Midwinter skies, planets, and orbits, and the stars of summer

by Bob Riddle

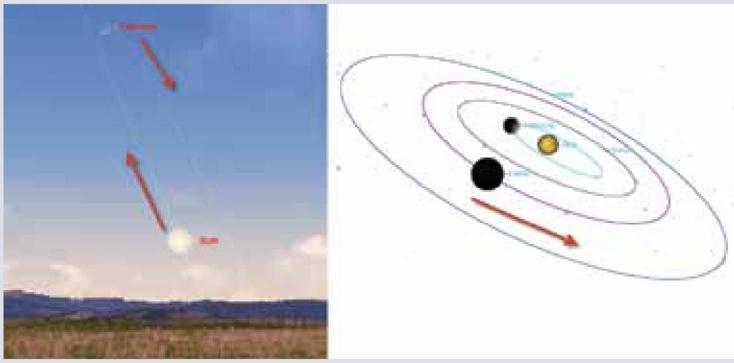
During the winter months, there are more hours of night than hours of daylight. It gets dark earlier with an earlier sunset time, and it stays darker later in the morning with a later time for sunrise. For many of us, including our students, it is dark during our morning and evening commutes. However, this longer span of nighttime makes it more convenient for viewing both evening (winter) and morning (summer) celestial objects.

For example, in the hour or so before local sunrise, the stars you see on the southern horizon are those you would typically see looking toward the south during the early evening hours of summer. Almost directly south, but not very high above the horizon, is the reddish star Antares, the "heart" of Scorpius, the Scorpion. The constellation to the east, or left, of the Scorpion is Sagittarius, the Archer. Two months ago, at the start of the Northern Hemisphere winter, this was the approximate location of the Sun. However, the Sun's apparent eastward motion along the ecliptic will "move" the Sun from Capricornus into the boundaries of Aquarius. To the right from Antares is the bright-bluish-white star Spica in Virgo, the Harvest Maiden. Approximately midway between these two stars, and appearing considerably dimmer, is the planet Saturn. During the first week or so of February, watch for the Moon to pass through this area as it wanes from last quarter near Saturn on February 3, near Antares on February 5, and then to a new Moon on February 10.

In the hour or so following local sunset time, the stars of Northern Hemisphere winter shine brightly over the southeastern horizon. These include familiar patterns such as the three stars in a diagonal line forming the belt of Orion; the V-shaped star cluster forming the face of Taurus the Bull; the Hyades; and the winter circle or hexagon of six bright stars encircling the belt of Orion. These are stars from Orion; Taurus; the Gemini Twins; and the two dogs, Canis Minor and Canis Major, respectively. Brightly shining Jupiter, with an altitude of 70°, is nearly straight up and right between the stars of the Hyades and the more compact star cluster the Pleiades.

Despite being the shortest month of the year, there is still time during February to catch nearly half of Mercury's revolution around the Sun. Last month, on January 18, Mercury was at superior conjunction, on the opposite side of the Sun from Earth. Since then, Mercury has moved toward the east and become visible as an evening "star" over the western horizon at sunset. As Mercury continues moving eastward in its orbit around the Sun, it will set a few minutes later each evening. Try this: Observe Mercury for as many consecutive evenings as is possible, but do so at the same time in the evening. You will notice that Mercury appears higher above the horizon at the same time each evening. However, because it is an inner planet, Mercury will eventually reach a point in its orbit where it starts moving westward back toward the Sun. Remember that we are on more or less the same orbital plane as Mercury and the other seven planets, so we see them orbit the Sun in a back-and-forth, or side-to-side, motion. The point in its orbit when an inner planet reverses direction is called *greatest elongation*. *Elongation* is simply the angular separation between an inner planet and the Sun as viewed from Earth, while *greatest elongation* is the maximum angular separation. Because Mercury is currently on the east side of the Sun, it is moving toward its greatest eastern elongation of 18° on February 16. On that date, Mercury will end its eastward movement and start moving westward, or retrograde, back toward the Sun and inferior conjunction on March 4.

FIGURE 1 February 16: Two views of Mercury at greatest eastern elongation



During February, Mercury will move past the outer planet Neptune, coming the closest on February 6 shortly after sunset. While Neptune is too far away and dim to be visible without optical assistance, it is interesting to gaze in that direction and know you are looking toward a planet that has only been seen through the lens of large telescopes or from images sent back from the *Voyager 2* spacecraft during its flyby in August of 1989. Two days after passing Neptune, Mercury will be closest to the planet Mars, coming within about 0.5° on February 8, as Mercury will be moving toward the east. Nearly three weeks later, on February 26, Mercury will again pass by Mars, but this time moving west and only coming within about 4°.

Counting the days? If so, you will have counted 30 for Mercury to move from superior conjunction to greatest eastern elongation (January 18 to February 16), and then only 16 days for Mercury to reach inferior conjunction. From superior conjunction through eastern elongation to inferior conjunction is approximately one-half of Mercury's orbit around the Sun. So how is it that the two quarters are not the same number of days?

How can there be an uneven numbers of days between the times of the two conjunctions and the two elongations as described in the preceding paragraph? Remember that the Earth moves about 1° each day, so the Sun is in apparent eastward motion of about 1° per day. Mercury, as an inner planet, is moving at a faster rate such that Mercury moves eastward faster than the Sun's apparent eastward motion, thus allowing Mercury to move ahead of, or pull away from, the Sun toward greatest eastern elongation as it will do this month (see Figure 1). However, from greatest eastern elongation (evening sky) to inferior conjunction, Mercury will be moving west, closing in on the Sun while the Sun continues its eastward motion. This part of Mercury's orbit will take fewer days because the closing rate between Mercury and the Sun is much faster than their separation rates.

Mercury will continue moving past inferior conjunction through when it reaches its maximum separation angle from the Sun at greatest western elongation (morning sky) and end its westward, or retrograde, motion. From western elongation, Mercury will move eastward, eventually catching up with the Sun, gradually moving behind it and superior conjunction. Mercury catches up with the Sun because Mercury and Venus, as inner planets, have faster orbital speeds around the Sun than the Sun's apparent motion based on the Earth's orbital motion.

Both inner planets, Mercury and Venus, follow the same pattern of cycling through these orbital positions relative to the Sun and our view from Earth. Outer planets, Mars and beyond, have a similar cycle of orbital positions, with the biggest differences coming from greater range of separation angles and that only inner planets can be at inferior conjunction. From the Earth, all planets have a superior conjunction, when they are on the opposite side of the Sun from the Earth. However, as they circle the Sun in the same direction, inner planets are limited to a smaller angular separation from the Sun because they circle only the Sun, while outer planets circle both the Sun and the Earth (see Figure 2).

Map this

Download and print the two pages making up the equatorial star chart from the Stephen F. Austin State University Observatory website (see Resources). Have students place them side by side so that the ecliptic and other labels line up and tape the two pieces together. This is an equatorial star chart that shows the entire sky from the celestial equator to 60° north and south. (As with a Mercator map of the Earth, when a rectangular map is made by flattening a sphere, the polar regions become distorted, or stretched out, while the center of the map, along the equator, is the least distorted.) Among other map activities, students could follow the Sun's daily position by noting the dates along the ecliptic. However, because constellation boundaries are not drawn, it is not always visually obvious that the Sun is "within" a particular constellation boundary. To see constellation boundaries, have students visit the Your Sky web page (see Resources). From there, students may produce a star chart for any date, time, and viewing location, and include things such as boundaries, the ecliptic, planets, the Sun, and our Moon.

Pan-STARRS and comets

The Panoramic Survey Telescope and Rapid Response System (Pan-STARRS) is a project that is currently using a remotely controlled 1.8 m–wide field telescope atop Haleakala, a dormant volcano in Hawaii. Operated by the University of Hawaii Institute for Astronomy, the wide-field telescope is used in part to systematically image the entire sky several times each month, looking for potentially hazardous objects such as comets and asteroids. At 1.8 m, the telescope may be, by comparison with those of other observatories, on the small size; however, it is the 1.4-gigapixel digital camera the telescope uses that blows the competition away. With a wide-field view of the sky and a digital camera capable of that resolution, everything within the telescope's light-gathering range is captured in each image. Images are taken in six wavelengths, so there are a wide variety of celestial objects captured, including stationary objects within and outside of our galaxy, as well as those on the move, such as asteroids and comets. While the primary goal may be to detect and catalog solar system objects that possibly pose a threat, there are a lot of data collected simply by regularly imaging the sky. The project will begin making its database available to the public during the spring of 2013. In the meantime, students could be directed toward the PAN-STARRS web page to read about the wide range of objects about which science data are being collected and studied.

Among the objects so far detected is Comet C/2011 L4 PANSTARRS. Since its discovery in 2011 by the Pan-STARRS telescope, the comet has brightened at a rate that suggests it may reach naked-eye visibility and sport a tail. During March, the comet will be closest to the Earth and the Sun and should be at its brightest with its tail the longest. Unfortunately, during that time, the comet will not be very high above the horizon for Northern Hemisphere viewing. However, it will climb higher above the horizon over the following months as it moves outbound from the Sun and steadily become dimmer as its distance increases. See websites in Resources for more information about the comet.

FIGURE 2 A comparison of orbital positions and separation angles for inner and outer planets

Inner planet	Separation angle	Outer planet	Separation angle
Superior conjunction	0°	Conjunction	0°
Eastern elongation	Mercury:18°–28° Venus: 45°–47°	Eastern quadrature	90°
Inferior conjunction	0°	Opposition	180°
Western elongation	Mercury:18°–28° Venus: 45°–47°	Western quadrature	90°

February

1 Anniversary of the shuttle Columbia disaster (2003)
2 Waning gibbous Moon near Spica
3 Last quarter Moon near Saturn
4 Mars near Neptune
5 Waning crescent Moon near Antares
6 Mercury near Neptune
7 Moon at perigee: 365,300 km (226,987 mi.)
Moon occults Pluto
8 Mercury close to Mars
10 New Moon
11 Thin waxing crescent Moon near Mercury
15 Waxing crescent Moon near Hamal (Aries)
16 Mercury at east elongation
17 First quarter Moon
Moon near the Pleiades
Cassini Titan flyby
18 Waxing gibbous Moon near Jupiter
19 Moon at apogee: 404,500 km (251,345 mi.)
21 Neptune at superior conjunction
22 Waxing gibbous Moon near Gemini Twins
23 Martian northern hemisphere winter solstice
24 Waxing gibbous Moon near Regulus (Leo)
25 Full Moon
26 Mercury near Mars

Visible planets

Mercury will be visible over the western horizon at sunset.
Venus will be too close to the Sun to be visible this month.
Mars will be visible over the western horizon and set one or two hours after the Sun.
Jupiter will rise before sunset and be high over the southern horizon at sunset.
Saturn will rise around midnight and be high over the southern horizon at sunrise.

Questions for students

1. Why do we not see the planets move around the Sun in circular orbits? (*The Earth, and therefore our view or perspective, is from the same plane [level], more or less, as the other eight planets. Therefore, from our perspective, the planets' orbital motion appears to be a side-to-side pattern centered on the Sun.*)
2. Do both inner and outer planets have retrograde or westward motion? (*Yes and no. All planets do have retrograde motion, but only the inner planets are really moving westward during their retrograde motion. For an outer planet, retrograde motion is an apparent motion caused by the faster-moving Earth passing the outer planet.*)
3. How many degrees toward the east does the Sun appear to move each day? How does this compare with the inner planets Mercury and Venus? (*The Sun appears to move 0.98° each day: 360° ÷ 365.25 Earth days; Mercury: 360° ÷ 88 Earth days = 4° each day; Venus: 360° ÷ 224.7 Earth days = 1.6° each day.*)
4. Research idea: Find your birthday along the ecliptic. Note the constellation it is "within" and compare this to the horoscope constellation associated with your birthday. Are the two constellations the same? If not, what would account for the difference? (*Students should discover that the shift in constellations is a result of precession of the Earth's axes. Students may also notice that precession has added a 13th constellation, Ophiuchus, to the zodiac as the ecliptic crosses part of the constellation. Constellations are part of the zodiac if the ecliptic path passes through the boundaries of that constellation.*)

Resources

Cassini Saturn mission—*http://saturn.jpl.nasa.gov*
Comet C/2011 L4 PANSTARRS—*http://cometography.com/lcomets/2011l4.html*
Pan-STARRS—*http://pan-starrs.ifa.hawaii.edu/public*
Riddle, B. 2005. Scope on the Skies: Dance of the planets. *Science Scope* 29 (3–4): 66–68.
Riddle, B. 2011. Scope on the Skies: Comet watch. *Science Scope* 35 (2): 86–88.
Space shuttle Columbia—*www.nasa.gov/columbia*
Stephen F. Austin State University Observatory—*www.physics.sfasu.edu/observatory/obs.htm*
Star chart—*observe.phy.sfasu.edu/SFAStarCharts/SFAStarChartsAll.pdf*
Voyager mission—*http://voyager.jpl.nasa.gov*
Your Sky—*www.fourmilab.ch/yoursky*

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