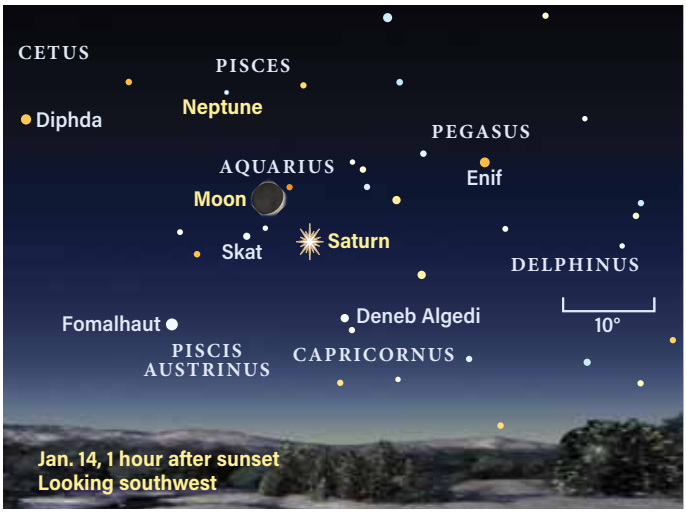


Comet Pons-Brooks is crossing the rich constellation Cygnus. Only brighter deep-sky objects are shown here, though many more abound.

An outburst to naked-eye brightness could happen! Comet researcher Richard Miles noted that Pons-Brooks can flare up more than 4 magnitudes in a night, and more than once per visit. Let's hope the jump we saw in July repeats.

Meanwhile, 144P/Kushida approaches Aldebaran from the west, possibly breaking 9th magnitude (though some sources suggest only 11th). And observers south of the equator get a very nice view of 7th-magnitude C/2021 S3 (PanSTARRS) as dawn breaks. Observers in the Gulf States can join in, but this PanSTARRS discovery quickly gets difficult from farther north. The geometry improves next month.

Hanging together



A crescent Moon visits Saturn in the evening sky midmonth. Neptune, although shown here, requires binoculars to spot.

The morning predawn sky hosts a trio of planets that quickly change relative position. Venus, the brightest and most obvious, rises early and is later joined by Mercury and Mars in the hour before sunrise, low in the southeast.

We'll start with **Venus**, shining at magnitude –4 and standing less than 1° north of Beta (β) Scorpii on Jan. 1. Antares, the brightest star in Scorpius, lies 9° below Venus. The planet rises a full three hours before the Sun, placing it well up in the southeastern sky before twilight begins. On the same morning, Mercury stands 5° high an hour before sunrise and shines at magnitude 0.5. A telescope reveals Mercury as a 9"-wide disk that is nearly 30 percent lit.

Venus moves into Ophiuchus and stands 6° north of Antares by the 6th. A waning crescent Moon approaches the following morning, hanging 16° east of Venus. On the 8th, the Moon lies 6.6° south of Venus and occults Antares for a limited area of the U.S. Observers in a narrow band from southern California up through the Rocky Mountain states may see the occultation in twilight. The star disappears around 6:30 A.M. MST and reappears around 7:40 A.M. MST, in daylight for most of the U.S.

Meanwhile, **Mercury** reaches 51 percent lit on the 7th and brightens to magnitude –0.1 on the 8th. The apparent size of its disk has shrunk slightly (7") as its orbit carries it away from Earth. The morning of Jan. 9 finds the waning Moon 7.5° south of Mercury. After the Moon departs the morning scene, Mercury and Venus move closer until the 17th, when they stand 11° apart. After this date, Mercury begins a slow fall back toward the Sun, extending its separation from Venus and brightening to magnitude –0.3 by the 31st.

Mars rises out of the Sun's glow in late January. Your first opportunity to spot it could be Jan. 19, when Mars stands 5° east of Mercury. Forty-five minutes before sunrise, look for Mercury about 6° high in the southeast and shining at magnitude –0.2. Now search closer to the horizon for Mars, a very dim magnitude 1.3 and only 2° high. Binoculars will aid your search.

Mercury and Mars close in on each other until Jan. 27, when they stand a mere 15' apart in twilight. You'll need a telescope to spot Mars right next to Mercury — a rare and remarkable pairing. They stand 2° high 45 minutes before sunrise. As a guide, Venus is 12° farther west along the ecliptic and 10° above the horizon. Through a telescope, Mars appears full and 4" wide, while Mercury shows an 84-percent-lit disk spanning 5". Venus' disk is 85 percent lit and 12" across.

Martin Ratcliffe *is a planetarium professional with Evans & Sutherland and enjoys observing from Salt Lake City.* **Alister Ling**, *who lives in Edmonton, Alberta, is a longtime watcher of the skies.*

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LOCATING ASTEROIDS
Surf and turf

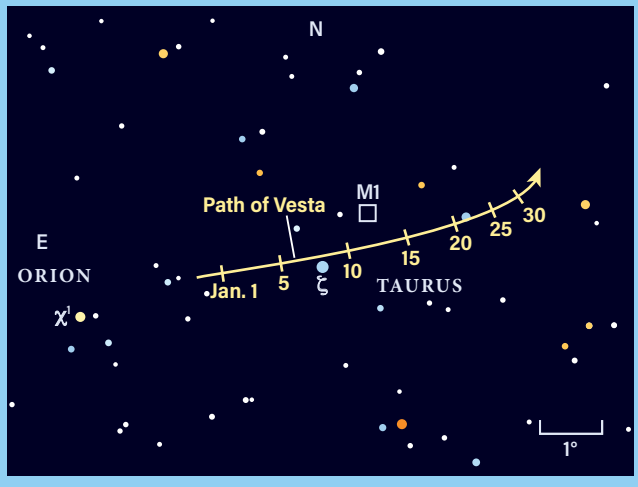
IT SHOULD TAKE LESS THAN FIVE MINUTES to make a sighting of 4 Vesta. With 31 nights in January, how many times can you spot it?

Start at the orange luminary Aldebaran, the eye of Taurus, then slide east along the southern horn of the bull to reach 3rd-magnitude Zeta (ζ) Tauri. Vesta is remarkably easy for binoculars or the smallest scope from suburbia, making it simple to record its shifting position night to night on an observing log page. Despite the presence of the Milky Way, the Taurus dust clouds suppress so much background starlight that there are few stars 6th magnitude or brighter here.

Take note as our 7th-magnitude main-belt asteroid steps north of Zeta from the 7th to the 9th. In one session, you can even see it shift over the course of two to three hours. Jan. 10 is the best for that, while on the 21st, the Moon may interfere too much. From a dark sky, Vesta dots the low-power field of the Crab Nebula (M1) from Jan. 11 to 13.

Fans of seeing double can watch the rapid change in position angle for the very unequal pairing of 2nd-magnitude Beta (β) Tauri and 10th-magnitude asteroid 37 Fides, only 90" to the star's south, on the 3rd.

By the horns



Vesta should be easy to snag as it slides by bright Zeta Tauri, the tip of Taurus' southern horn.

VINCE FARNSWORTH

BARNARD'S LOOP

Many of the sky's emission nebulae appear small, requiring high magnifications to even bring them into view. Some also can be hard to locate. Not Barnard's Loop. Cataloged as Sharpless 2–276, this massive deep-sky object spans more than 10° within Orion.

Its common name comes from American astronomer Edward Emerson Barnard, who, during the last decade of the 19th century, photographed it while taking wide-field images of the sky.

Barnard's Loop is one component of the Orion molecular cloud complex. Other well-known celestial objects that are part of this complex include the Orion Nebula (M42), the Horsehead Nebula (Barnard 33), the Flame Nebula (NGC 2024), and M78, which is the sky's brightest reflection nebula.

The Loop (it's actually an arc) is centered on the Orion Nebula. Ultraviolet radiation from hot new stars there causes the Loop to glow, mainly in Hydrogen-alpha light. And although that makes it an emission nebula, researchers at the Center for Astrophysics | Harvard & Smithsonian used both 2D and 3D data to show that it probably formed from a supernova explosion between 2 million and 4 million years ago.

By far, the best views of this object are created by astroimagers, but you can still observe its brightest parts. Giant binoculars equipped with nebula filters are the best way to search for it. That's because no telescope has a wide enough field of view to take in even the brightest section, which stretches nearly 6°.

Still, if you want to use a telescope, start with the eyepiece that provides the widest field and attach a nebula filter to it. You must view from a dark site and be willing to take your time. With your scope pointed to the general area, start moving it around slowly. What you're looking for is a slight diffuse brightening in that part of the sky. —M.E.B.

M67

M67 is the second-best open cluster in the constellation Cancer the Crab. At magnitude 6.9, it's outshone only by the Beehive Cluster (M44). It has a diameter of 29', nearly the same as the Full Moon. You'll find it easily through binoculars or a small telescope 1.7° due west of magnitude 4.3 Alpha (α) Cancri. It was first seen in 1779 by German astronomer Johann Gottfried Koehler.

Through a 4-inch telescope, you'll resolve roughly two dozen stars in M67. Increase the aperture just to 6 inches, and 50 individual stars will shine forth. A dozen of these stars are brighter than 11th magnitude. As you observe M67, note the yellow star HIP 43519 on its northeastern edge. It glows at magnitude 7.8 but it doesn't belong to the cluster; instead, it lies in the foreground.

M67 lies between 2,600 and 2,900 light-years away.

DAN CROWSON

And although astronomers know it's an old cluster, they haven't pinned down an exact age for it yet. Estimates range between 3.5 billion and 5.5 billion years, which make it the oldest nearby open cluster.

Estimates of its mass aren't much more precise. Various researchers have pegged it somewhere between 1,100 and 1,400 solar masses. It contains at least 500 stars, of which about 100 are Sun-like. Another 150 are white dwarfs, and the remainder are red giants or blue stragglers.

Because of its age, M67 has no stars hotter than spectral type F. And as it continues to age, the hottest stars will eventually become G-type (like the Sun) and progressively cooler. And speaking of similarities to our star, a study of starspots on 20 of M67's stars by the Leibniz Institute for Astrophysics Potsdam and Johns Hopkins University conducted in 2016 showed that they (and probably the vast majority of the stars in the cluster) rotate at the same rate as the Sun. —M.E.B.

FORNAX DWARF

ESO/DSS2/GIUSEPPE DONATIELLO

The Fornax Dwarf is a satellite galaxy of the Milky Way, and the second discovered. It was found by astronomer Harlow Shapley, shortly after he identified one in Sculptor (see #65). He described both in a 1938 *Nature* letter as new "stellar systems" outside the Hubble galaxy classification system.

It has a magnitude estimated at 7.4, which is spread over an area of about 20' by 13' — in other words, a very low surface brightness.

Unlike the Sculptor Dwarf, this dwarf is unique in that it has its own swarm of six globular clusters — a high number for a type dE4 galaxy. John Herschel discovered the brightest globular in the Fornax Dwarf system in 1835, more than a century before Shapley found the galaxy itself. Why? Because globulars are so small that their light is more concentrated, making them appear brighter and easier to find. Sculptor and the other dwarf elliptical galaxies around the Milky Way had surface brightnesses too low for past telescopes — even when they *were* found! Shapley discovered the Fornax Dwarf on photographic plates. It was a challenge to observe visually, requiring both a large aperture and a wide field. Today's telescopes are a quantum leap ahead of those in the mid-20th century. In the last several decades, the number of similar satellite galaxies has grown significantly, with discoveries of objects in at least 28 other constellations.

Fornax's globular clusters are curious for other reasons, too. Four are typically ancient, over 12 billion years old. One is about 9 billion years old, while another is very young, around 2 billion years old. Why such a wide range of ages? It is possible they came from other dwarf galaxies that no longer exist due to encounters with the Milky Way. — A.G.

ALAN DYER

PENCIL NEBULA

The Pencil Nebula (NGC 2736) is the brightest part of the Vela supernova remnant (see #76). About 11,000 years ago, humans in the Southern Hemisphere witnessed a brilliant new star in what is now known as the constellation Vela. It would have been the brightest object in the sky after the Sun. The progenitor star was massive; its death was a type II supernova. For comparison, the famous supernova of 1054 that created the Crab Nebula (M1) was magnitude −4, visible in the daytime for three weeks. It is about 6,500 light-years away. Vela was nearly seven times closer!

The Vela supernova remnant is reminiscent of the Veil Nebula in Cygnus and the Jellyfish Nebula (see #48) in Gemini. Both are now glowing arcs of gas; the former is 3° across and 2,400 light-years away, while the latter is 50' across and 5,000 light-years distant. The Vela supernova remnant (also cataloged as Gum 16) is much larger, composed of thin filaments of gas spread across 8° of the southern sky. NGC 2736 itself is about 815 light-years away. As supernova remnants go, this one is practically in our backyard.

Its name describes the shape: a thin, pencil-like cloud of glowing hydrogen. The half-degree-long nebula lies right on the galactic plane, roughly 3° south-southwest of Lambda (λ) Velorum. The nebula is located about 4.5° west of the Vela pulsar and is moving through space at a speed of 400,000 mph (644,000 km/h). The eastern side of the Pencil Nebula is the brightest as it encounters gas in the interstellar medium. The famous deep-sky observer John Herschel discovered this object in 1835 from an observatory in South Africa. — A.G.

ANTENNAE GALAXIES

NGC 4038/9, known as the Antennae or Ringtail galaxies, are a well-known pair of colliding galaxies in Corvus. Halton Arp designated them No. 244 in his famous 1966 *Catalogue of Peculiar Galaxies*. The duo started as a normal and barred spiral that began interacting an estimated 900 million years ago, when life on Earth was just beginning to blossom into multicellular organisms. During the Cambrian Period some 500 million years ago, while trilobites were crawling in our oceans, the two galaxies passed through one another. During the Coal Age 300 million years ago, stars and gas were being flung from the galaxies out into the intergalactic medium, beginning their journey to create the "antennae" visible in photographs today. If you prefer the Ringtail moniker, the "ring" is the now-ragged spiral, NGC 4039, while the "tail" is what's left of the barred spiral, NGC 4038.

One of the reasons these galaxies are so bright is that they are in starburst mode. The collision sent shock waves through them, compressing gases and increasing the rate of star formation. Such starburst galaxies are well documented. At an estimated 45 million light-years away, these aren't even the closest examples. M82 in Ursa Major is only 12 million light-years distant and NGC 253 in Sculptor is 10 million light-years away.

Nonetheless, 11th-magnitude NGC 4038/9 are some of the easiest interacting galaxies to find. Look 3.5° southwest of Gamma (γ) Corvi (or ¾° north of 31 Crateris). Their weird shape can be seen in small telescopes. Large scopes reveal uneven brightness due to patches of star clouds and dark nebulae typical of many starburst galaxies. Both nuclear regions are visible with larger telescopes. This may be a glimpse of what M31 and the Milky Way might look like in a few billion years — who knows! — A.G.

DYLAN O'DONNELL

ANT NEBULA

Menzel 3, also called the Ant Nebula, lies about 3,000 light-years away in the southern constellation Norma. At magnitude 13.8 and about 1' across its longest dimension, it is a faint target for observers. Like many obscure objects, this one reveals some amazing detail only with large telescopes. The name comes from the way its shape resembles a garden ant, with a clearly defined head and thorax. Shapes like this are associated with bipolar planetary nebulae.

In addition to the core where the formative star is located, there are four distinct outflow structures associated with this nebula. The two bulb-shaped lobes are punctuated by faster-moving gas on each side. There are also two hourglass-shaped filamentary columns and two cone-shaped rays that radiate in slightly different directions. One peculiar feature that distinguishes the Ant Nebula from similar objects is an equatorial ring, called a chakram, surrounding the central star. Its formation is thought to be related to the star's evolution.

Two theories postulate how such a weird nebula might form. The central star might be a binary. To influence the nebula, its components must be very close, perhaps separated by as little as the Earth-Sun distance. At that proximity, the outside of the bloated red giant creating the nebula might extend beyond its companion — a star inside a star! As the smaller star orbits the larger one, its influence might create the odd nebular shape.

A second theory posits that the dying star is spinning and its strong magnetic field is creating the fantastic shapes. Moving at 620 miles per second (1,000 km/s), the gas follows the lines of the magnetic field as they escape into space; as the gas is lit by ultraviolet light from the star, it reveals the shape of the magnetic field.

No matter the cause, the result is beautiful. – A.G.

SATURN NEBULA

ALAN DYER

The Saturn Nebula (NGC 7009) was one of the first oddball planetary nebulae known. As the name suggests, this dying star resembles the planet — albeit crudely. It doesn't actually have rings but sports highly elongated equatorial projections, called ansae. William Herschel observed it from England in 1782 but William Parsons, Earl of Rosse, named it in the 1840s, after his 72-inch telescope revealed the odd structures.

Today, a good 8-inch telescope will give you a nice view, revealing the shape it took larger speculum mirrors to see nearly 180 years ago. At 8th magnitude, this object is bright enough for scopes over 6 inches to show a brilliant green color. The nebulae around dying solar-type stars typically emit this fluorescent green glow as oxygen gas in the envelope is excited by the central stellar remnant.

What causes the odd shape? Multiple eruptions from the star — now a white dwarf — sent new gas to interact with previous outflows. Planetary nebulae are diverse, as the dynamic interaction of gases as the star loses mass often creates unique structures. Most of that detail is too fine to be seen in typical amateur telescopes.

Look 1° west of Nu (ν) Aquarii to find this wonderful object. The magnitude 11.5 central star is visible in modest instruments, not a challenge compared to the Ring Nebula (M57). The brightest portion of the nebula is 24" by 17" and distinctly oval in shape. The outer shell nearly doubles its size. Like many planetaries, determining its distance is challenging. Estimates place NGC 7009 anywhere from 2,000 to 4,000 light-years away. That means the gas envelope is between 0.2 and 0.4 light-year across. – A.G.

LEMON SLICE NEBULA

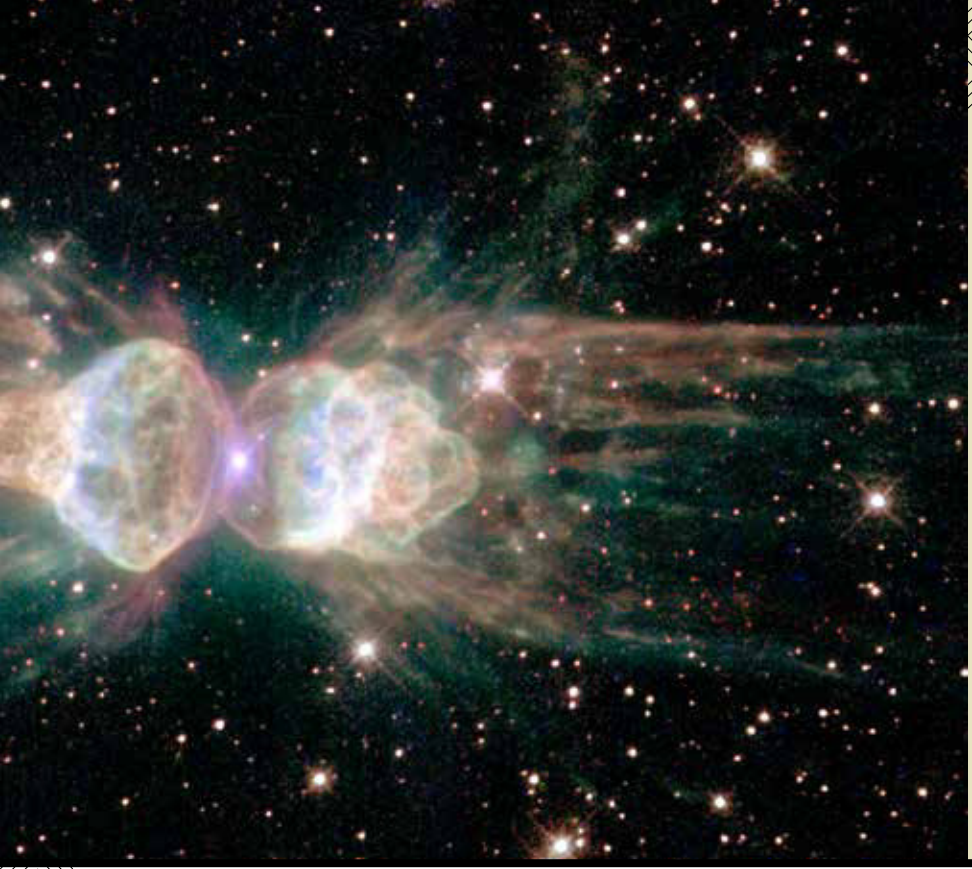
You'll find the Lemon Slice Nebula (IC 3568) in the far northern reaches of Camelopardalis the Giraffe. The name comes from a Hubble Space Telescope false-color image showing a yellow disk with a "fibrous" radial pattern that resembles a lemon in cross-section. Visually, the color is decidedly nondescript; if anything, it is a more typical bluish from ionized gases like oxygen and nitrogen.

IC 3568 has the distinction of being the northernmost planetary nebula at 82.5° in declination. It lies nearly midway between Polaris and Kochab, forming an obtuse triangle from its position outside the border of Ursa Minor. At magnitude 10.6, it's bright enough for a small telescope. The Lemon Slice has two shells. The brighter inner shell is only 6" in diameter, roughly the apparent size of Uranus. The outer shell is 18" across and is best seen in larger telescopes because it has a lower surface brightness. The central star is easily seen at magnitude 12.3.

Planetary nebulae with multiple shells are typical, as the central star sheds gas periodically as it evolves. The outer shell is often too faint to see visually or, as in this case, requires a large telescope.

The Lemon Slice Nebula lies about 4,500 light-years away, with a diameter of 0.4 light-year. That's 2.4 trillion miles (3.8 trillion kilometers), or more than 25,000 times the distance from Earth to the Sun! It's small compared to other planetary nebulae, but huge compared to the solar system. When our Sun becomes a planetary nebula in 5 billion years, it will expand into the Oort Cloud, the sphere of debris far beyond the orbit of Pluto. – A.G.

NASA/ESA/HUBBLE/KEVIN M. GILL (CC BY 2.0)



NASA, ESA, AND THE HUBBLE HERITAGE TEAM (STSCI/AURA)

NGC 6231

NGC 6231 is sometimes called the Northern Jewel Box Cluster because resembles the original Jewel Box Cluster (NGC 4755 [see #82]) in Crux. But at nearly –42° in declination, calling it "northern" is a bit confusing. Also called the Baby Scorpion because it is located near Zeta[1] (ζ) and Zeta[2] (ζ²) Scorpii, which form the base of the constellation Scorpius' tail, NGC 6231 is the head of the False Comet, an area rich in stars trailing down to Mu (μ) Scorpii.

There are several nebulae in the area, though most are difficult to see. The region around this cluster contains numerous hot, luminous young stars. Such stars have a spectral classification of O or B and are formed from the same gas cloud; these groups are called OB associations. The cluster is part of the Scorpius OB1 association and lies 5,500 light-years away. Zeta[1], considered one of the most luminous stars in the sky, is a member. Zeta[2] lies only 150 light-years away and, while visually brighter, is intrinsically less luminous than Zeta[1]. The cluster and OB association lie in the arm of the Milky Way closer to the center of the galaxy than the one housing our Sun. The region is surrounded by a large, faint cloud of gas and dust called RCW 113.

For observers at northern temperate latitudes, it's another brilliant object located near or below the horizon. Where it rises, this young cluster is worth a look. It is the 6th-brightest cluster in the whole sky at magnitude 2.6, with a width of 14'. It's a great object for binoculars or a small telescope. NGC 6231 was first recorded by Italian observer Giovanni Batista Hodierna before 1654. He developed a list of noncometary objects some 120 years before Charles Messier. –A.G.

ALAN DYER

ESO/DSS2, GIUSEPPE DONATIELLO

BARNARD'S GALAXY

Barnard's Galaxy (NGC 6822) is the easiest Local Group member to observe in Sagittarius. It was discovered by Edward Emerson Barnard in 1884 with a 6-inch refractor; this late-19th-century Vanderbilt University astronomer was one of the first prolific astrophotographers. His atlas of dark nebulae is a major part of his legacy, but capturing NGC 6822 was also one of his many accomplishments.

At 1.5 million light-years, it is just beyond the gravitational pull of the Milky Way. And at 7,000 light-years across, it's the same size as the Small Magellanic Cloud, but the irregular galaxy is drifting alone.

Its magnitude of 9.3 is deceptive because the light is spread over 16' by 14'. With dark skies, I've seen this galaxy multiple times in scopes ranging from 6 to 10 inches. Others have seen it in binoculars under magnitude 6.5 skies! Larger apertures coupled with nebula filters will reveal bright emission nebulae, especially on the galaxy's northern end, making it a fascinating object to view. Paul W. Hodge cataloged 188 HII regions in this galaxy in 1988. He also noted 16 OB associations — groups of hot, luminous stars. Hodge counted 363 stars brighter than 18th magnitude, meaning a 20- to 25-inch telescope may resolve some stars. These may give the galaxy a grainy texture, like a globular cluster just below the limit of your ability to resolve. It's an interesting target for the serious observer.

A wide-field telescope may also pick up the bright planetary nebula NGC 6818 less than a degree to the north-northwest. The Little Gem Nebula glows at 10th magnitude and spans only 20" — and at 6,000 light-years away, it is 250 times closer to us. –A.G.

DARK DOODAD

The Dark Doodad Nebula, unlike the Horsehead or Saturn nebulae, has one of those names that has stuck but isn't particularly descriptive. (The general definition for *doodad* is a small object whose name you can't remember or do not know.) Technically, it's the 149th object in Aage Sanqvist's 1977 article "More southern dark dust clouds." Dennis DiCicco is credited with naming it while in Australia observing Halley's Comet in 1986. I'd simply call it the Comet Shadow Nebula, as photos show a darker "comet head" that grows paler toward the "tail."

Just what is the Dark Doodad? It's a comet-shaped molecular cloud in the deep southern constellation Musca the Fly. Its narrow, dense mass blots out background stars in an otherwise rich part of the Milky Way. Stretching 3° (the width of six Full Moons) across the sky, it's an ideal binocular object. Like many dark nebulae, this one is relatively close by, only 700 light-years away. That translates to a dust cloud over 30 light-years across. That's equivalent to the distance between Sol and Delta (δ) Eridani (Rana).

This nebula is easy to find, located less than a degree northwest of Gamma (γ) Muscae. The transparency of this region of the Milky Way is evident in the brightness of the globular cluster NGC 4372 positioned a few minutes of arc from the "tail's" terminus. The magnitude 7.2 cluster is located some 19,000 light-years behind the Dark Doodad. This is yet another case of two different deep-sky objects located in the same area of the sky, projected onto one field of view. —A.G.

ALAN DYER

ESO/M. BELLAZZINI ET AL.

SAGDIG

SagDIG (also called Sgr dIG or ESO 594–4) is one of the Milky Way's dwarf irregular galaxy neighbors. In fact, SagDIG stands for Sagittarius Dwarf Irregular Galaxy. Don't confuse it with SagDEG — the Sagittarius Dwarf Elliptical Galaxy, discovered in 1994.

At 3.4 million light-years away, SagDIG lies slightly farther than M33, the Pinwheel Galaxy in Triangulum. Discovered June 13, 1977, using the 1-meter Schmidt telescope at the European Southern Observatory, it rates as nearly impossible to observe. The galaxy's estimated visual magnitude is 15.5; while it's possible to observe 16th-magnitude galaxies with a 20-inch telescope under excellent skies, SagDIG's light is spread over an area of 2.9' by 2.1', making it much more elusive than its magnitude suggests.

Large optics and absolutely transparent skies are a prerequisite to attempt visual observations. (Let's see you prove me wrong!) SagDIG is located about 2° east of Rho (ρ) Sagittarii and 4° above the ecliptic. It lies about 4.5° southwest of Barnard's Galaxy (see #58).

Research on this outermost member of the Local Group indicates that its metal-poor stars are relatively young, ranging from 4 billion to 8 billion years old. It has been through an extended period of star formation, though there is no evidence of remaining star-forming gas clouds today. Its stars appear spread out on the sky, allowing at least a dozen background galaxies to shine through SagDIG. —A.G.

RED SPIDER NEBULA

The Red Spider Nebula (NGC 6537) is a planetary nebula in Sagittarius located 2.5° north of the bright open cluster M21. At 13th magnitude and roughly 1' across, it can easily fall below the radar of observers among the more interesting objects in that area of the sky. However, don't let the name fool you. The red color is photographic in nature, not visual. And the spider shape is beyond all but the largest telescopes. For most, it may look like a disk with irregular edges. NGC 6537 can be seen in modest telescopes under excellent sky conditions, but its small size makes it a challenge. There is a similar object that's much easier to see: the Bug Nebula (NGC 6302) in Scorpius. It has a similar shape, which is visible in modest instruments. Both are classified as bipolar planetary nebulae.

NGC 6537's odd shape is thought to be related in large part to a companion of the hot white dwarf that generated and now energizes this nebula. That white dwarf has a surface temperature as high as 50 times hotter than the Sun's. The density of gas surrounding the center makes the suspected binary impossible to see. Some astronomers think that unusual magnetic fields created the bipolar structure. The pressure from the star's solar wind created waves not unlike those made by wind blowing across a lake — although these waves are a tad larger!

The distance to NGC 6537 is subject to much uncertainty. The current best guess is between 1,900 and 4,000 light-years. —A.G.

ESO

DYLAN O'DONNELL

RHO OPHIUCHI REGION

The Rho Ophiuchi Region is a large, complex region of stars, emission nebulae, and dark nebulae covering an area 4.5° by 6.5°. Its impressive size is due to proximity. The Rho Ophiuchi complex is only 460 light-years away, just slightly farther than the Pleiades Cluster (M45). The object is so large, even most rich-field telescopes will only sweep up a portion at a time. The field contains the dark nebulae Barnard 44 and 45, Lynds 1688 and 1689, the reflection nebula IC 4604, and the emission nebula Sharpless 2–9. The globular cluster M4 and the stars Rho (ρ) Ophiuchi and Sigma (σ) Scorpii further diversify the field, making it a wonder of the summer sky.

The brightest star in Scorpius, Antares, makes this region easy to locate, given its position 3° southeast of the complex. In 3D space, Antares is located some 90 light-years beyond the complex, while Rho is a binary with two blue stars about 65 light-years in front of the clouds. Sigma Scorpii, a quadruple system, is 300 light-years behind the complex, while M4 is some 6,500 light-years beyond it!

Large binoculars under very dark skies may be most revealing. The brightness of Antares interferes with the dim nature of the nebulae, but the V formed by the two Lynds dark nebulae can be seen. The only visually colorful object in the field is the red giant Antares. It almost seems unfair that the human eye is not sensitive to color in objects that are so diffuse. But there are plenty of subtle gray and black features to observe in this region. And while it is subtle visually, for an astrophotographer skilled with color filters and merging images, the region can be made to look like someone dropped cans of blue, yellow, and red paint on a starry canvas. —A.G.

2MASS/UNIVERSITY OF MASSACHUSETTS/IPAC/CALTECH

PG 1634+706

PG 1634+706 is the most distant object in the universe visible in an amateur telescope. This quasar, located in Draco, varies from magnitude 14.2 to 14.7. If you can see Pluto in your scope, you can see this object. Until the advent of space telescopes and large adaptive optics and mirrors, quasars were the most distant objects known. Most were over 2 billion light-years away, which translates to photons emitted when cyanobacteria were Earth's most advanced life. With JWST, however, we can now see young galaxies at even greater distances.

The redshift of this object is 1.337, making it a midrange quasar. (The current record-holder has a redshift of 7.642, about 13 billion light-years away.) PG 1634+706 is "only" about 9 billion light-years away and can be seen in a 10- or 12-inch scope under excellent skies. Think about it: You can see light from an object that is twice as old as our planet and the entire solar system that we call home.

When I saw this quasar through a 25-inch scope, I was humbled by pondering the infinitesimal odds of those particular photons reaching my eyes after traveling across the cosmos for nearly 9 billion years. That is one of the attractions of astronomy as a hobby: There are many opportunities to be awed by our universe. And it doesn't have to be an in-your-face total solar eclipse to bring out the wonder.

The quasar's designation (PG) is for Palomar Green (Bright Quasar Survey); the numbers are its approximate coordinates. If you like stretching your observing to the most ancient photons you can see, there are some one dozen to two dozen quasars brighter than magnitude 14.7 scattered across the sky. —A.G.

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NASA AND THE HUBBLE HERITAGE TEAM (STSCI/AURA); ACKNOWLEDGMENT: A. GOMEZ (CERRO TOLOLO INTER-AMERICAN OBSERVATORY)

GOMEZ'S HAMBURGER

Gomez's Hamburger (IRAS 18059–3211) is another of those deep-sky objects with a strange name. Arturo Gomez, an astronomer at Chile's Cerro Tololo Inter-American Observatory, discovered it in 1985. As celestial burgers go, this one is plain — no cheese or condiments, just a light-colored bun with dark meat in between.

The nature of this magnitude 14.4 object has been the subject of some debate. Astronomers initially thought it was an edge-on planetary nebula. More accurately, it was thought to be the earliest stage in the formation of a planetary nebula, called a protoplanetary nebula (not to be confused with a planet-forming protoplanetary *disk*). Such objects are rare because this stage only lasts about 1,000 years. After that, the white dwarf blazes through the dust cloud. Based on that initial classification, IRAS 18059–3211's distance was placed at 6,500 light-years.

As astronomers found other objects with dark belts bifurcating their glow, more recent investigations have reinterpreted this dusty meal. Current evidence suggests Gomez's Hamburger is indeed a protoplanetary disk surrounding a young star. This also moves the object's distance significantly closer to us: a mere 800 to 900 light-years.

Astronomy is rife with objects that were mysterious to astronomers a generation or two ago but now are well understood. If you have a large telescope and excellent skies, look about ½° southwest of the globular cluster NGC 6558 in the heart of the Milky Way, just west of a line from Gamma (γ) to Epsilon (ε) Sagittarii (which form the spout of the Teapot). I'll take fries with that! —A.G.

SCULPTOR DWARF

The Sculptor Dwarf Galaxy is one of the Milky Way's dozens of known satellite galaxies. At roughly 300,000 light-years away, this dwarf elliptical galaxy (classified as dE3) was the first satellite of the Milky Way discovered telescopically, found by Harlow Shapley in 1937. (The Magellanic Clouds were known prehistorically, since they are easy naked-eye objects in the Southern Hemisphere.)

Like large galaxies, dwarfs may be spiral or barred spiral, elliptical, or irregular. They also vary in size and mass. The Sculptor Dwarf is a lightweight, coming in at only 30 million solar masses. M32, a satellite of the Andromeda Galaxy, is much a heftier dwarf elliptical galaxy with 3 billion solar masses. While that sounds large, consider that a normal-sized elliptical like M49 is 200 billion solar masses!

In 2017, astronomers published high-precision three-dimensional motions of stars in the Sculptor Dwarf — the first time this had been done for a dwarf galaxy. The positions of 100 stars were measured with the Hubble Space Telescope in 2002 and then 12 years later with ESA's Gaia space observatory. The results showed the stars move preferentially in elongated radial orbits, indicating the presence of dark matter that increases toward the center of the galaxy.

Observing the Sculptor Dwarf is challenging but not impossible under dark skies and a good southerly latitude. It can be seen with a 6-inch telescope in southern U.S. skies. Look 4° due south of Alpha (α) Sculptoris. It's nearly 9th magnitude, which sounds bright, but that light is spread over a piece of sky roughly the size of the Full Moon. Photographs show the stars are very slightly more concentrated toward the center, but there is nothing resembling a core. —A.G.

65

DESI LIS, GIUSEPPE DONATIELLO

BURBIDGE'S CHAIN

Burbidge's Chain in Cetus the Whale is one of a few examples of a group of galaxies lying some distance beyond a nearby, brighter foreground galaxy — in this case NGC 247. Stephan's Quintet (see #15) near NGC 7331 and Hickson 56 near NGC 3718 are others.

Although these galaxies are challenging to observe, this chain is easy to locate. Find Diphda (Beta [β] Ceti) and scan about 3° south-southeast. (As a side note, Diphda is brighter than Alpha [α] Ceti, Menkar.) The foreground object, NGC 247, is a whale of a galaxy. It's bright — magnitude 9 — and large, 19' by 5.5' across. Burbidge's Chain is just slightly northeast from the northern tip of this large galaxy. As observing targets go, this is a tough one. The string of four spiral galaxies ranges from about magnitude 14 to 17, meaning a large aperture and excellent skies are essential. At –20° in declination, the farther south you observe from, the greater your chance of success. For astroimagers, a good picture of NGC 247 should reveal Burbidge's Chain, too.

Several chains in Halton Arp's *Atlas of Peculiar Galaxies* resemble this one: Arp 325 in Virgo, near the Boötes border; and Arp 332 in Eridanus, near the Fornax border. Both are faint and require large telescopes to observe.

NGC 247 itself is worthy of scrutiny even if the background group isn't visible. It's quite large because it lies only 11 million light-years away. (Burbidge's Chain is about 300 million light-years distant.) NGC 247 is part of the Sculptor Galaxy Group. This near-edge-on SAB(s)d spiral is small, only 70,000 light-years across, and has a low surface brightness. There is a pronounced gap on one side of the spiral, so some call it the Needle's Eye Galaxy. –A.G.

TERRY ROBISON

SPIROGRAPH NEBULA

IC 418, the Spirograph Nebula, is a planetary nebula in the constellation Lepus the Hare. This type of nebula is a preview of what will happen to the Sun in roughly 5 billion years, as all solar-type stars are destined to become red giants and then white dwarfs. This process of "downsizing" creates a planetary nebula. (Less massive stars slowly cool down after exceptionally long lives and more massive stars become supernovae.)

While many planetaries look similar in a telescope, especially among the rings and disks, their subtle variations become obvious when imaged with large telescopes. No two planetary nebulae are identical, particularly because there are many variables at play when shaping such nebulae. Also important is the perspective of the observer. Most aging stars eject matter from their poles. If we see a polar view, the disk shape is obvious. But if we have an equatorial perspective, it may take on a boxy appearance. As the nebula expands, the presence and density of interstellar material will deform the shape by slowing down the momentum of dispersing nebular gas. Companion stars certainly play a role in the final appearance, and astronomers even speculate the presence of planets, especially gas giants, could affect the shape as well.

The Spirograph Nebula gets its name from the microstructure inside the spherical nebula. Anyone who played with that toy will remember the fascinating designs it made using ellipses. IC 418's double shells of gas similarly host irregular clumps distributed along various ellipses. This nebula lies roughly 2,500 light-years away and spans nearly a third of a light-year. Planetary nebulae are short-lived objects that persist for up to 10,000 years before dispersing to invisibility, enriching the galaxy with matter than can be recycled to create future stars and planets. –A.G.

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

NGC 300

NGC 300 is a neighbor of the Sculptor Dwarf (see #65), located about 4° to its south-southwest. Its distance is just over 6 million light-years, putting it just outside our Local Group. Some astronomers consider it a member of the Sculptor Group, the closest galaxy group beyond the Local Group. Others put it somewhere between these groups. It is thought to be gravitationally bound to NGC 55, a bright, large SB-type edge-on galaxy 8° west.

The galaxy is a spiral with a less distinct central hub than Edwin Hubble's Sc class. It is an Sd — usually designated SAd. (The A indicates it's a normal spiral rather than barred, or SB.) Its diameter is 94,000 light-years, a bit smaller than the Milky Way. It has tightly wound spiral arms with an overall blue color typical of this type of galaxy. Most of its HII regions are located in the inner half of the galaxy's diameter, but the most massive lies at the terminus of one arm.

NGC 300 is magnitude 8.3 and 20' by 13' in size. If you have a good view of objects at a declination of –37°, it's a nice binocular object. For many observers, it is either very low or never rises above the horizon. This galaxy is reminiscent of M33 in Triangulum, a class SAcd with a slightly more distinct core. Observers at latitudes between the Tropic of Cancer and the Tropic of Capricorn may be able to make comparisons the same night, since the two galaxies have similar right ascensions.

NGC 300 has produced bright events that didn't fit the profiles of either supernovae or regular novae. This galaxy is one worth monitoring for other stellar outbursts. —A.G.

ALAN DYER

ALAN DYER

SNAKE NEBULA

B72, also called the Snake Nebula, in Ophiuchus is another of Barnard's discoveries. When observing dark nebulae such as this, you're looking for dark places in the heavens. Such a search requires good skies where the richness of the Milky Way makes it obvious when something is obscuring it. (Earthly clouds don't count!)

Considered relatively nearby at 650 light-years distant, B72 is compact, running 6' in a northwest–southeast direction. It is narrow, ranging from 2' to 3' thick. The densest part of the dust cloud forms an S; it was called the S Nebula before the moniker Snake Nebula became popular. Its 5-light-year-long sinuous nature appears in small telescopes under skies where the Milky Way glows bright. Look about a degree and a half north-northeast of Theta (θ) Ophiuchi, a magnitude 3.25 multiple star. The area is rich in dark clouds. Look for a set of nearby "holes" ("plugs" might be more apropos) in the background glow: B68, B69, B70, and B74. (Barnard 68 is the densest and darkest of the four.)

The whole region is a wonder to scan with a wide-field telescope or large binoculars. The Snake is at the top of the Pipe Nebula, a large cloud spanning 5° in length and more than 3° in width. That's large enough to be visible to the naked eye from latitudes with good views of the southern sky. And if the Snake and Pipe aren't enough, they're also part of a large nebular complex called the Dark Horse Nebula, which covers a generous 10° by 10°. —A.G.

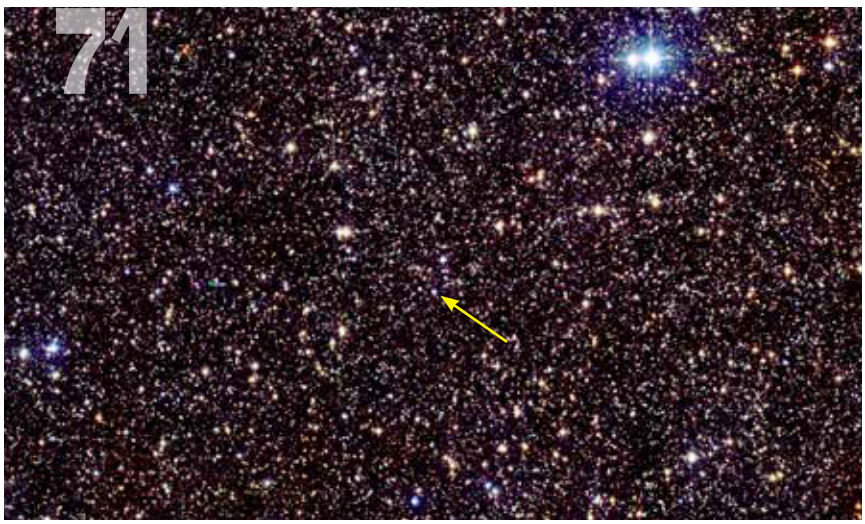
SS 433

Aquila's SS 433 is one of the weirdest stellar objects in the sky. Its designation is from C.B. Stephenson and N. Sanduleak's catalog of stars with hydrogen emission lines, which typically have extended envelopes surrounding them. This object's peculiar nature sparked intense research on it around 1980. Astronomers now describe it as the first known microquasar.

Quasars are supermassive black holes billions of times the mass of the Sun. Now, think of such behemoths shrunk down to the scale of a single star. SS 433 consists of an A-type star orbiting a stellar-mass black hole surrounded by an accretion disk. Powerful X-rays radiate energy away from the disk as opposing jets of superheated gas shoot along the axis of rotation. The pair lies in the heart of the supernova remnant W50, also called the Manatee Nebula. Recent investigations have discovered the region also emits gamma rays.

You can find SS 433 just over 1° southeast of 19 Aquilae, in a rich star field near two open clusters (NGC 6755 and 6756). Visually, SS 433 appears as one faint star among many — and at 15,000 light-years distant, that isn't surprising. Its light varies irregularly, but the times I observed it, it was about 14th magnitude. It lies just offset from a small group of stars consisting of an 11th-magnitude sun with a close pair of mid-12th-magnitude stars to its south, and a 13th-magnitude star just south of these.

As soon as I read of its existence, I sought out a telescope large enough to see it. I'm sucker for observing usual objects, even if they look like ordinary faint stars. But we know that looks are deceiving. If only we had X-ray vision! —A.G.



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THOR'S HELMET

Thor's Helmet (NGC 2359) is an emission nebula in Canis Major that has been relegated to obscurity by the brighter Orion Nebula (M42) in the same part of the sky. Like many HII regions, though, NGC 2359 is a fascinating object and worthy of attention from all deep-sky observers.

Between 12,000 and 15,000 light-years away, Thor's Helmet is roughly 10 times more distant than M42. This cloud is about 30 light-years across and surrounds Wolf-Rayet star WR7 (HD 56925). Compared to our Sun, this star is 280,000 times brighter, 16 times more massive, and 1.3 times larger. It's emitting copious radiation, typical of short-lived massive stars that end in a blazing supernova explosion. This might be one of those rare stars that has already exploded but the light of its supernova hasn't reached us yet.

Cassiopeia's Bubble Nebula (NGC 7635) is a similar object, though less pronounced. Thor's Helmet has bright "wings" and a more complex shape due to interactions with adjacent molecular clouds. Thousands of solar masses of gas lie within this nebula complex. Images show six projections of ionized gas, of which I've visually seen three using a 20-inch telescope from the Florida Keys.

To locate NGC 2359, scan about 9° northeast of Sirius. This object is smack on the galactic plane. The nebula is easy to find with an 8-inch telescope. The wings require a slightly larger aperture but aren't too difficult. NGC 2361 is a bright feature on the round top of the helmet. Other neighbors in the same part of the sky include the open clusters NGC 2374 about 1.5° east, Haffner 6 about 0.5° east, and Basel 11A about 1° southwest.

The winter Milky Way is often missed due to frigid observing conditions, but this weird object is worth a look. —A.G.

ESO/INSERRA ET AL.

CARTWHEEL GALAXY

When astronomer Fritz Zwicky discovered ESO 350–40 (now called the Cartwheel Galaxy) in 1941, he considered it one of the most complicated known galaxy structures, based on its stellar dynamics. Little did he know how abundant peculiar galaxies were in the universe. Boris Vorontsov-Velyaminov in the late 1950s and Halton Arp in the early 1960s systematically scanned the Palomar Observatory Sky Survey to get a better handle on the number of galactic oddities throughout the cosmos. Unfortunately, the Cartwheel Galaxy's –33° declination in Sculptor put it too low for their search.

Today, astronomers know significantly more about galactic collisions and how they affect structure and star formation. The symmetry of this system indicates a smaller companion passed through the center of a larger spiral galaxy. The gravitational effect is similar to a shock wave shaped like a ring. As the shock moved out through the spiral arms, it swept up and compressed dust and gas, disrupting the original spiral structure and creating many new stars. (Hence, the Cartwheel is considered a starburst galaxy.) The angular momentum of the larger galaxy's disk was not eliminated, so a new spiral form is returning. In addition to the outer ring, the nuclear region also has a torus of young stars and a dust cloud, giving this object a double ring.

There are three companion spiral galaxies, two close by and a third that is more distant. The distant companion has a trail of neutral hydrogen connecting it to the Cartwheel, and is thought to be the hit-and-run instigator.

This system lies a half-billion light-years away. It has a low surface brightness, making it a difficult magnitude 15.2 object. It lies roughly 5° degrees east of the Sculptor Dwarf, a member of the Local Group. —A.G.

P. HORÁLEK/ESO, CROPPED BY SZCZUREQ/WIKIMEDIA COMMONS

73 GUM NEBULA

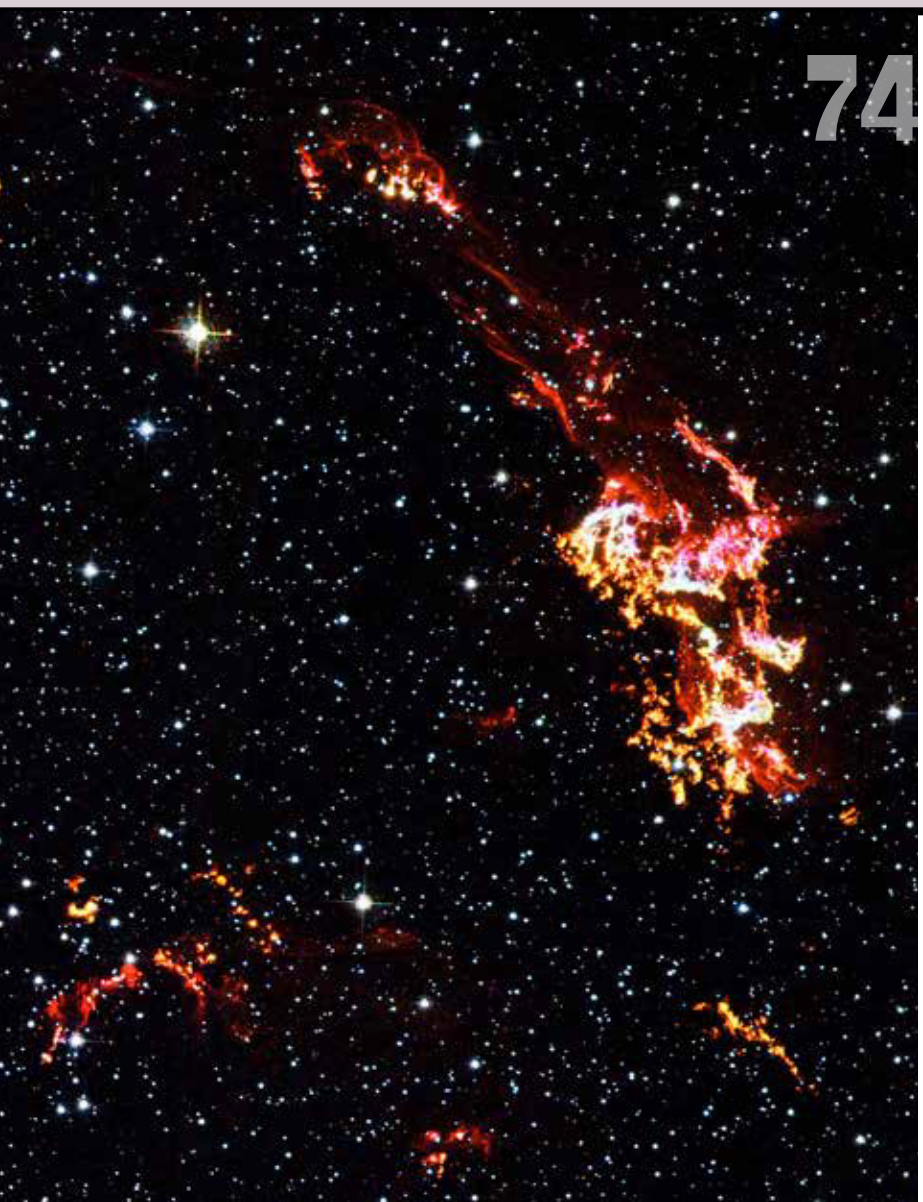
The Gum Nebula does not carry this name because it looks like celestial bubble gum. Instead, it was named after its discoverer, Colin S. Gum, an Australian astronomer who published a list of hydrogen clouds (called HII regions) in 1955. The Gum Nebula (12 in his catalog) is the largest emission nebula in the sky, spanning about 36° in the constellations Vela and Puppis. That's the width of 72 Full Moons!

How could such a large object remain unknown until 1955? Its surface brightness is too faint for visual observation. Perhaps it was photographed by others, but Gum found it while creating a systematic catalog of southern HII regions, so his name stuck (if you will pardon the pun).

The Gum Nebula is estimated to be 1,000 light-years across, putting the nearest edge only 450 light-years from us and the farther edge some 1,500 light-years away. For comparison, the more familiar Orion Nebula (M42) is about 1,350 light-years distant and 24 light-years wide. In the sky, M42 appears roughly 1° across (the width of two Full Moons). Its greater density and surface brightness make it easy to see with the naked eye.

Gum 12 is a bit of an oddity. Astronomers speculate it is a million-year-old supernova remnant rather than an HII region. Yet it contains cometary globules — star-forming regions with tail-like features — found in many emission nebulae. It also contains the remnants of the Vela supernova, estimated to be just 11,000 years old.

One other curious piece of trivia about the Gum Nebula: It was photographed by the Apollo 16 astronauts using high-speed film, through the window of their capsule during the darkest part of their flight, while the Sun and Earth were both behind the Moon from their point of view. —A.G.



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

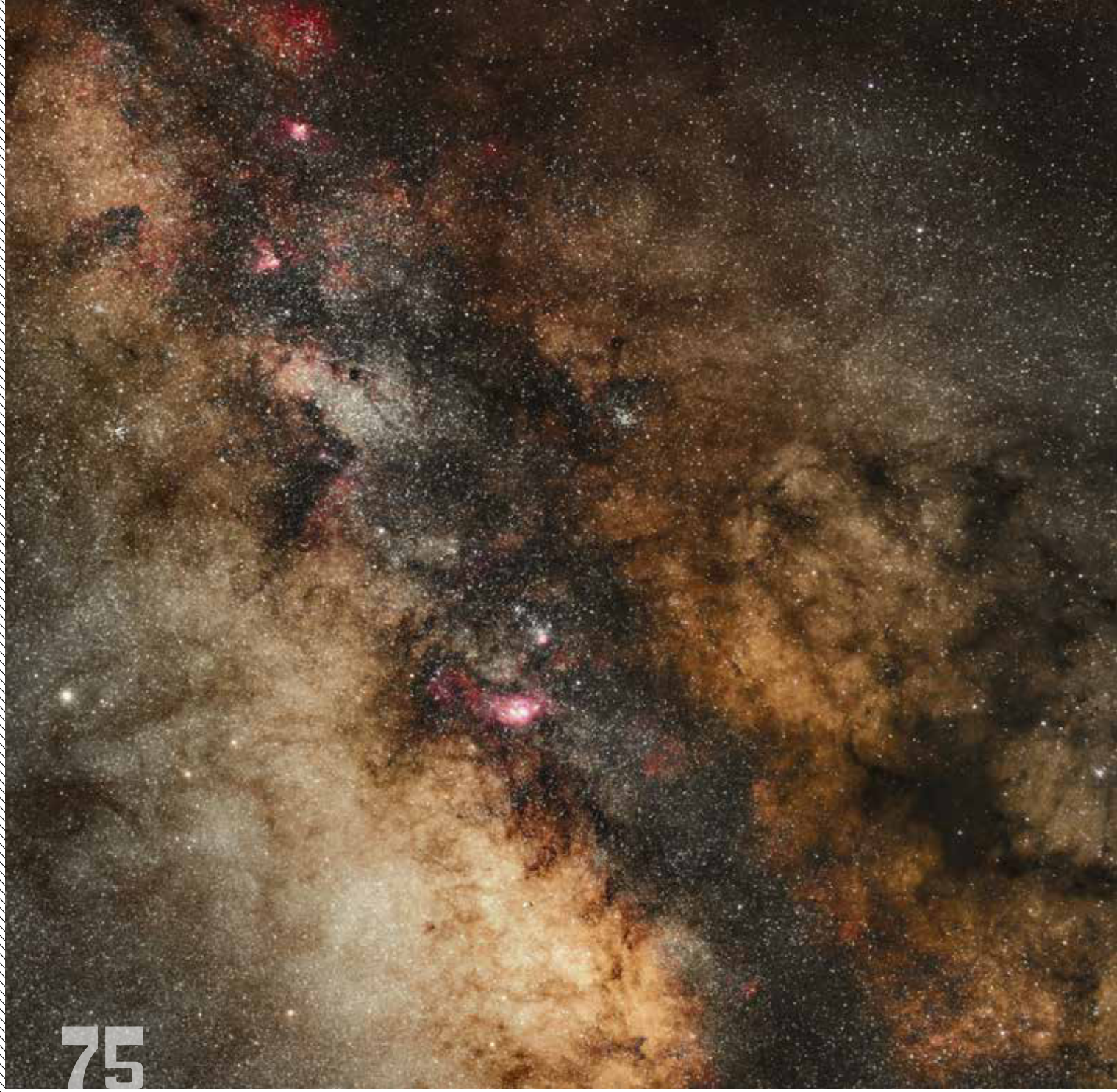
74 KEPLER'S SUPERNOVA

The time for visually observing Kepler's Supernova (CTB 41) passed nearly 420 years ago. In 1604, Kepler's Star was the last supernova in our galaxy visible to the naked eye. Tycho's Star, another Milky Way supernova, was in 1572, only 32 years earlier.

Despite its name, Johannes Kepler didn't discover it. The observer Lodovico delle Colombe noted it on Oct. 9, 1604. Kepler didn't see *De Stella Nova*, as he called it, until the 17th, when it blazed to magnitude –2.5 in Ophiuchus and was visible in the daytime for several weeks. He made meticulous observations over the course of a year until it faded from naked-eye visibility. His observations were published in 1606 in *De stella nova in pede serpentarii* (*On the new star in Ophiuchus' foot*).

The progenitor star in this type Ia supernova is thought to have been closer than 20,000 light-years, located near the edge of the nearby dark nebula complex Barnard 268–270 (which somewhat resembles Snoopy from *Peanuts*). If this supernova had been a half-degree east, it might have remained invisible, all light blocked by these dust clouds.

Today, the supernova remnant is very bright at radio and X-ray wavelengths. But it's not a younger version of the famous Crab Nebula (M1) in Taurus. The Crab was created by the type II supernova blast resulting from the death of a single massive star, and observationally doesn't look the same. By contrast, type Ia supernovae like Kepler's occur when a white dwarf in a binary system siphons material from its companion until a runaway thermonuclear reaction causes the white dwarf to explode. Some filaments were noted in 1941, when astronomers discovered the remnant associated with the blast, now glowing at 19th magnitude. —A.G.



GIUSEPPE DONATIELLO

75 GALACTIC CENTER

At –29° in declination, our Milky Way's galactic center — located in Sagittarius — is low for most Northern Hemisphere observers. It passes straight overhead in winter for those in southern Australia; South Africa; and parts of Argentina, Brazil, and Chile.

Astronomers know a lot about barred spiral galaxies like the Milky Way from observing many examples (such as M83). A nucleus forms the core, surrounded by a central hub and flat disk. Astronomers have used many tools to map the Milky Way in three dimensions. Harlow Shapley used globular clusters to determine the Sun was about 30,000 light-years from the center. (Modern measurements give 26,000 light-years.) Others mapped superluminous giant stars. Radio astronomers had the most success since radio waves are transparent to stars and nebulae. They also determined where our galaxy's nucleus is located and that it has a massive black hole in the center.

You can point a telescope in the direction of the Milky Way's nucleus, but you can't see it. Why? Try looking at your neighbor's back porch light from the front yard of their house with all the doors and windows closed. You might be able to tell if it's on by the light shining on the trees in the backyard, but the light fixture itself is obscured.

That doesn't mean you shouldn't look in this direction; knowing what's hidden behind the rich star field makes it worth the effort. Within 2° of the galactic center are at least three open clusters, an emission nebula, and a planetary nebula. These include Collinder 347, a magnitude 8.8 cluster involved with the emission nebula Sharpless 2–16. A degree northeast is Collinder 351. A small dark nebula lies to its west. Scan the region and see what else you can find. —A.G.

THE VELA SUPERNOVA REMNANT

This vast wreath of glowing gas was ejected after a massive star went supernova around 11,000 years ago in the constellation Vela the Sails. Lying over 800 light-years away, the supernova's filamentary remains are scattered across the sky. One of the closest cosmic cataclysms to our Sun, it is also among the most historic.

In the mid-1950s, astronomers found in Vela one of the largest radio sources in the heavens. Not until 1960 did they link the radio source to a filamentary nebula visible in optical wavelengths — what we now call the Vela supernova remnant (SNR). Eight years later, Australian astronomers raised the possibility that the Vela Pulsar, a 23rd-magnitude neutron star, was the source of the remnant. This was one of the first proposals indicating that neutron stars are forged in the aftermath of certain types of supernova explosions.

Without question, much of the Vela SNR is a target for wide-field astroimagers, as this spread of wispy threads spans 4.5° of sky. The Pencil Nebula (see #52) is its brightest segment. Two other sections are worth targeting under very dark skies with larger apertures. The first is a narrow 1'-long streak of light, oriented northwest-southeast, around R.A. 8h32m, Dec. −45°30'; this feature will extend into a 4'-long crescent with greater apertures. The other is a pale phantom filament (oriented east-west) a few arcminutes northwest of 4th-magnitude e Velorum (HD 73634).

To explain the object's haphazard structure, European Southern Observatory astronomers have proposed a scenario in which multiple objects have interacted with the Vela SNR, including the binary system Gamma2 (γ^2) Velorum, the IRAS Vela Shell, the Vela OB2 association, and the Gum Nebula (see #73). —S.J.O.

KAPTEYN'S STAR

DIGITAL SKY SURVEY/CENTRE DE DONNÉES ASTRONOMIQUES DE STRASBOURG

Kapteyn's Star, a 9th-magnitude red subdwarf, speeds through space with a proper motion second only to Barnard's Star (see #46). This nomadic wonder is visible in the northern reaches of the constellation Pictor the Painter. The star moves to the southeast at 8.7" per year, or the apparent diameter of the Moon every two centuries. The star's rapid apparent motion is due to its proximity (12.8 light-years away) and its high velocity (150 miles per second [245 km/s]) toward our Sun.

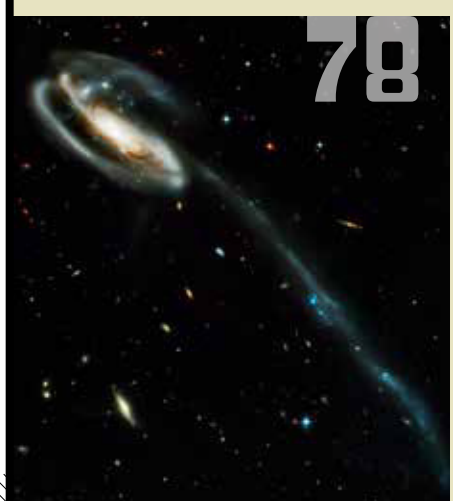
Kapteyn's Star is also the nearest star to our Sun that does not belong to the Milky Way's disk but to its halo, the spherical component of the galaxy made of older stars with fewer heavy elements. Peculiarly, Kapteyn's Star orbits our galaxy backwards. Astronomers now believe the star may have once belonged to a dwarf galaxy consumed by the Milky Way early on in its history — the same dwarf galaxy that is now the great globular star cluster Omega Centuri. In 2014, it was announced that Kapteyn's Star had two possible planets, one of which, Kapteyn c, is a Neptune-like exoplanet.

The star owes its discovery to the efforts of two individuals. In 1897, Dutch astronomer Jacobus Kapteyn noticed that a star was missing on a photographic plate taken at Cape Observatory in South Africa. The Scottish astronomer Robert Innes solved the mystery when he found the missing star east of its original position while surveying the southern stars from the Cape with a 7-inch refractor. —S.J.O.

TADPOLE GALAXY

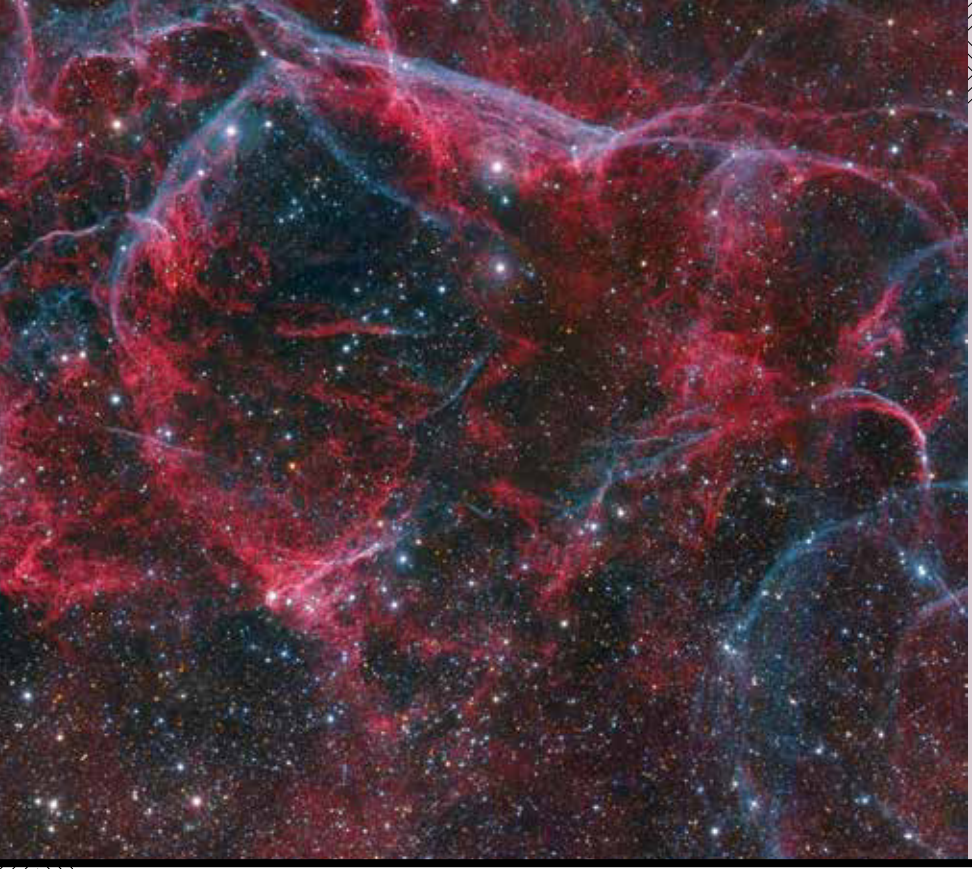
Dim, distant, and distorted, the Tadpole Galaxy (UGC 10214) in the constellation Draco the Dragon is a nearly edge-on barred spiral galaxy sporting a massive tail of stars that stretches across 280,000 light-years of space. Apparently, 100 million years ago a small compact spiral galaxy crossed in front of UGC 10214 (as seen from our perspective on Earth some 420 million light-years distant), and their mutual gravitational pulls resulted in an extragalactic collision.

When a large galaxy smashes into a smaller one, the smaller galaxy's stars are either incorporated into the larger galaxy or ejected into intergalactic space. When UGC 10214 took hold of the mini-spiral, it swung the smaller galaxy some 300,000 light-years behind its "back." In the process, tidal forces ripped away the smaller galaxy's stars, gas, and dust, stringing them out in a long tadpolelike tail — instigating prodigious star formation along the tidal tail and in UGC 10214's arms. As it ages, the Tadpole Galaxy will likely lose its tail. Meanwhile, some of the clusters within the tail will become orbiting satellites of UGC 10214, while others will perhaps be consumed by the barred spiral.



NASA, H. FORD (JHU), G. ILLINGWORTH (USCS/LO), M. CLAMPIN (STSCI), G. HARTIG (STSCI), THE ACS SCIENCE TEAM, AND ESA

You'll find UGC 10214 about 3° south of Theta (θ) Draconis. It shines dimly at magnitude 14.6, so 12-inch or larger telescopes and powers between 150x and 200x will serve observers best, as will extremely dark skies and excellent transparency. —S.J.O.



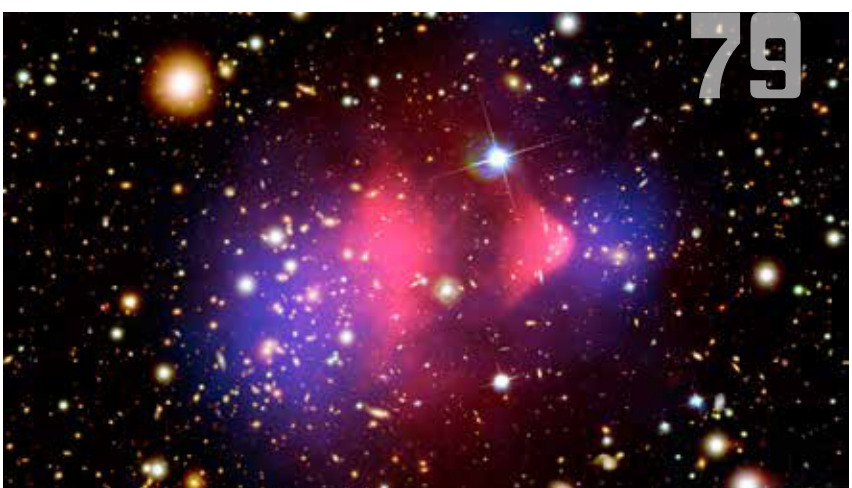
HAREL BOREN/WIKIMEDIA COMMONS

THE BULLET CLUSTER

The Bullet Cluster is a massive collection of two large groups of galaxies some 3.8 billion light-years distant. The two groups appear to have collided in one of the most energetic events known in the universe since the Big Bang.

The aftermath has provided dramatic evidence for the existence of dark matter. In 2006, astronomers published data from NASA's Chandra X-ray Observatory that show how the collision heated the existing gas to millions of degrees. They also obtained optical images with the Hubble Space Telescope as well as the Very Large Telescope and Magellan Telescope in Chile. By studying the combined cluster's gravitational lensing effects — the bending and magnifying of light from objects behind it — astronomers were able to map out the Bullet Cluster's mass. An overlay of this map onto the combined X-ray and optical images revealed that its mass does not line up with the observed matter, implying that the observed gravitational lensing must be created by invisible, or dark, matter, which is not subject to the same drag forces as the gas.

Why are these groups called the Bullet Custer? Because a sub-cluster, the "bullet," has collided with the main cluster, approximately in the plane of the sky, producing a strong bow shock in the intracluster gas during the collision. In images, it appears like a snapshot of a bullet piercing an apple. You'll find the cluster (or not, because it is extremely dim) in Carina the Keel, about 6° east-southeast of the brilliant star Canopus. Like dark matter, the cluster's brightest members are likely to be virtually invisible to most visual observers, as they shine around magnitude 20 and fainter. –S.J.O.



NASA/CXC/CFA/M. MARKEVITCH; OPTICAL AND LENSING MAP: NASA/STSCI, MAGELLAN/U. OF ARIZONA/D. CLOWE; LENSING MAP: ESO WFI

SKYVIEW AND CALTECH/STSCI; COLOR IMAGE PROCESSING BY W. RENZ

P CYGNI

P Cygni is a remarkable novalike luminous blue variable — a blue supergiant or even a hypergiant so massive it's barely holding itself together. With a mass up to 60 times that of the Sun, this behemoth is a beacon of luminosity about a half-million to a million times brighter than our star; P Cygni is, in fact, one of the most luminous stars known in our galaxy. Lying some 6,500 light-years distant, 5th-magnitude P Cygni is also one of the most distant stars one can see with the unaided eyes under a dark sky — as long as it doesn't decide to fade, which it has in the past.

The star first appeared on the celestial scene Aug. 18, 1600, when Dutch astronomer Willem Janszoon Blaeu saw it shining forth as a "new" 3rd-magnitude star near Sadr (Gamma [γ] Cygni). It remained bright for several years before episodically fading in and out of naked-eye view — until around 1715, when its light settled on the edge of naked-eye visibility, where it remains today.

Seen through binoculars and backyard telescopes, P Cygni is an unassuming sight, a speck of sapphire starlight. What's invisible to our eyes are the shells of dust and gas that P Cygni has been erratically ejecting from its surface for some 20,000 years. Today the star continues to lose mass steadily at some 300 million times the rate of our Sun via the solar wind. P Cygni's strong winds, however, form expanding shells that show up like fingerprints in the star's spectrum as an odd pairing of adjacent emission and absorption features, now known as the P Cygni profile. One day, P Cygni will erupt as a supernova and likely subsequently collapse into a black hole. –S.J.O.

ABELL 194

Abell 194 is a tight cluster of 100 or more galaxies about 250 million light-years distant in Cetus the Whale, and about 1° southeast of 7th-magnitude 43 Ceti. The cluster's heart harbors 10 objects from the *New General Catalogue* shining roughly between magnitudes 12 and 13.5. Seven of these are arranged in a line along with several fainter objects, oriented northeast-southwest. They stretch across 30' of sky like a piece of extragalactic thread.

The cluster's brightest member is also the most peculiar. Shining at 12th-magnitude, NGC 541 has a long radio jet that appears to be interacting with a blue dwarf galaxy (Minkowski's Object) just 1' to the east-northeast. Recent studies have shown that the dwarf's young stellar population (roughly 7.5 million years old) suggests that NGC 541's jet either induced hot, young blue stars to form in clumps of gas in a stellar bridge that connects with Minkowski's Object, or it heightened the dwarf galaxy's star formation rate by directly interacting with it.

Many fainter galaxies make up the rest of Abell 194. Observers using moderate to large telescopes have plumbed the depths of this cluster, which offers a bright congregation of galaxies to amateur astronomers. I'm not aware of any visual observations of Minkowski's Object, however. Sighting it would be a great challenge for monster-scope users, especially at star parties. –S.J.O.

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ESO/Y. BELETSKY

JEWEL BOX CLUSTER

One of the gems of the night, the Jewel Box Cluster (NGC 4755) appears to dangle from the eastern arm of the Southern Cross like a pearl earring. Early explorers first saw it as a 4th-magnitude star, leading Johann Bayer to label it in his 1603 *Uranometria* catalog as Kappa (κ) Crucis. Its identity remained singular until Abbé Nicolas Louis de Lacaille used a ½-inch telescope to resolve it into half a dozen stars during his 1751–1753 exploration of the southern skies from the Cape of Good Hope. Its "Jewel Box" moniker derives from a description by John Herschel who called it a "casket of variously coloured precious stones."

Today all one needs is a binoculars or a small telescope to see the cluster's sapphire and ruby gems set against the black marble of dust in the Coalsack Nebula (see #89). This intervening dust makes the cluster's distance difficult to determine, while a mysterious mix of youthful blue stars and aged red supergiants makes its evolutionary age uncertain. Conservative estimates, however, place the cluster some 6,400 light-years distant, with an age somewhere between 7 million and 16 million years.

Most backyard telescopes will reveal only a fraction of its 100-plus brightest members, which are crammed into an area only 10' across. Through a telescope, the cluster appears to have two groups: one bright, one faint. Is the Jewel Box a melding of two star clusters or a visual line-of-sight oddity? –S.J.O.

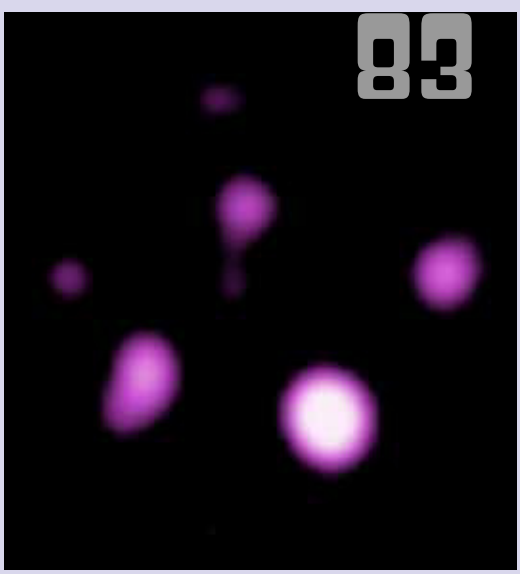
THE CLOVERLEAF

The Cloverleaf is a 17th-magnitude quasar whose image has been reproduced four times through gravitational lensing — an occurrence caused by the powerful gravitational field of a massive, intervening galaxy, which has bent and magnified the light from this distant quasar to produce the multiple images we see.

Equally fascinating is that in X-ray imaging by NASA's Chandra orbiting telescope, one of the four quasar images appears brighter than the others — an effect likely caused by microlensing, where a single or binary star in the intervening galaxy has passed directly in front of the supermassive black hole at the quasar's heart.

What's more, at 11 billion light-years away, the Cloverleaf quasar is one of the most distant objects known to possess a large amount of cold molecular gas (notably carbon monoxide), which appears to be surrounding the quasar in a rotating disk. This molecular gas complex has an infrared mass of some 10 billion Suns, which, when combined with the object's active galactic nucleus, provides evidence there was abundant material and ample conditions for large-scale star formation in the early universe.

The Cloverleaf quasar lies about 8° south of brilliant Arcturus in Boötes, and roughly 1° north of the 12th-magnitude galaxy NGC 5532. Large amateur telescopes should be able to detect the optical quasar but resolving it is another matter, requiring crisp sub-arcsecond resolution. –S.J.O.



NASA/CXC/PENN STATE/G. CHARTAS ET AL.

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NOIRLAB/NSF/AURA

ETA CARINAE

Eta Carinae, the fire opal wonder of the southern skies, currently shines as a 4th-magnitude star system nested in the vast Carina Nebula. It is one of the seven wonders of the deep southern skies. The system is dynamic: The primary star is a hypergiant, roughly 100 times the Sun's mass and 4 million times its luminosity. Through binoculars and telescopes, Eta has a rich orange hue, which, unlike other stars of its magnitude, seems to burn with a mysterious steady light, like a distant Mars. When we look at this star, we are, in fact, not seeing a star at all, but the gaseous remains of the biggest explosion that any star is known to have survived in our galaxy.

Historical records show that Eta Carinae varied between magnitude 1 and 3 in the late 1820s and early 1830s. Then, in 1843, it erupted to magnitude –0.7 (outshining nearly all the night sky's stars) before hitting rock bottom in 1968 at magnitude 7.6. Today it hovers around magnitude 4. The 1843 event sent out two opposing expanding lobes, which squeezed out of a dense torus of cold dust and gas before expanding like a balloon inflating in a napkin ring. This weird figure-8 pattern is known as the Homunculus Nebula. Through a 4-inch telescope at high power, the southern observer Ernst Hartung saw the Homunculus as an "orange-red nebula about 3" wide." When I saw it in 1982 through the 9-inch refractor at Carter Observatory, it looked like two puffs 1' on either side of an intense core of light. –S.J.O.

EINSTEIN CROSS

85

ESA/HUBBLE & NASA

The Einstein Cross (Huchra's Lens) is one of the most profound examples of gravitational lensing, a phenomenon first deduced by Albert Einstein. Images of the Einstein Cross appear to be a galaxy with four nuclei; this is what Harvard University astronomer John Huchra saw when he discovered this bizarre object.

But these "nuclei" do not belong to the galaxy. Instead, we are seeing the way the gravitational field of the galaxy PGC 69457 (some 400 million light-years distant) is lensing and magnifying the light of the quasar Q2237+0305 (some 8 billion light-years distant), which happens to lie directly behind the galaxy along our line of sight. The gravitational lens (the galaxy) is breaking the quasar's light into four distinct images of the same object in a crosslike arrangement.

Equally bizarre is that occasionally, the lensed components vary in relative brightness. This microlensing effect occurs whenever a star in the foreground galaxy passes in front of one of the quasar images, causing the image to temporarily intensify.

You'll find Huchra's Lens in Pegasus about 2.5° southeast of 37 Pegasi. While the brightness of the components can range anywhere from magnitude 15.5 to 18.5 depending on microlensing effects, some observers have estimated the combined lens shines as brightly as magnitude 14 — or about the average brightness of Pluto. Then again, that light is spread across 1.6'. The intervening galaxy shines around magnitude 15. High powers (400x to 600x) may show it best.

Several amateur astronomers have succeeded in separating two components with telescopes as small as 18 inches. The fainter components likely require 24-inch and larger telescopes. –S.J.O.

ALAN DYER

THE COMA GALAXY CLUSTER

The Coma Cluster of galaxies is among the densest known. This turbulent array of more than 3,000 galaxies (mostly ellipticals and lenticulars) forms a dim backdrop to the brighter Coma Berenices star cluster. Lying 330 million light-years distant, it is the nearest massive cluster of galaxies, parading across more than 20 million light-years of space. While the galaxies house billions of stars, a weird collection of nearly 50 cluster members appears to be almost invisible. These ghostlike objects appear to be rich in invisible dark matter — matter that cannot be seen but whose presence is inferred from gravitational effects.

While no one knows how these oddities originated, recent studies suggest they may be "failed" infant galaxies comprising 98 percent dark matter and just 2 percent observable matter. Astronomers posit that when the great gravitational pull of the Coma Cluster dragged these infants into its fold 7 billion years ago, it stripped them of their gas and dust — the ingredients needed to form new stars. The fact that these galaxies held together for so long suggests they must harbor lots of dark matter; otherwise the gravitational pull of other galaxies in the cluster would have torn them apart. Exactly how much dark matter they possess remains disputed as it is not an easy feat to measure their mass.

Reasonably bright objects in the Coma Cluster of galaxies are within reach of a 12-inch telescope under a dark sky: NGC 4889, 4793, and 4874. Larger apertures will reveal untold numbers of additional wonders. –S.J.O.

THE BOOMERANG NEBULA

The Boomerang Nebula is one of the most puzzling bipolar reflection nebulae known. It lies 5,000 light-years distant in Centaurus, just 3⅓° north-northeast of Gacrux (Gamma [γ] Crucis) in the Southern Cross.

The Boomerang looks similar to other objects of its kind, displaying two nearly symmetrical wings of dust and gas that span only 1′ of sky (or about 1.5 light-years at its distance of 5,000 light-years). But unlike others of its kind, the Boomerang's central star is ejecting jets of matter from its poles at a rate that's up to 100 times greater than normal (or 10 billion times faster than our Sun at present). What's more, the nebula's deep interior has a temperature of only 1 degree Celsius above absolute zero (nearly minus 460 degrees Fahrenheit), making it one of the coldest known natural environments in the universe.

We are likely seeing a rapidly dying red giant star transitioning into a planetary nebula. The star has swelled to consume a smaller companion star that eventually merged with its core, causing a violent and rapid ejection of material that is expanding so fast it has rapidly cooled, becoming a cosmic freezer.

Despite the seemingly dire description, the nebula is surprisingly bright. It was so apparent in my 8-inch telescope that I immediately set up my 3-inch Tele Vue refractor and was able to see it, especially at moderate to high magnifications. The nebula appears similar to the Double Bubble Nebula (NGC 2371/2) in Gemini. –S.J.O.

BILL SAXTON (NRAO/AUI/NSF); NASA/HUBBLE; RAGHVENDRA SAHAI

WOLF 359

Lying at a distance of only 7.9 light-years, Wolf 359 is the fifth closest star to our Sun, moving 4.7" per year against the background stars of Leo. Shining at magnitude 13.5, this red dwarf has a mass of 0.09 solar mass, making it one of the lowest-mass stars known.

Like many red dwarfs, Wolf 359 can undergo sudden increases in brightness before returning to normal within a few minutes. In 1950, German astronomer Hans-Ullrich Sandig became the first person to detect one such flare, noting "the star always 13.5 ... was about 1 magnitude brighter than usual." As this was the first evening he observed the star, he could not "say anything about the duration of the brightening."

Since that initial event, astronomers have studied flare-rate activity across the star's spectrum, finding that eruptions occur about once every two hours on average. While most of these are micro-events, only increasing by fractions of a magnitude, about 10 times a year Wolf 359 undergoes a superflare. This is when the star's brightness soars one magnitude or more, as Sandig observed. More recently, on March 20, 2022, the star achieved visual magnitude 11.6.

ROBERT J. VANDERBEI

While the cause of Wolf 359's rapid flare production remains uncertain, astronomers think it could be enhanced magnetic activity linked to either the star's rapid spin (once every 2.7 days) or interaction with possible exoplanets. However, no exoplanets have been confirmed around Wolf 359 as of yet; two candidates were reported in 2019, but one was found to be a false positive in 2021. –S.J.O.

COALSACK NEBULA

ESO/S. BRUNIER

The naked-eye wonder of the Southern Cross is only overshadowed by its ink-black neighbor, the Coalsack Nebula. One of the most popular dark nebulae in the heavens, the Coalsack is roughly the same size and shape as Crux (about 5° by 7°), darkening the surrounding Milky Way like a black fog at the foot of the Cross. Probably known since humans first pondered the stars, this void appears in many legends, including those of Botswana's Basarwa people, who envisioned it as the head of the dark Giraffe.

Sometimes referred to as the Black Magellanic Cloud, this nebula can seem like a vacancy left behind after its matter was used to form a nearby star cluster (in this case the Jewel Box [see #82]). However, we now know that these dark areas are cold dusty clouds of molecular hydrogen gas that dim the light of whatever lurks behind them.

When we look upon the Coalsack, we are likely not seeing a single sheet of dust, but a conglomerate of two overlapping dark clouds at distances of 610 and 790 light-years. Stare steadily at it under a dark sky (especially through binoculars or a wide-field telescope) and you will see it consists of several charred ribs — parallel trails of darkness like celestial shadow bands. Use binoculars or a telescope to spy the 7th-magnitude open cluster NGC 4609 near 5th-magnitude BZ Crucis; the cluster is not associated with the Coalsack but lies some five times more distant.

By the way, the intensity of the Coalsack is created by a contrast illusion where dark nebulosity happens to be surrounded by a brilliant swath of Milky Way. Place the Coalsack among the stars of Cygnus and it would lose its luster. —S.J.O.

T TAURI

T.A. RECTOR/UNIVERSITY OF ALASKA ANCHORAGE, H. SCHWEIKER/WIYN AND NOIRLAB/NSF/AURA

T Tauri is the prototype of an irregular class of variable stars found only in nebulae and young clusters. English astronomer John Russell Hind discovered T Tauri and its associated nebulosity (NGC 1555; 1' west) on Oct. 11, 1852, while searching for minor planets with a 7-inch refractor. The next day, he announced his findings in the *Astronomische Nachrichten*: "Last night I noticed a very small nebulous-looking object in [Taurus, just north of the Hyades near Epsilon]: it was south-preceding a star of 10th mag, which, to my surprise, has escaped insertion on the map for 4h R.A. recently published — possibly [the star] may be variable."

Curiously, while the variations of T Tauri appear to be linked to changes in the brightness of the nebula, their erratic behaviors are not in sync. Of T Tauri's fluctuations, Mount Wilson Observatory astronomer Alfred Joy wrote in 1945, "The variations in light of the T Tauri stars are so irregular and unpredictable that classification by means of their light curves is practically impossible."

T Tauri sporadically jumped from magnitude 9.3 to 14 between 1864 and 1916. Over the last half-century, data from the American Association of Variable Star Observers show that while T Tauri's brightness varies by a few tenths of a magnitude every day, its general long-term trend shows it randomly fluctuating between magnitude 9.3 and 12.

T Tauri is a newly formed star less than 10 million years old, with a mass less than three Suns. Its behavior may be due to activity in the star's atmosphere, or perhaps remaining dust and gas from the nebula in which it was conceived, which can temporarily obscure light streaming from the star. So be prepared for anything when you look. —S.J.O.

RR LYRAE

RR Lyrae, an old yellow giant star 850 light-years distant in northwest Lyra, near the border of Cygnus, is the prototype of one of the most important classes of pulsating variable stars. RR Lyrae-type stars can be used as standards for measuring distances in space, especially for globular clusters. Harvard College Observatory astronomer Williamina Fleming discovered RR Lyrae itself while examining a photographic plate taken on July 13, 1899. Further investigation showed the star varying in brightness every 13.6 hours from magnitude 7 to 8.

Fleming also noted that this variable behaved like other variable stars she had previously discovered in globular star clusters; as RR Lyrae was by far the brightest and easiest to observe spectroscopically, it became the eponym of the class. Her discovery was, in fact, peculiar, as it was the first RR Lyrae-type star to be discovered outside of a cluster.

In 1916, Harvard astronomer Harlow Shapley noted that the shape of RR Lyrae's light curve and the timing of its peaks cycle through a span of 40 days. The phenomenon became known as the Blazhko effect, after Russian astronomer Sergei Blazhko, who in 1907 first observed similar behavior in the RR-Lyrae-type variable RW Draconis. To this day, astronomers do not have an adequate understanding of what causes the effect.

Shapley also used RR Lyrae-type variables to systematically determine the distance and distribution of globular clusters around our galaxy. This study led him to believe that the Milky Way is 300,000 light-years in diameter and that our Sun was not at the center, but rather some 60,000 light-years from it. While he was off by a factor of 2 or 3, he had the basic picture right. –S.J.O.

ROBERT J. VANDERBEI

ALAN DYER

STREICHER 7

Streicher 7, the Tiny Southern Cross asterism, is the seventh asterism created by the prolific writer and renowned South African observer Magda Streicher. In her 2012 book *Astronomy Delights*, she describes it as a "group of stars that represents a small constellation Crux impression, with the long axis pointing towards the south-east. I am dedicating this asterism to a very special person, Carla (le Roux) Graham. She lost her battle with acute myeloid leukaemia in 2010, and my sincere wish is that the stars in this cross may shine brightly in thought of her memory and the legacy she left behind."

You'll find this personal tribute among the stars about 1.6° south of the dynamic NGC 2516, the Southern Beehive Cluster, one of the young open clusters that share common motion though space with the Pleiades (M45).

Streicher estimates the 6'-long asterism shines at magnitude 4, but it appears much fainter. As with the Southern Cross, the asterism has three stars of similar brightness, with the southernmost being the brightest (and reddest). The fourth, fainter star of the Cross marks its western arm, while the faint one in Streicher 7 marks the eastern arm. The long axis of Streicher 7 points to the southeast. –S.J.O.

SOUTHERN PLEIADES

Just 4½° due south of Eta Carinae, at the northern tip of the Diamond Cross asterism, lies the 2nd-magnitude open star cluster IC 2602. Popularly known as the Southern Pleiades, it shines forth as the fifth-brightest open cluster in the entire heavens. This island of starlight harbors at least 60 members spread across 50' of sky; some 30 of these stars shine brighter than 9th magnitude. And while the view of the cluster is dominated by the light of 3rd-magnitude Theta (θ) Carinae, ironically, that star is not a part of the group.

So why the Southern Pleiades moniker? Abbé Nicolas Louis de Lacaille thought this sparkling aggregation of largely blue-white diamonds looked "like the Pleiades" through his diminutive ½-inch 8x telescope. Using optical aid is the key — without question, the Southern Pleiades looks best through binoculars.

What's weird is that the southern and northern Pleiades are, in their natures, near twins. Both are youthful, between 50 million and 100 million years young, respectively. The Southern Pleiades lies roughly 480 light-years away, while the Pleiades lies 448 light-years distant. Both sport at least 10 stars of 6th magnitude or brighter — though the remaining number of bright stars in the Pleiades trumps those of its southern rival. –S.J.O.

ALAN DYER

NASA, H. FORD (JHU), G. ILLINGWORTH (UCSC/LO), M. CLAMPIN (STSCI), G. HARTIG (STSCI), THE ACS SCIENCE TEAM, AND ESA

MICE GALAXIES

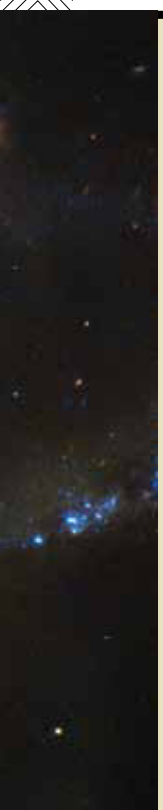
The Mice Galaxies (NGC 4676 A and B; also cataloged as Arp 242) are a close-knit pair of roughly 14th-magnitude spiral galaxies engaged in a tidal embrace. Their name refers to their two tremendously long tails of stars and gas, one extending from each body.

Structures formed by clumps of stars separated by expanses of dim matter in the longer of the two tails have led astronomers to believe that the two galaxies already passed through one another hundreds of millions of years ago. Computer simulations have confirmed this scenario and suggest we are now seeing the Mice approximately 160 million years after that event. As they are still tidally attracted to one another, they will likely repeat their slow-motion dance, passing through one another multiple times over the next billion years until they coalesce to form a single elliptical galaxy.

Chandra X-ray Observatory images have detected strong starburst-driven winds from the minor axis of each galaxy. This finding is totally unexpected in such a rapidly evolving and turbulent merger; it is, in fact, the first time that such a hot gaseous outflow has ever been seen in a full-blown merger.

The galaxies lie some 290 million light-years distant in the Coma Galaxy Cluster (see #86). You'll find them about 4.8° east-northeast of Gamma (γ) Comae Berenices and 1.5° south-southeast of the magnificent magnitude 10.5 barred spiral galaxy NGC 4656, popularly known as the Hockey Stick Galaxy.

Larry Mitchell of Houston showed me the Mice through his 24-inch telescope at the 1986 Texas Star Party, but it wasn't until the 1999 Texas Star Party — after gaining experience with deep-sky observing — that I was able to detect the tails through the same instrument. How small of a telescope can you use to detect the Mice and their tails? –S.J.O.



NASA & ESA; ACKNOWLEDGEMENT: JUDY SCHMIDT (GECKZILLA)

ATOMS FOR PEACE GALAXY

Imagine a face-on spiral galaxy lying at the center of a thick, spiraling ring of dust. Now place these at the center of a vast sphere of alternating concentric rings of gas and dust, across which slice several ghostly arms, rich in star formation, and pendulous matter at the ends. Put it all together and you have NGC 7252 in Aquarius, one of the most bizarre extragalactic sights in the universe.

The diminutive (2' x 1.5') galaxy lies about 200 million light-years distant. It shines at 12th magnitude, so moderate to large apertures will see it best. Still, you'll have to use your imagination to "see" the wonder of it all — namely the dramatic aftermath of two spiral galaxies in an advanced stage of merging.

The main body of the galaxy (the blue spiral in the center) is a single-nucleus merger remnant. The merger caused significant star formation in both the nuclear remnant and the galaxy's outskirts some 600 million to 700 million years ago. The observed formations have led astronomers to believe that this galaxy merger is in the initial stages of evolving into an elliptical galaxy — perhaps a blue, star-forming elliptical galaxy, which astronomers have found at much greater distances.

NGC 7252's nickname seems a bit out of place. It honors the name of a speech President Eisenhower gave in 1953, in which he promoted nuclear power for peaceful purposes. That speech, combined with the fact that NGC 7252's appearance recalls the orbits of electrons around the nucleus of an atom, led to the galaxy's moniker — though the reality of mergers is anything but peaceful. –S.J.O.

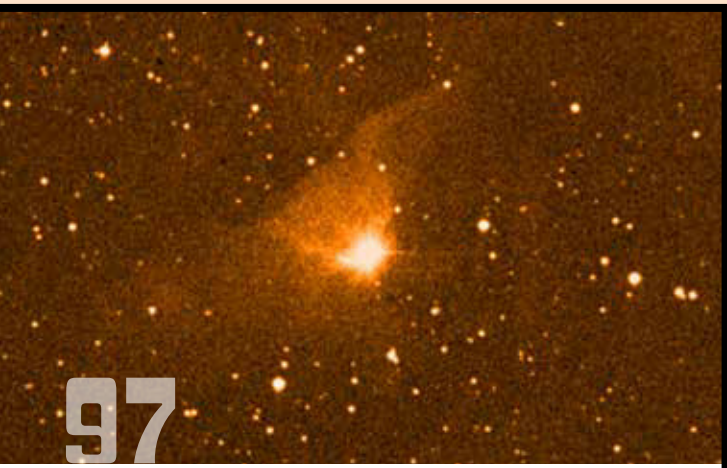
M87

NASA, ESA, AND THE HUBBLE HERITAGE TEAM (STSCI/AURA); ACKNOWLEDGMENT: P. COTE (HERZBERG INSTITUTE OF ASTROPHYSICS) AND E. BALTZ (STANFORD UNIVERSITY)

M87 stands apart from its roughly 2,000 neighbors in the Virgo Cluster of galaxies for a number of reasons. For one, this supergiant elliptical is one of the most massive in our local universe, housing 100 billion stars with a total mass nearing 2 trillion Suns. But perhaps it is most famous for what lies at its core: one of the best-studied supermassive black holes, and the first to have its shadow captured in a photograph. That groundbreaking image of the 6.5-billion-solar-mass black hole, named M87*, was released in April 2019 by the team behind the Event Horizon Telescope, an international network of radio telescopes.

Also famously appearing in photographs of M87 is the jet of matter being expelled from its central black hole's surroundings at nearly the speed of light. In 1918, Heber Curtis at Lick Observatory took a photographic plate of the galaxy and noted the jet as a ray of light emerging from the galaxy. As a visual target, it's an observing challenge of the tallest order; it wasn't until years later that Otto Struve finally sighted the 5,000-light-year-long feature using the 100-inch telescope at Mount Wilson. The first amateur visual detection was made by Barbara Wilson in her 20-inch reflector at the Texas Star Party in 1991.

Your view of this galaxy from your own backyard will likely be a little more typical: a glowing orb with a fuzzy outer shell. It sits about 3½° northwest of Rho (ρ) Virginis glowing at magnitude 9.7 and spanning 7'. Only 10' southwest of the object is a dimmer elliptical, 11th-magnitude NGC 4478, which may require moderate to high magnification to see well. –S.J.O.



ESO

FU ORIONIS

FU Orionis is the prototype of a class of novalike variables that undergo some of the most extreme variability seen in pre-main sequence stars. FU Orionis and its kin characteristically flare by several magnitudes over a period of one to 10 years before dimming slowly over 20 to 100 years. The underlying cause of these flare-ups remains unknown. One idea is that they are youthful stars like T Tauri (see #90) that suddenly accrete a lot of mass from its disk. Overloaded, the star material heats as it is being absorbed, resulting in the visible brightening.

FU Orionis itself burst onto the scene in 1936, rising from mid-16th magnitude by a factor of more than 100 in about 200 days. And it kept going: A year later, it had increased in brightness by nearly 7 magnitudes (to magnitude 9.6). An optical arc of reflection nebulosity accompanied the eruption and remains visible to this day. FU Orionis also undergoes small amplitude flickering (perhaps created by a jittering of magnetic jets), which may be the stellar version of "growing pains" that all T Tauri stars experience before settling down on the main sequence.

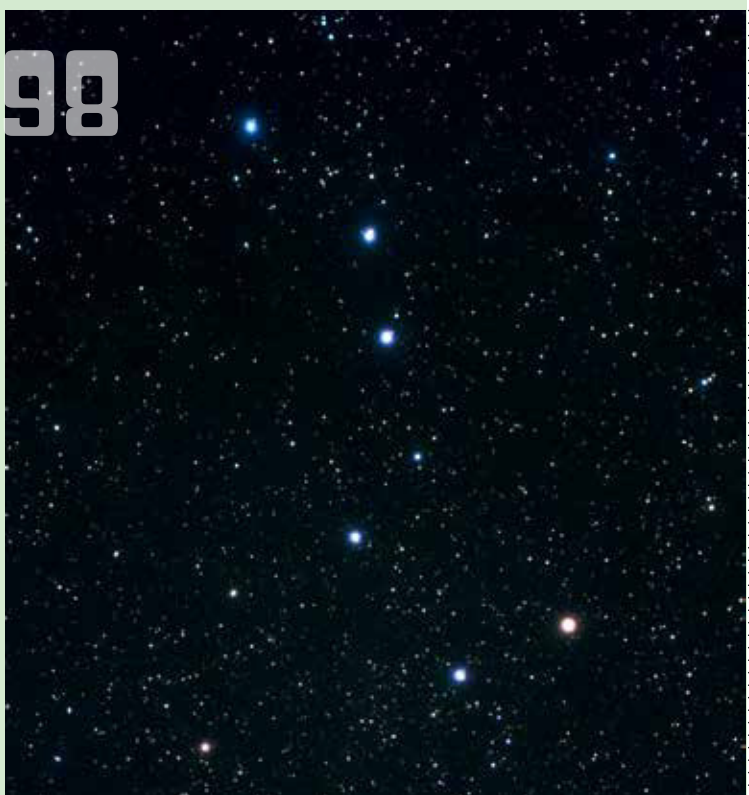
Astronomers remain keenly interested in FU Orionis and others in its class as these stars may provide insight into how stars evolve onto the main sequence and form planetary systems. Presently shining at 9th magnitude, FU Orionis is a great target for small telescope users, especially as it lies about 2° east-southeast of 4th-magnitude Phi² (φ²) Orionis. –S.J.O.

URSA MAJOR MOVING GROUP

The seven brightest stars in the constellation Ursa Major comprise one of the brightest and most recognized star patterns in the night sky: the Big Dipper or Plough. The five stars between (but excluding) Dubhe in the Big Dipper's bowl and the tip of its handle (Alkaid) mark the core of the Ursa Major Moving Group — the closest gathering of stars to Earth that share a common origin.

Lying 80 light-years away, the group also contains nine fainter members. A wider stream of roughly 46 associates are spread across the sky. These include the binary star Menkalinan in Auriga as well as Adhafera in Leo. Gravity from passing clouds of dust and gas have been slowly ripping this family apart like fizz from a seltzer tablet in water.

One gem among them is the second star from the end of the Big Dipper's handle (Mizar), which is a celebrated optical double. Early Arabian skywatchers considered seeing Mizar's 4th-magnitude companion Alcor a test of visual acuity. In 2008, George M. Bohigian of Washington University School of Medicine in St. Louis, Missouri, reported in *Survey of Ophthalmology* that this ancient test is approximately equivalent to the modern metric of 20/20 vision. –S.J.O.



A. FUJII/HUBBLE

NASA, ESA, AND THE HUBBLE HERITAGE TEAM (STSCI/AURA)

NGC 5189

NGC 5189 is one of the more bizarre-looking planetary nebulae, appearing more like an exploding barred spiral galaxy than a shell of gas released from a dying Sun-like star. Until the 1960s, this curious object was believed to be an emission nebula. The reverse S-shape symmetry and hyper-chaotic knotty details of NGC 5189's shells are the most puzzling morphological structures known among planetary nebulae.

NGC 5189 belongs to an extremely restricted class of these nebulae that exhibit ansae — small appendages on either side, giving the illusion of rings. But unlike other planetaries, NGC 5189 sports not two ansae, but five! NGC 5189's shape is reminiscent of a lawn sprinkler, with matter being expelled from the star, which is wobbling as it rotates.

The bizarre structure could be a result of powerful polar outflows from an interacting binary star system, whose components orbit one another once every four days at the nebula's core. Evidence is mounting that one of the companions is a rare low-mass Wolf-Rayet star with a mass equal to that of the Sun. This star is at an advanced stage of evolution and losing mass at a very high rate. If this star had multiple outbursts (there is evidence for at least three expanding bubbles of hot gas), each at different velocities, it would induce shock waves in the surrounding gas, creating the complex system of knots and filamentary structure we see.

You'll find this intriguing 10th-magnitude planetary 1¾° southeast of magnitude 4.5 M Centauri. The nebula covers 2.5' of sky, which spreads out its light, resulting in a low surface brightness. Under dark skies, a 4-inch telescope will reveal the nebula's irregular structure, looking like a 1.5'-long knot of light about 5' northwest of a magnitude 7.5 star. At higher magnifications, the object appears mottled and snakelike, slithering through patches of space. The object stuns when viewed through a 12-inch scope, revealing its irregularities and winding extensions. –S.J.O.

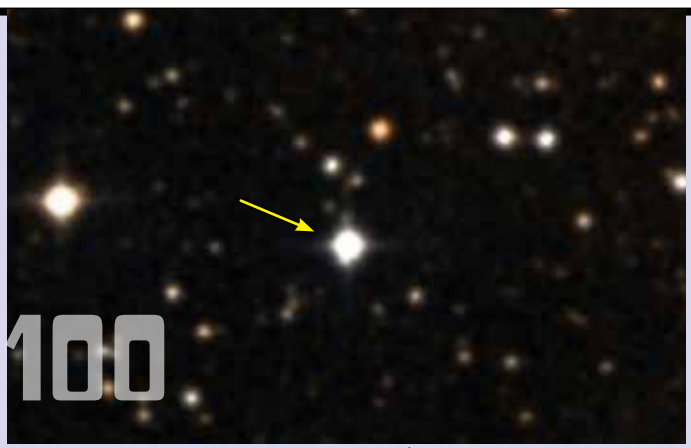
TABBY'S STAR

Tabby's Star is a mysterious Sun-like star some 1,500 light-years distant in Cygnus the Swan, just a few arcminutes northeast of open star cluster NGC 6866. But unlike our Sun, this 12th-magnitude star dims randomly, by anything from 5 to 22 percent, for days at a time.

The phenomenon has left researchers baffled. If it were a giant planet passing in front of the star, it would make more regular eclipses. A Jupiter-sized planet would also only block about 1 percent of the star's light, meaning the planet would be unlike anything known.

What's equally bizarre is that after American astronomer Tabetha "Tabby" S. Boyajian discovered the star's grand and irregular fluctuations in 2015, follow-up observations by astronomers around the world revealed that the overall magnitude of the star has been gradually dimming over the years. How can this be?

Some proposed theories are believable, including brightness changes intrinsic to the star, perhaps caused by its magnetism or changes in heat flow in its interior. Others are more out there — like activities by an extraterrestrial race. One of the most plausible explanations is that the dimming is caused by chunks of an orphaned exomoon. Such a moon could have been pulled away from its planet by gravitational interactions with Tabby's Star; as the moon came close to the star, it disintegrated, sending dust clouds into stellar orbit. These dust and chunks of rock are now moving between us and Tabby's Star in a clumpy cloud, which would at least explain the irregular brightness variations. Then again, who knows? –S.J.O.



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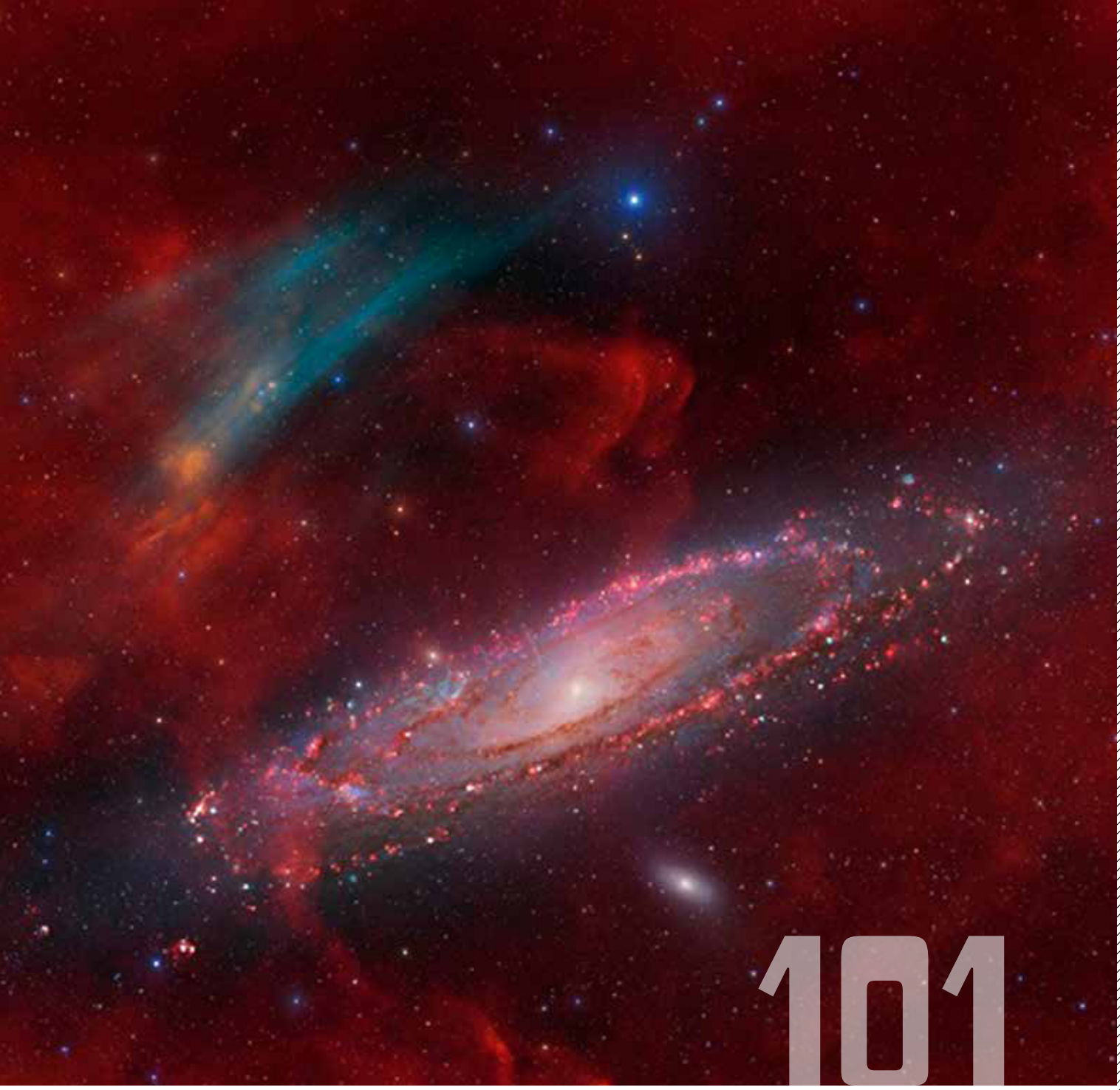

MARCEL DRECHSLER/XAVIER STROTTNER/YANN SAINTY

STROTTNER-DRECHSLER-SAINTY OBJECT 1

Strottner-Drechsler-Sainty Object 1 (SDSO-1) is a newly discovered filamentary emission nebula 1.2° southeast of the Andromeda Galaxy's (M31) nucleus. In 2022, French astroimager Yann Sainty used a 4-inch Takahashi refractor, a CMOS astronomical camera, and a range of filters to capture a total of 111 hours of exposure of the galaxy. The faint glow revealed itself in data taken with an Oxygen-III (OIII) filter after Marcel Drechsler and Xavier Strottner processed and analyzed the data.

While an untold number of imagers across the globe soon started to capture the plasma arc using an OIII filter and all manner of telescopes, it seemed only a matter of time before SDSO-1 became a target of visual interest. Indeed, given the visual prowess and tenacity of today's amateur astronomer, it's not surprising that several observers have already claimed to have seen it using telescopes as small as 2.4 inches and as large as 30 inches. But these are early days. The question is, what, if anything, can you see?

The origin of this 1.5° by 0.45° teal arc of ionized oxygen gas is still under investigation. Possibilities include an old planetary nebula, supernova remnant, or some other gas structure in our Milky Way, placing it in the foreground when we look at M31. It could also be a feature in the halo of M31 itself — perhaps a shock caused by tidal interactions with our Milky Way. Or, it could be a tail in a giant stellar stream formed when a satellite globular cluster or dwarf galaxy was torn apart and stretched out by Andromeda's gravity. Currently, there is no explanation that completely explains the object's origin. Who knows what other weird and mystifying objects amateur astronomers will discover in the years to come? –S.J.O.

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