SOLVED:
Georgia O'Keefe Mystery
PAGE 34

SLOAN DIGITAL SKY SURVEY:
Astronomy's Workhorse
PAGE 20

DIY:
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PAGE 70

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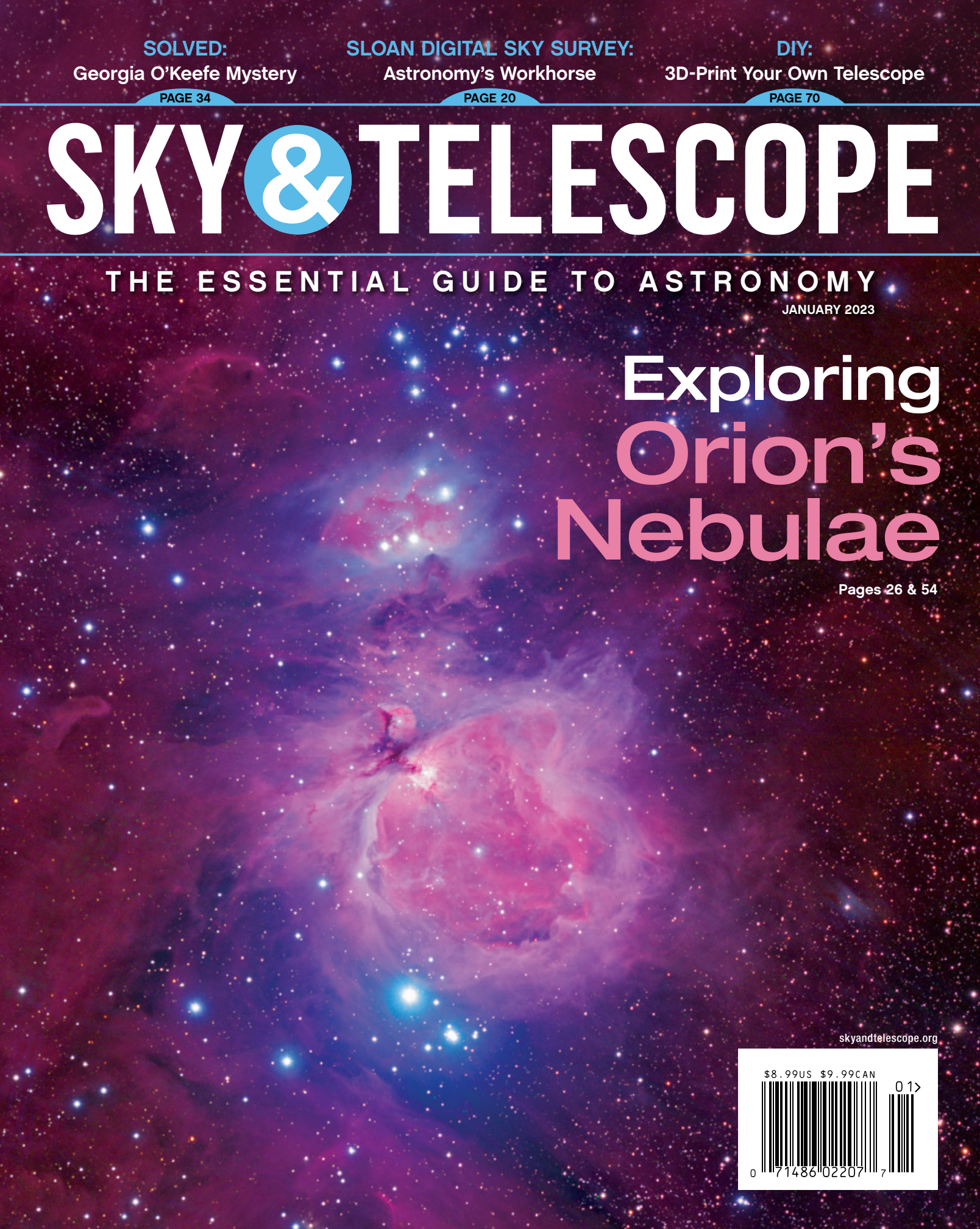
JANUARY 2023



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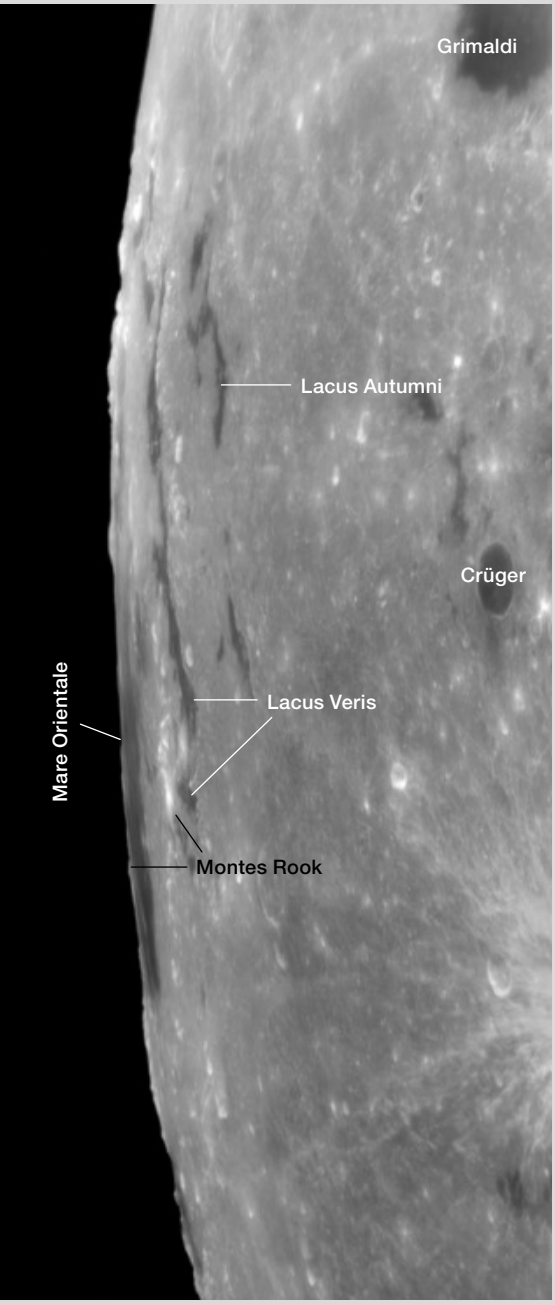
Observing on the Edge

January offers a rare opportunity to glimpse one of the Moon's most challenging features.



▲ This month, a favorable libration brings the southwestern limb of the Moon into view.

The Moon spins once on its axis and completes one revolution around Earth in the same interval of time, so our satellite always presents the same familiar face. But it's never *exactly* the same face.

The shape of the Moon's orbit is slightly elliptical, causing the distance between the Moon and Earth to vary between about 28 and 32 Earth diameters every month. In accordance with Kepler's second law of motion, our satellite's orbital speed is fastest when it's at *perigee* (closest to Earth) and slowest when it's at *apogee* (farthest away). As a result, the Moon's constant speed of rotation alternately leads and lags its orbital position, making it appear as if the Moon is slowly oscillating from east to west with an amplitude of almost 8 degrees. Known as *libration in latitude*, this apparent wobble allows terrestrial observers to peer around the Moon's eastern and western limbs.

Favorable librations that occur when the southwestern limb is sunlit provide opportunities to observe one of the most imposing formations on the Moon, **Mare Orientale**, the Eastern Sea. Centered at 95° west longitude, just beyond the Moon's western limb, it marks the site of the impact of a large asteroid around 3.8 billion years ago. Despite its age, Orientale's almost pristine state of preservation makes it the most striking example of a multi-ring impact basin on the entire Moon.

The name Mare Orientale is an anachronism. In 1961 the International Astronomical Union dispensed with the astronomical convention of lunar coordinates based on telescopic views and adopted the astronautical convention that defines east as the direction of sunrise for someone standing on the Moon. Suddenly the Eastern Sea was awkwardly located on the Moon's western limb. A proposal to rename the feature Mare Pacificus was briefly entertained, but the old name was deemed too well established to be changed.

Images taken by the Lunar Orbiter 4 spacecraft in 1967 clearly revealed Orientale's bulls-eye structure for the first time. Flooded by dark basalt lavas, the central mare measures almost 330 kilometers (205 miles) in diameter and is completely encircled by a pair of concentric mountain ranges. Resembling ripples made by throwing a stone into a pond, these circular scarps are the result of shock waves in the lunar crust, which was liquefied by the colossal, basin-forming impact. The inner rim, measuring 620 km across, is marked by **Montes Rook** (the Rook Mountains). The more rugged **Montes Cordillera** defines the basin's 930-km-wide outer rim. Isolated peaks in this range tower to heights of 6 km above the central floor of the basin.

Even the best telescopic views of Mare Orientale are impaired by foreshortening. At mean libration, the surrounding mountain ranges often appear silhouetted against the background sky as irregularities on the lunar limb. German astronomer Johann Hieronymus Schröter charted them during the 1780s. However, only slivers of the central basin's dark floor can be seen. The most prominent are two dusky ribbons nestled in the lowlands between the concentric mountain rings known as **Lacus Autumni** (Lake of Autumn) and **Lacus Veris** (Lake of Spring). They

SEAN WALKER / *S&T*

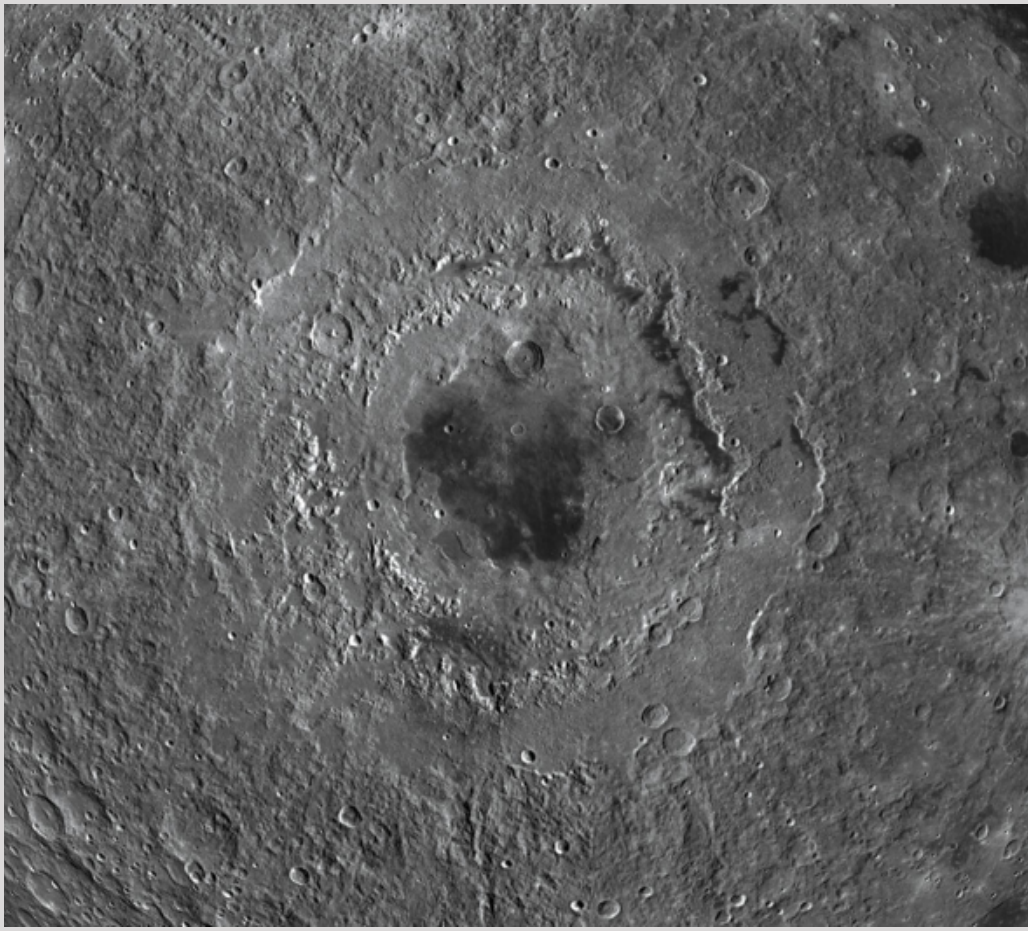
were first recorded in drawings by the artist Jean Patigny that served as the basis of a large Moon map issued in 1679 by Giovanni Domenico Cassini of the Royal Observatory in Paris.

Given these fleeting and fragmentary glimpses, it should come as no surprise that Mare Orientale was discovered, forgotten, and rediscovered several times. In an obscure letter that appeared in an 1872 edition of the *Annals of the Astronomical Observatory of Harvard College*, the leading American geologist Nathaniel Shaler wrote of his suspicions that the Rook Mountains marked the ramparts of a giant crater on the lunar farside. Three decades later, Julius Heinrich Franz, director of the observatory at the University of Breslau (now Wrocław), announced the finding of "new *maria*, among them the large extended Mare Orientale, at -90° longitude, -14° to -22° latitude . . ." This was the first use of the name, but the International Astronomical Union didn't adopt it at the time, and it lapsed into obscurity.

Franz's publications in German escaped the attention of even the most avid British lunar observers like Hugh Percy Wilkins, who announced in 1937 the discovery of "a large, very foreshortened, dark plain" at the very same location. Wilkins christened this feature "The Lunar Mare X." Nine years later, his close associate Patrick Moore claimed yet another discovery of this feature and proposed that it be named Mare Orientale.

Prior to spacecraft images, the most remarkable revelation about Orientale came in 1961. At the University of Arizona's newly founded Lunar and Planetary Laboratory, a team led by Gerard Kuiper was compiling a "rectified" lunar atlas. Projecting lunar photographs onto a white, 3-foot-diameter globe made of plaster of Paris and re-photographing them from directly overhead showed features undistorted by foreshortening. One of Kuiper's most gifted graduate students, William Hartmann, recalls:

> *On its black supports in the dark photo studio, brightly illuminated by its projector down the hall, the globe seemed a realistic new planet . . . Walking around looking at it from different sides I realized there were a lot of these giant concentric ring bulls-eye features that had not been properly recognized.*



▲ This mosaic recorded by NASA's Lunar Reconnaissance Orbiter clearly shows the multi-ringed "bullseye" pattern marking the Orientale basin.

NASA / GSFC / ARIZONA STATE UNIVERSITY

Although only a fraction of Orientale could be seen from this new perspective, its distinctive form was obvious to Hartmann, who coined the term "multi-ringed basin":

> *I remember being struck by a 'eureka' experience . . . To me, a striking aspect of these discoveries was that while observers in the previous four centuries had pushed to detect ever-smaller features of the moon with ever-larger telescopes, these largest-of-all geologic structures had gone virtually unrecognized!*

This season's prime opportunities for viewing Mare Orientale occur in the early morning on January 13th through the 16th. Finding Orientale won't be difficult — look along the western limb just to the south of the dark floor of the prominent crater **Grimaldi**. Under the high Sun angle, the elongated bands of dark lavas that make up Lacus Autumni and Lacus Veris will stand out against the brighter surrounding mountains. The bright hairline of light right on the limb is sunlight reflected by the inner escarpment of the Rook Mountains on the far side of the basin. My most vivid impressions of this vast, 930-km depression are of its shallowness — with only 6 km of vertical relief, it's shallower than the saucer under a teacup.

■ Contributing Editor **TOM DOBBINS** has always been an avid observer of our closest celestial companion.