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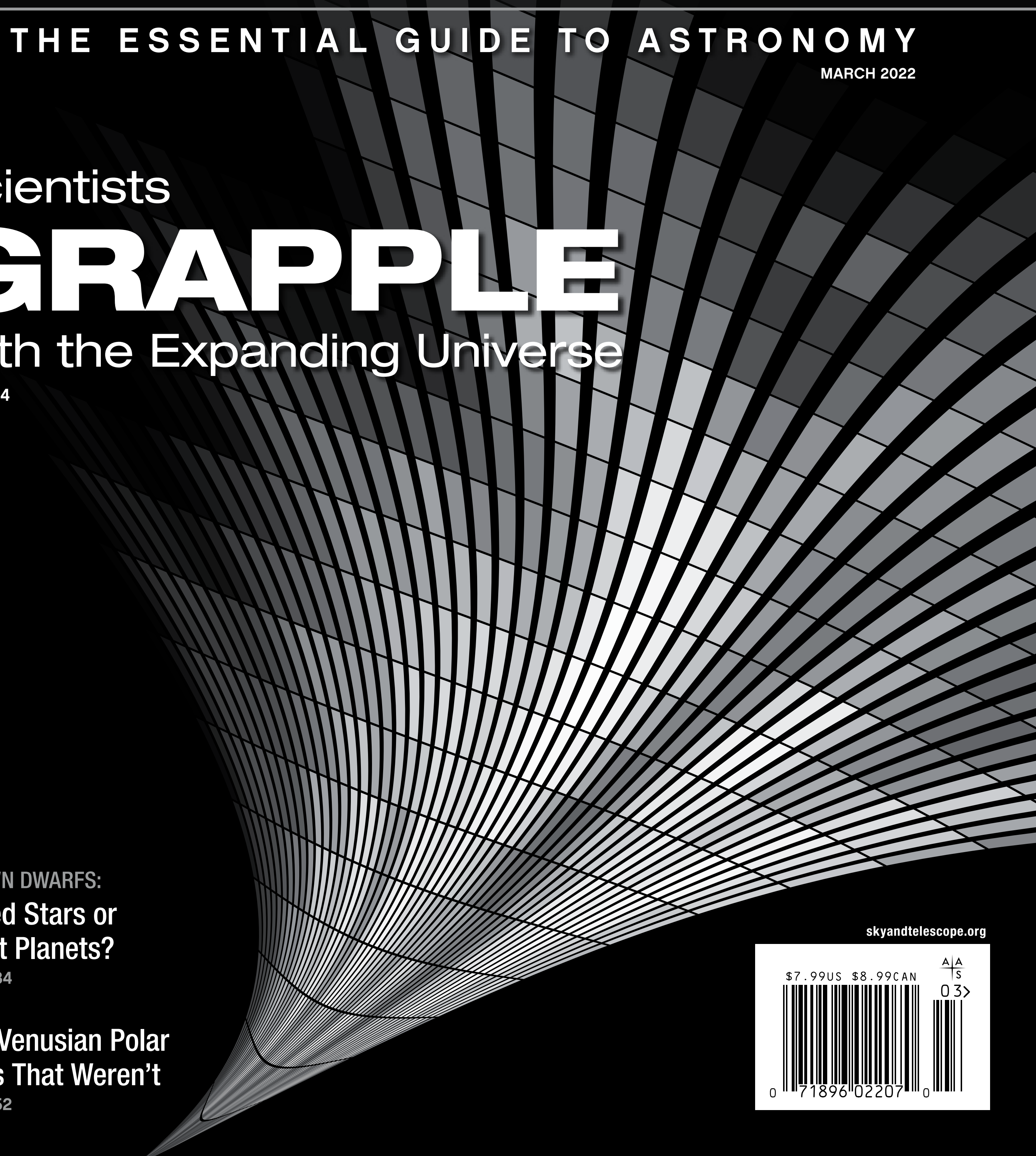

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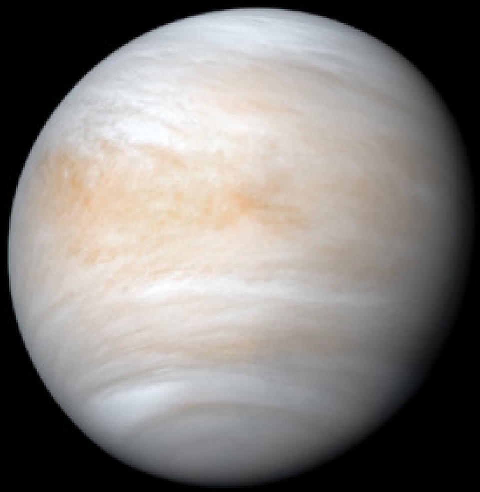


◀ Venus in false color as seen by NASA's Mariner 10 spacecraft in 1974

NASA / JPL-CALTECH

Venusian Cusps, Caps, and Collars

Features near the poles of the hottest planet were once mistaken for polar caps.

For telescopic observers, the dazzling face of Venus is a bitterly disappointing sight compared with the richly detailed disks of Mars and Jupiter. The planet's surface is concealed from prying eyes by an unbroken canopy of clouds, overlaid by a thick haze. It's not unusual for experienced observers working with powerful instruments to find Venus utterly featureless. The few visible markings are almost invariably diffuse, ill-defined shadings of very low contrast.

The preeminent 18th-century Venus observer Johann Hieronymus Schröter failed to detect any markings for nine years, until in 1788 he was finally able to glimpse ". . . the ordinarily uniform brightness of the planet's disk to be marbled by a filmy streak." In 1890, Irish astronomer Agnes Mary Clerke lamented "What we see is a shell of clouds . . . The eye accordingly finds sure anchorage nowhere." It's no wonder that for more than three centuries observers reported wildly conflicting values for the planet's rotation period and axial tilt!

Early in the 19th century, keen-eyed German astronomer Franz von Paula Gruithuisen reported seeing brilliant spots visible near the horns or "cusps" of crescent Venus, persisting well into the planet's gibbous phase. These features varied in brightness, size, shape, and general outline from day to day and even from hour to hour.

Nevertheless, Gruithuisen compared these cusps to the polar caps of Mars, suggesting that they mark the location of the planet's poles of rotation. This proved to be a very lucky guess indeed. It was only when scientists bounced radar waves off the planet's surface in the 1960s that the rotational axis was finally established as being inclined by less than 3° from the orbital plane — not far off from Gruithuisen's estimate.

During the 1870s, confirmations of Gruithuisen's "cusp caps" trickled in from prominent observers, notably Hermann Carl Vogel and Wilhelm Oswald Lohse at Bothkamp Observatory, Étienne Trouvelot at Harvard College Observatory, and Camille Flammarion at the Juvisy-sur-Orge Observatory. Some observers even reported dusky collars surrounding the bright spots, further mimicking the Martian polar caps. Many suspected that the cusp caps were snowfields on lofty plateaus and attributed their changing visibility and appearance to variations in the density of the overlying clouds and haze.

A host of skeptics regarded the bright caps and dusky collars as optical illusions, often citing Walter Augustin Villiger's "artificial planet" experiments conducted at Munich Observatory during the 1890s. Villiger painted smooth, 2-inch-wide rubber balls white and had people view them through a 5-inch refractor while illuminating them with a spotlight. At several hundred meters the balls had same apparent size as Venus, and by shifting the location of the spotlight he could simulate the planet's phases. Many sketches of these featureless spheres by his test subjects bore an uncanny resemblance to drawings of Venus, replete with shadowy markings near the terminator and bright cusps.

Villiger certainly demonstrated the perils of assuming that features on Venus are real simply because they have been seen by independent observers. But the cusp caps and collars portrayed by his test subjects were never as prominent or well-defined as those in many actual depictions of the planet.

In 1927, Yerkes Observatory astronomer Frank Ross dispelled any lingering doubts about the reality of the cusp caps when he photographed them through ultraviolet filters with the 60- and 100-inch reflectors at Mount Wilson Observatory. Ross wrote that his striking images left "no doubt of the existence of these bright areas," which he characterized as "undoubted facts to be reckoned with."

We now have a better understanding

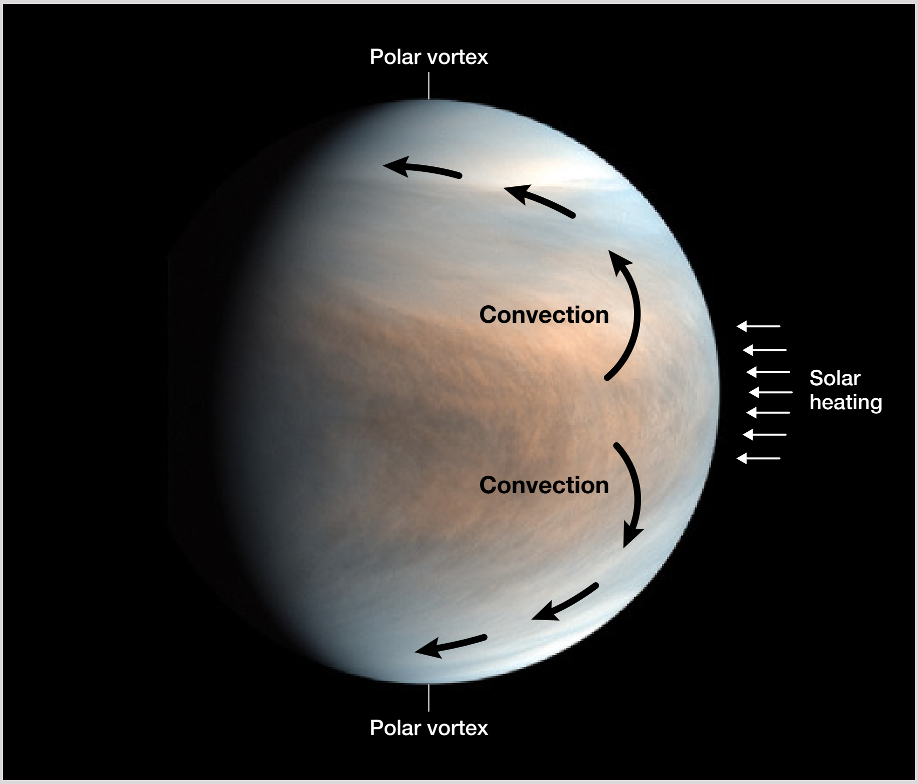
of how these features arise. Convection largely governs atmospheric circulation on Venus. Near the equator, the intense sunlight causes hot air to rise and flow toward the poles. These strong laminar winds extend to latitudes between 60° and 70°, where air starts to descend and flow back towards the equator beneath the visible cloud canopy. This region is the site of the dusky "cold collars," which appear narrow to earthbound observers due to foreshortening. At even higher latitudes, atmospheric circulation is dominated by the whirlpool pattern of powerful polar vortices, which are covered with bright cloud hoods. These features are the cusp caps.

In 1842, Gruithuisen wrote, "I find that spots were seen sometimes at both poles, at other times at one pole alone." This observation has also proved accurate. Recent ground- and space-based observations show that the speed and strength of zonal atmospheric currents on Venus can vary considerably and often show hemispheric inequalities. This discovery may account for the results of a 1958 statistical review by James Bartlett of 830 Venus observations made by members of the Association of Lunar and Planetary Observers from 1944 to 1956. Bartlett found that one or both cusp caps were visible in 54% of the observations: The south cap alone was seen 11% of the time, the north cap 7%, and both caps simultaneously 35%.

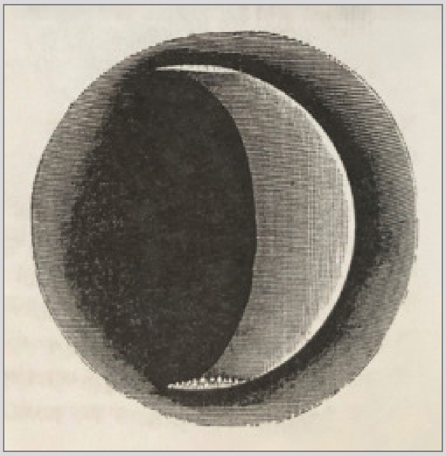
Cloud features on Venus stand out boldly in images recorded using a monochrome planetary camera and ultraviolet filter. They are usually subtle in visible light and always difficult to discern visually, unless steps are taken to reduce glare using a neutral-density filter or, better yet, a variable polarizing filter (*S&T:* Nov. 2020, p. 52). Color filters can also dramatically increase their visibility by boosting contrast. While most observers prefer the Wratten 38A violet filter, prolific British Venus observer Valdemar Axel Firsoff claimed that the combination of a green filter and a polarizing filter gives the best views. Imagers equipped with high-speed video cameras and an ultraviolet filter rountinely record the cusp caps.

The romantic visions of polar snows on Venus are banished forever. But following the ever-changing appearance of the cusp caps and cusp collars remains a rewarding opportunity to contribute to our understanding of the dynamic atmosphere of our closest planetary neighbor.

■ Contributing Editor **TOM DOBBINS** has occasionally glimpsed details in the clouds of Venus with the aid of filters but never without them.



▲ The pattern of atmospheric circulation on Venus is evident in this false-color ultraviolet image from the Japanese Akatsuki spacecraft. Convection from intense solar heating drives winds toward high latitudes, where a zonal flow parallel to the equator eventually predominates near the polar vortices.



▲ In 1878, French astronomer and artist Étienne Trouvelot depicted brilliant spots along the margin of the southern cusp cap that he imagined were snow-capped peaks.

▲ British observer David Graham made this rendering of gibbous Venus in 1988 showing the cusp caps while observing through his 6-inch refractor at 286×.

DIAGRAM OF ATMOSPHERIC CONVECTION: GREGG DINDERMAN / *S&T*; VENUS: JAXA / ISAS / DARTS