

DEEP-SKY OBSERVING

These easy-to-observe objects offer a variety of smoke rings, spheres, and colored disks. /// BY STEVE GOTTLIEB

See winter's best planetary nebulae

English astronomer William Herschel began his survey of the heavens in 1783. He encountered several small, striking, symmetrical nebulae. They looked similar to Uranus' blue-green disk Herschel had discovered in 1781, so he dubbed them "planetary nebulae."

A planetary nebula's formation begins with an aging red-giant star. An outflowing stellar wind gently expels the star's outer atmosphere. As the star depletes its nuclear fuel supply, instabilities accelerate the outflow and expose the star's smoldering, dense core — a white dwarf. An energetic stellar wind from the white dwarf plows into the previously ejected material, compressing and sculpting the gas.

Although many planetaries appear as symmetrical disks or rings, long-exposure images reveal a wild menagerie of exotic shapes: multiple rings and shells, butterfly wings, and expanding knots called FLIERS (fast, low-ionization emission regions).

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Many planetaries have a high surface brightness. This allows you to use high magnification to resolve structure and, possibly, reveal the white dwarf, rings, outer halos, and bipolar lobes. Planetaries glow predominantly in the green light produced by doubly ionized oxygen (at about 500.1 nanometers). Narrowband filters, such as an OIII filter, increase the contrast between a nebula and the background sky. A filter improves the view from either a dark or light-polluted site. The winter Milky Way is home to many remarkable planetaries. Follow along on this tour of my favorite 10.

Start in Perseus

Begin with the **Little Dumbbell Nebula** (M76), located just 1° north-northwest of 4th-magnitude Phi (ϕ) Persei. M76 is a

superb example of a bipolar planetary, exhibiting two symmetric outer wings. Herschel described M76 as "two, close together, both very bright," and it received two NGC numbers: 650 and 651. A 6-inch scope will display this elongated double structure with the southwest lobe more prominent.

Seen through my 18-inch reflector, the two mottled lobes bracket a darker center. Adding an OIII filter to the eyepiece shows a larger halo surrounds this main structure, and two sweeping outer "wings" emerge within this halo. The wings' appearance mimics a barred spiral galaxy. The "arm" attached at the northeast end sweeps around toward the west and doubles the nebula's apparent diameter.

Across the border to Taurus

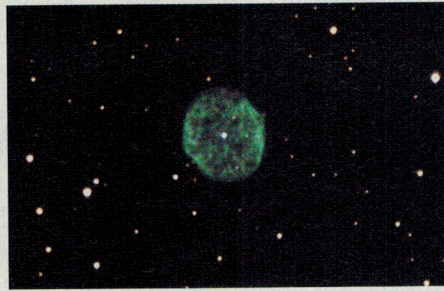
Herschel discovered **NGC 1514** in November 1790 using his 18.5-inch speculum mirror (a brittle alloy of copper and tin). The nebula's appearance was so striking that it caused him to rethink the prevailing view that nebulae were all unresolved stellar aggregates.

After observing NGC 1514, he wrote "A most singular phenomenon! A star of about 8th magnitude with a faint luminous atmosphere of circular form, and about 3 minutes in diameter. The star is perfectly in the center and the atmosphere is so delicate, faint and equal throughout that there can be no surmise of its consisting of stars; nor can there be a doubt of the evident connection between the atmosphere and the star." Herschel speculated a luminous fluid was responsible for this phenomenon.

A 6-inch scope reveals a delicate 1'-wide halo surrounding a magnitude 9.4 central star. Use a narrowband filter. It will cut



NGC 1514 in Taurus lies 3.5° east-southeast of Zeta (ζ) Persei. This magnitude 10.9 planetary has a 1'-wide inner shell marked by bright knots of material. ADAM BLOCK/NOAO/AURA/NSF



NGC 1501 lies 7° west of Beta (β) Camelopardalis. This faint blue-gray planetary glows at 12th magnitude and measures almost 1' across. ADAM BLOCK/NOAO/AURA/NSF

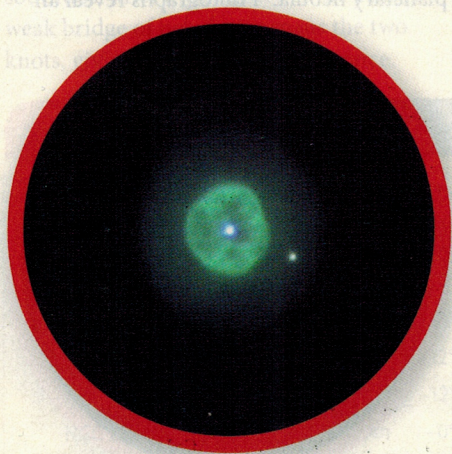
down the star's glare and enhance the nebulosity. Through my 18-inch scope and an OIII filter, the halo increases to nearly 2.5' in diameter and the surface brightness becomes noticeably uneven, with the halo's northwest quadrant clearly brighter. A small, darker "hole" surrounds the central star, and the irregularly lit halo contains a bright "knot" on the southeast side. NGC 1514 resides 3.5° east-southeast of 3rd-magnitude Zeta (ζ) Persei.

North to the Giraffe

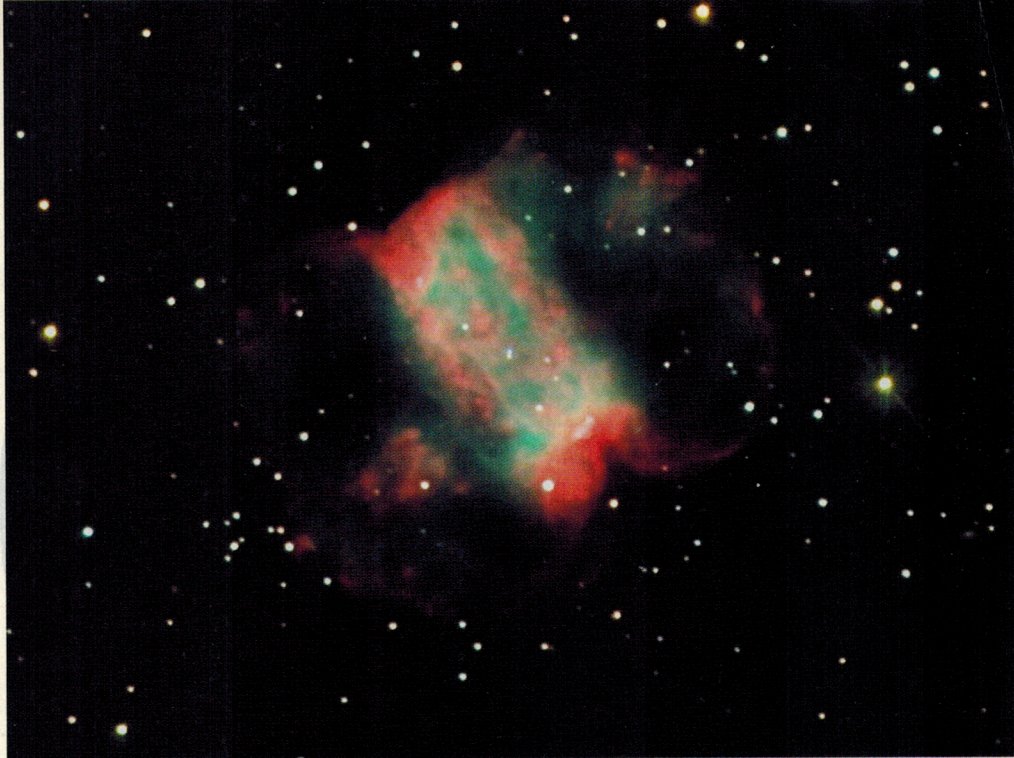
NGC 1501 in Camelopardalis lies near Kemble's Cascade, a wonderful 3°-long chain of 20 stars at 8th magnitude that tumbles from northwest to southeast. On the cascade's southeast side is the bright open cluster NGC 1502, and our planetary target resides less than 1.5° due south. A 6-inch scope shows a 45"-wide, crisp blue-gray disk with no central star. Through my 18-inch at 280x, a magnitude 14 central star shines steadily, and the disk extends slightly from southwest to northeast. In good conditions, the outer rim appears mottled or clumpy and a small, darker center is visible around the central star.

Planetaries down south

NGC 1535 has long been one of my favorites. This gorgeous planetary shows a concentric double-shell structure and pale blue-green color. You can find it 4° east-northeast of 3rd-magnitude Gamma (γ) Eridani. A 6-inch scope displays the bright inner disk and hints of an outer envelope.



NGC 1535 appears similar to the Eskimo Nebula (NGC 2392) in both structure and color. Use a 12-inch or larger telescope to see NGC 1535's pale blue-green hue. This magnitude 9.4 object lies more than 5,000 light-years away. ADAM BLOCK/NOAO/AURA/NSF



THE LITTLE DUMBBELL NEBULA (M76) in Perseus ranks as the faintest object on Messier's list. This magnitude 10.1 planetary nebula measures 2.6' by 1.6' and lies 3,400 light-years from Earth. ADAM BLOCK/NOAO/AURA/NSF

With my 18-inch at 380x, the planetary appears round with a slightly elongated, striking blue inner ring 20" across. The inner portion exhibits small, dark gaps immediately surrounding the magnitude 12.5 central star. A faint outer envelope encompasses the inner shell and roughly doubles the object's diameter.

Herschel's son, John Herschel (1792–1871), seemed confused with NGC 1535's classification because his notes read, "A mottled disk, but so hazy at the borders that I have no doubt of its being a very distant and highly compressed globular cluster. It is not a planetary, though a near approach to one." Take a close look, and see if you agree with his description.

The **Butterfly Nebula** (NGC 2346) in Monoceros is a beautiful bipolar planetary with a bright, oval disk and large outer lobes that form celestial wings to the northwest and southeast. The magnitude 11.5 central star is a close spectroscopic binary. Also known as V651 Mon, this well-studied eclipsing variable star dips to magnitude 13.5 during each 16-day orbit.

Locate NGC 2346 by scanning less than $\frac{3}{4}$ ° southwest of 4th-magnitude Delta (δ) Monocerotis. A 6-inch telescope with a narrowband filter will reveal a faint disk 30" across surrounding the central star.



THE BUTTERFLY NEBULA (NGC 2346) classifies as a bipolar planetary nebula. Large gaseous lobes form the butterfly's "wings." This object's central star is a close eclipsing binary. During its 16-day period, its magnitude changes from 11.5 to 13.5. DOUG MATTHEWS

AND CHARLES BETTS/ADAM BLOCK/NOAO/AURA/NSF

Through my 18-inch scope, the irregular, mottled disk extends to 50". This nebula has a pinched corner on the northwest side and a hint of a larger gossamer halo.

The **Spirograph Nebula** (IC 418) is a compact, high-surface-brightness planetary in Lepus that appears as a 10th-magnitude star at low power through a 4-inch scope. A common search technique is to "blink" for such diminutive planetaries. Carefully move a narrowband filter (a Hydrogen-beta filter works well with this type of object) in and out between the eyepiece and your eye. Search for a point (the planetary) that stays bright when seen through the filter while the surrounding stars dim. Once you've identified the planetary, high magnification will tease out a small halo surrounding the magnitude 10.5 central star.



PLANETARY TARGETS

USE THIS FINDER CHART to locate the planetary nebulae in this story. We've set the chart to show mid-winter stars an hour past sunset. *ASTRONOMY: ROEN KELLY*



THE SPIROGRAPH NEBULA (IC 418) shines at magnitude 9.3 and lies a bit more than 5° north-northwest of Arneb (Alpha [α] Leporis). The Hubble Space Telescope's Wide Field and Planetary Camera 2 captured this false-color image. *NASA AND THE HUBBLE HERITAGE TEAM (STScI/AURA)*

The Hubble Space Telescope revealed an amazing, intertwined mesh of filaments weaving through this planetary, similar to a spirograph drawing. Although this structure is not visible in the eyepiece, the Spirograph Nebula does display a reddish hue through large telescopes. Through my 18-inch at 100x, a 10"-wide halo with a rosy tint at its outer edge surrounds the central star. Higher magnification displays the halo better but subdues the color.

Although many planetary nebulae are small in stature and may get lost in rich Milky Way fields, don't pass them over for splashier objects. They provide wonderful targets to hone your observing skills, and, with experience, you'll discover their delicate beauty.

Over to Puppis

The rich open cluster M46 in Puppis is a winter star-party favorite with a uniform carpet of 100 to 200 stars spread over 30'. The annular planetary nebula **NGC 2438** adorns the cluster on the northeast side. Although it appears to float among the dense mat of stars, the planetary is superimposed on the cluster. NGC 2438 lies 2,900 light-years distant, while M46 sits roughly 5,400 light-years from Earth.

French comet-hunter Charles Messier (1730–1817) discovered the cluster in 1771



NICOLE BIES AND ESTIBRO HERNANDEZ/ADAM BLOCK/NOAO/AURA/NSF

NGC 2438 appears superimposed on the northern side of open cluster M46 in Puppis. Although this planetary measures only about 1' across, a 4-inch scope easily reveals it.

but missed the planetary due to his instruments' relatively poor quality. Today, a 4-inch telescope reveals this celestial bubble. Through an 8-inch scope, it displays a dark center. Through my 18-inch, the planetary spans 70" at 320x. At this power, an irregular ring is prominent, and a 20"-wide center glows weakly. A 13th-magnitude star (not the central star, however) is just northwest of the center, and a second fainter star lies nearby, toward the southwest. An 11th-magnitude star hugs the southeast edge.

NGC 2440 is a remarkable bipolar planetary William Herschel discovered in 1790. He succinctly described it as a "beautiful planetary nebula." Photographs reveal an



NGC 2440 resides in Puppis 13.6° east of Sirius (Alpha [α] Canis Majoris). This 9th-magnitude planetary nebula has a chaotic structure and lies about 4,000 light-years away. *JEFF CREMER/ADAM BLOCK/NOAO/AURA/NSF*

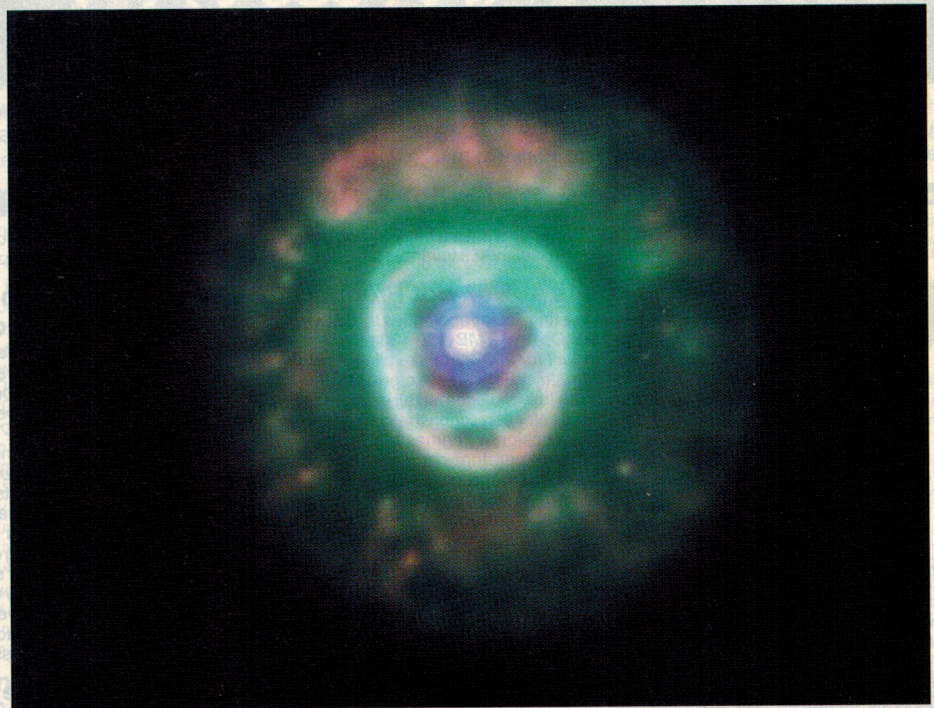
amazing, complex structure with internal filaments, gas blobs, and two lobes. The magnitude 18 central star is a scorcher, with a temperature of roughly 360,000° F (200,000° C). That's more than 30 times the Sun's temperature, and it ranks this star as one of the hottest known white dwarfs.

Find NGC 2440 by dropping 3.4° south from M46. A 6-inch scope at 75x easily reveals a small, hazy oval 20" to 25" in diameter. Through my 18-inch scope, the view is extraordinary at 380x. The bright, boxy inner region contains two knots. A faint outer halo is oriented southwest to northeast with two wings similar to a galaxy's spiral arms. The nebulosity is weaker to the southwest where a cup-shaped dark notch protrudes into the central region.

End in Gemini

When William Herschel ran across the **Peanut Nebula** (NGC 2371-2) in 1785, he assumed it was a double nebula and cataloged each lobe separately. To locate the Peanut Nebula, start at Castor (Alpha [α] Geminorum) and sweep 3° southwest. Through a 6-inch telescope, you'll find only a small, hazy patch, but 10-inch and larger scopes will resolve this unusual planetary's bipolar nature. John Herschel was confused by the structure, which he described as a "curious, bright double nebula or an elongated bi-central nebula."

Through my 18-inch at 380x, I can resolve two bright lobes oriented southwest to northeast with 30" of separation. Each knot measures 15" to 20" across with the southwest knot the brighter of the pair. A weak bridge of nebulosity spans the two knots, giving a "dog bone" appearance.



THE ESKIMO NEBULA (NGC 2392) looks like its namesake because of overlapping, expanding gas shells. This 9th-magnitude object lies about 3,000 light-years away.

Our final object — the **Eskimo Nebula** (NGC 2392) — is a double-shelled showpiece described by William Herschel as a "star of 9th magnitude with pretty bright, milky nebulosity equally dispersed all around." In early photographs, vague facial features in the interior and a detached outer shell inspired the nickname. But recent Hubble images show the interior contains a maze of intersecting filaments, and the hood resolves into an array of radial jets.

To find the Eskimo Nebula, look 2.4° east-southeast of magnitude 3.5 Delta Geminorum. A 6-inch scope at 50x reveals a small blue disk dominated by a magni-

tude 9 central star. Through my 18-inch, the view is mesmerizing at 800x — the white dwarf is surrounded by a darker hole within an irregularly lit annulus 20" across. A dark, narrow moat divides the inner shell from a large, low-surface-brightness outer halo nearly 1' in diameter.

Winter may not be your favorite observing season. As you center one after another of these spectacular planetary nebulae in your eyepiece's field of view, however, you'll hardly notice the chill in the air. ■

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Get cold-weather observing tips at www.astronomy.com/toc.

TEN PLANETARY TREATS

Name	Constellation	R.A.	Dec.	Size	Magnitude
M76	Perseus	1h42m	1°34'	163" by 107"	10.1
NGC 1501	Camelopardalis	4h07m	60°55'	56" by 48"	11.9
NGC 1514	Taurus	4h09m	30°47'	136" by 121"	10.9
NGC 1535	Eridanus	4h14m	-12°44'	48" by 42"	9.4
IC 418	Lepus	5h28m	-12°47'	40" by 35"	9.3
NGC 2346	Monoceros	7h09m	-0°48'	60" by 50"	11.9
NGC 2371-2	Gemini	7h26m	29°29'	74" by 54"	11.2
NGC 2392	Gemini	7h29m	20°55'	47" by 43"	9.2
NGC 2438	Puppis	7h42m	-14°44'	73" by 68"	10.8
NGC 2440	Puppis	7h42m	-18°13'	74" by 42"	9.3

Key: R.A. = Right ascension; Dec. = Declination; both coordinates are 2000.0.



THE PEANUT NEBULA (NGC 2371-2) exhibits two bright lobes through telescopes 10 inches or more across. Because of its twin nature and the constellation in which it lies, astronomers also refer to NGC 2371-2 as the Gemini Nebula.