One Good Target

With Some Other Sights Worth Seeing While You're in the Neighborhood

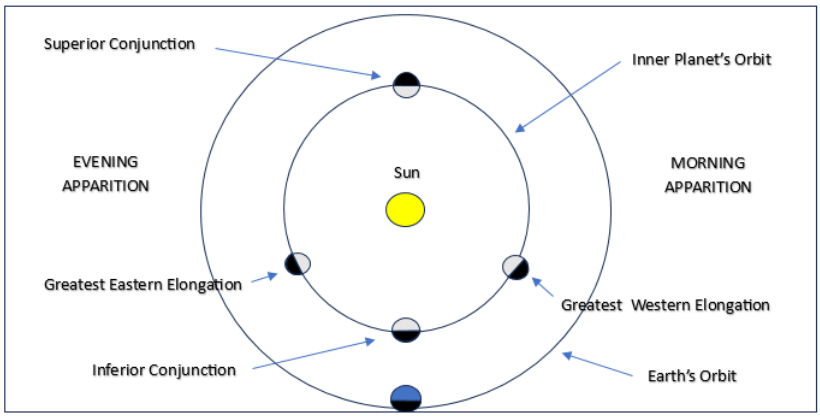
November

Observing the Inner Planets:

The Peculiar Geometry (and Terminology) of Mercury and Venus

As most amateur astronomers know, our word *planet* comes from an ancient Greek word meaning *wanderer* – but the inner planets, Mercury and Venus, might have been better described as *the moonlike palace guard:* they're *moonlike* because they are the only planets that display phases like the Moon, and like *the palace guard* because they don't appear to meander along the ecliptic like the other planets, but instead move in a pendulum motion over a short distance centered on the Sun, marching back and forth like well-trained sentries, and alternating between morning and evening duty.

Although these two planets are similar in many respects, they're at opposite ends of the spectrum when it comes to finding them in the sky. When Venus is up, it's usually the brightest thing out there, seldom dimmer than mag -3.8 at its faintest, easy to spot even in a bright twilight sky (except in its narrowest crescent phase). At its brightest, it reaches mag -4.9, visible in daylight with a little effort. Mercury, on the other hand, is much less intense. Its orbit is more eccentric than that of any other major planet, and its apparent magnitude varies considerably based on where it is along that orbit: it can be as bright as mag -2.5 and as faint as mag +7.25, and is brightest when it's closest to the Sun (and therefore hiding in the brightest twilight). As a result, for many observers, just finding Mercury is enough of a challenge.



The *phase* exhibited by the inner planets depends on where the planet is in relation to the Earth and Sun. Venus and Mercury are at full phase when they're at *superior conjunction*, on the opposite side of the Sun from us (as when the outer planets are at *opposition*). They're at new phase – and therefore invisible to us –

when they're at *inferior conjunction*, directly between us and the Sun (as when the outer planets are at *conjunction*). Gibbous and crescent phases occur as the inner planets move through their orbits, with the thinnest crescent phases occurring when the planet appears closest to the Sun, and therefore most difficult (and sometimes dangerous) to observe.

There is also a correlation between the inner planets' conjunctions and their *apparent size* as seen in our sky. They're closest to us and therefore largest at inferior conjunction (when they're in a crescent phase), farthest away and therefore smallest at superior conjunction (when they're gibbous). As seen from Earth, Mercury ranges from 4.6 arcseconds wide in its full phase at superior conjunction to a 10.4 arcsecond crescent at inferior conjunction, while Venus ranges from 9.5 arcseconds when full to a surprisingly large 62 arcsecond crescent when it's closest to us at inferior conjunction.



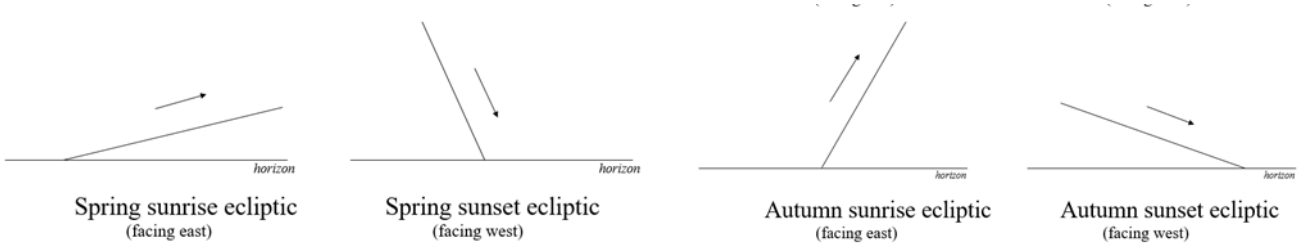
Phases of Venus: Credit Statis Kalyvas - VT-2004 programme

The inner planets' *pendulum motion* begins with the planet at inferior conjunction, after which it begins its *morning apparition* as a thin crescent west of the rising Sun, just barely emerging from the solar glare. The planet moves westward, a little farther away from the Sun on each successive morning, exposing a little more illuminated area each day, then reverses course and moves to the east, back towards the Sun, and eventually disappears into the Sun's overpowering brightness as it approaches its full phase at superior conjunction. After days to weeks hidden by the Sun's intense light, it re-emerges in its *evening apparition* as a gibbous disk, visible just after sunset to the east of the setting Sun. The planet then repeats its "running away, then running back" dance on the Sun's east side, slowly shrinking back to a thin crescent, before once again disappearing into the twilight as it approaches inferior conjunction, beginning the cycle anew.

The *perceived brightness* of Mercury and Venus depends on the inner planet's phase and its distance from us, both of which are constantly changing. The planet's distance matters because of the inverse-square law, which tells us that the intensity of light, including the sunlight reflected off those planets, diminishes with the square of distance. The inner planet's distance from us also determines the size of its disk as seen from Earth, and its phase determines the percentage of the disk that appears illuminated from our perspective. Venus and Mercury both reach their *greatest illuminated extent* (GIE) when the illuminated area is largest. Due to Mercury's highly eccentric orbit, its GIE occurs irregularly from apparition to apparition. For Venus, GIE occurs midway between greatest elongation and inferior conjunction, when Venus presents as a crescent of about 39 arcsec diameter and 27% illuminated. It's important to remember that GIE does not mark the point where the planet is brightest (*greatest luminosity*): for Venus, greatest luminosity occurs within a few days of GIE, but for Mercury the divergence can be much greater (again due to its highly eccentric orbit).

The *elevation* of the inner planets – their distance above the horizon when we observe them – is partly determined by their perceived distance from the Sun. As an *evening star*, the inner planet follows behind (and thus east of) the setting Sun; as a *morning star*, it emerges above the horizon before (and thus west of) the rising Sun. It reaches *greatest elongation* (its largest apparent distance from the Sun, as seen from Earth) when the angle formed by the Sun, the inner planet, and Earth is 90° – and that varies, depending on where the inner planet is in its elliptical orbit: greatest elongation is smallest when the inner planet is closer to the Sun (near *perihelion*), and largest when it's farther from the Sun (near *aphelion*). Greatest elongation for Mercury ranges from 18° to 28°. For Venus, the range is 45° to 48°.

The inner planets' elevation is also strongly affected by *the angle between the horizon and the ecliptic*, which varies from season to season – a variation that most noticeably affects the path of the Sun and the Moon across our sky. In summer, because our hemisphere is tilted towards the Sun, the ecliptic stands tall against the horizon at noon, and the Sun follows a relatively high path. For the same reason, the ecliptic makes a relatively flat angle with the horizon at summer midnight, and the full Moon therefore rides low across the sky. The situation reverses in winter, with a low Sun and a high full Moon. In spring and autumn, both the Sun and the full Moon follow intermediate paths, but the ecliptic stands tall at spring sunset and autumn sunrise, and remains low near the horizon at spring sunrise and autumn sunset.

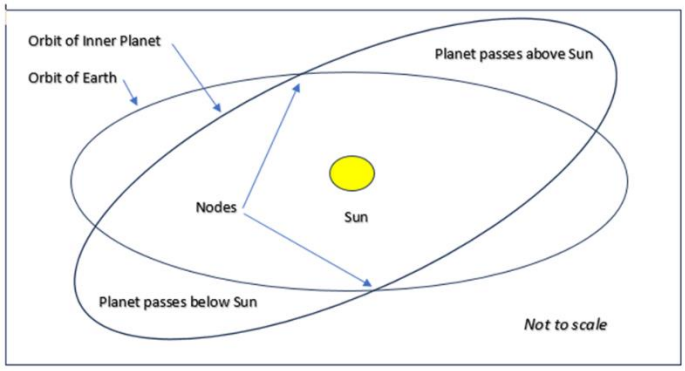


When the ecliptic is flat and low, Venus and Mercury are unable to convert much of their distance from the Sun into vertical distance above the horizon, and they remain low in the twilight sky. When the ecliptic makes a steep angle with the horizon, however, the inner planets convert more of their distance from the Sun into distance above the horizon, and that increased elevation brings them into a darker, more revealing sky. For that reason, they're best seen as morning stars in the Fall, and as evening stars in the Spring.

At greatest elongation, exactly half of the planet's disk should be illuminated, as seen from Earth – a condition known as *dichotomy*. But due to the inner planets' eccentric orbits, dichotomy does not occur precisely at the point of greatest elongation, as it would if their orbits were perfectly round. Instead, it occurs as long as 5 days before or after greatest elongation – before greatest elongation during evening apparitions, and after it in morning apparitions. This discrepancy is known as *the Schröter effect*, named for the 18th century German astronomer who first noticed it.

Because Venus possesses an atmosphere, the horns of its crescent phase can appear to extend beyond 180° of arc. That's because the atmosphere carries the Sun's refracted light (albeit faintly) into regions that are not directly illuminated – a phenomenon sometimes referred to as *cusp extension*. It becomes visible when the crescent is extremely thin, just a few percent illuminated, when the tips of the crescent can extend through 240° of arc, and even form a complete ring around the planet near inferior conjunction. To see the planet's atmosphere, look for a faint glow extending beyond the tips of the bright crescent horns. (This effect does not occur on Mercury because it has no meaningful atmosphere).

The orbit of Venus tilts 3.4° in relation to the plane of Earth's orbit (the *ecliptic*). The difference is 7° for Mercury's orbit. Thus when the inner planets reach inferior conjunction, they pass above or below the Sun as seen from Earth, unless they are at one of the two points (called the *nodes*) at which their orbit intersects the orbit of Earth. If Mercury or Venus reaches inferior conjunction when crossing a node, it will pass directly between us and the Sun, and we will see a *transit* of the planet across the Sun's face.



While transits of Mercury or Venus are dramatic observing events, they are unfortunately rarer than rare. Venus transits occur in pairs separated by only 8 years, but more than a century passes between pairs: some of us had the opportunity to see two Venus transits in our lifetimes, in 2004 and 2012, but the next pair won't occur until 2117 and 2125. Mercury transits are somewhat more frequent, but still extremely uncommon: the last one happened in 2019, and there won't be another one visible in North America until 2049 (although Mercury transits in 2032 and 2039 will be visible from other parts of the world).

So once we've got all that geometry and terminology down pat, what can we see when we observe the inner planets? To start, you'll want to use enough power to reveal the planet's phase – you might need 200x or more, especially in the case of Mercury. See if you can discern the burnt grey coloring of Mercury, and marvel at the stunning brilliance of Venus as sunlight rebounds off its highly reflective cloud tops. You won't see surface details on either of these worlds: Mercury hides its surface by remaining tiny even when at its largest, and by appearing only near the horizon, where details are obscured by a thick layer of turbulent atmosphere, while Venus wraps her secrets in an opaque layer of clouds that consist mainly of sulfuric acid. Try spotting Venus in daylight, naked-eye or in binoculars, but be sure you're standing in the shade so the object throwing the shadow is between you and the dangerously bright Sun. During its thin crescent phase, see whether you can detect the subtle glow extending beyond the tips of the crescent's horns, as sunlight diffuses through the Venusian atmosphere. Enjoy the ethereal beauty on display on the too-infrequent occasions when Venus and the Moon present similar crescents near one another in the twilight sky.

Neither Mercury nor Venus offers the cavalcade of assorted sights that can be had while observing Jupiter, or while observing Mars during a close opposition, or even while observing the Moon – but the inner planets have charms of their own. They're gorgeous in their crescent phases, glorious in their gibbous ones, and it's sometimes an accomplishment just to locate them. They're rewarding targets whenever we take the time to hunt them down. Don't neglect them in your observing plans.

Rick Gering / November 2026