Tracking planets around the Sun

by Bob Riddle

Since this series about the solar system began last September, the six visible planets, as well as the other two planets too distant to be seen with unaided eyes, have traveled along their respective orbital paths. In the process, the planets have, in some instances, shifted from visibility during the evening in the west, to being visible in the morning skies in the east. This is occurring regularly and the changing locations of the planets can be tracked in a variety of ways using any of several celestial coordinate systems.

In earlier columns, the celestial coordinate system of hour circles of right ascension and degrees of declination was introduced along with the use of an equatorial star chart (see SFA Star Charts in Resources). This system shows the planets' motion relative to the ecliptic, the apparent path the Sun follows during the year. An alternate system, using heliocentric longitude, places the viewer in an above-the-solar-system viewpoint, tracking the planets in their near-circular orbits around the Sun.

Heliocentric longitude

This is a coordinate system where planets are plotted on polar graph paper (see Resources) using degrees ranging from 0 to 360. The Sun is located at the 0° point and does not move, while the planets move in increasing longitude counterclockwise from the 0° point. Using the data in Figure 2, students can plot the positions for the planets over a three-month period, approximately the orbital period or length of one Mercurian year. For the outermost planets, the longitudes are given using more precise values, as these planets move less than 1° each month. One degree in the sky is approximately twice the angular diameter of the full Moon (29–33 minutes of arc).

As students plot the planet positions, they should keep in mind that the orbits they are plotting are on circles, while all of the planets actually have orbits that are somewhat elliptical. Students can use Figure 1 to compare the shapes of the orbits. Eccentricity is a measure of how circular or elliptical the shape of an orbit is using a scale from 0 to 1 where 0 is a circle and 1 is a straight line. This is an appropriate time to review or introduce Kepler's laws of planetary motion.

To continue the plotting of planetary heliocentric longitudes, download or print the monthly coordinates from the Planet Watch website (see Resources). An alternate source that gives more flexibility in its application is the freeware program Interactive Computer Ephemeris (ICE). It can be downloaded from the link provided (see Resources) and used to generate heliocentric longitudes, as well as other astronomical data. The program runs in a DOS window on a PC and is a bit confusing at first use; once it is

FIGURE 1 Planet orbital data

	Mercury	Venus	Earth	Mars	Jupiter	Saturn	Uranus	Neptune
Distance from Sun (million miles)	36.0	67.2	93.0	141.6	483.8	890.8	1,784.8	2,793.1
Perihelion (million miles)	28.6	66.8	91.4	128.4	460.1	840.4	1,703.4	2,761.6
Aphelion (million miles)	43.4	67.7	94.5	154.9	507.4	941.1	1,866.4	2,824.5
Orbital period (Earth days)	88.0	224.7	365.2	687.0	4,331	10,747	30,589	59,800
Orbital eccentricity	0.205	0.007	0.017	0.094	0.049	0.057	0.046	0.011

FIGURE 2 Heliocentric coordinates and average distance from the Sun

Mercury

Date	Longitude (°)	Distance (AU)
March 1	227	0.450
March 31	314	0.416
April 10	354	0.361
April 30	110	0.316
May 10	163	0.364
May 30	233	0.456

Venus

Date	Longitude (°)	Distance (AU)
March 1	279	0.727
March 31	326	0.7280
April 10	342	0.7275
April 30	14	0.7255
May 10	30	0.7242
May 30	62	0.7215

Earth

Date	Longitude (°)	Distance (AU)
March 1	160	0.9908
March 31	190	0.9990
April 10	200	1.001
April 30	220	1.007
May 10	229	1.009
May 30	248	1.013

Mars

Date	Longitude (°)	Distance (AU)
March 1	124	1.639
March 31	137	1.656
April 10	141	1.660
April 30	150	1.665
May	154	1.665
May 30	163	1.664

Jupiter

Date	Longitude (°)	Distance (AU)
March 1	276	5.225
March 31	279	5.214
April 30	281	5.203
May 30	284	5.192

Saturn

Date	Longitude (°)	Distance (AU)
March 1	155	9.281
March 31	156	9.290
April 30	157	9.298
May 30	158	9.306

Uranus

Date	Longitude (°)	Distance (AU)
March 1	348	20.096
March 31	348	20.096
April 30	349 12′	20.097
May 30	349 31′	20.097

Neptune

Date	Longitude (°)	Distance (AU)
March 1	321 50′	30.041
March 31	322 00′	30.040
April 30	322 11′	30.039
May 30	322 22′	30.039

set up, it will calculate useful data about planets for students to plot and study.

March equinox

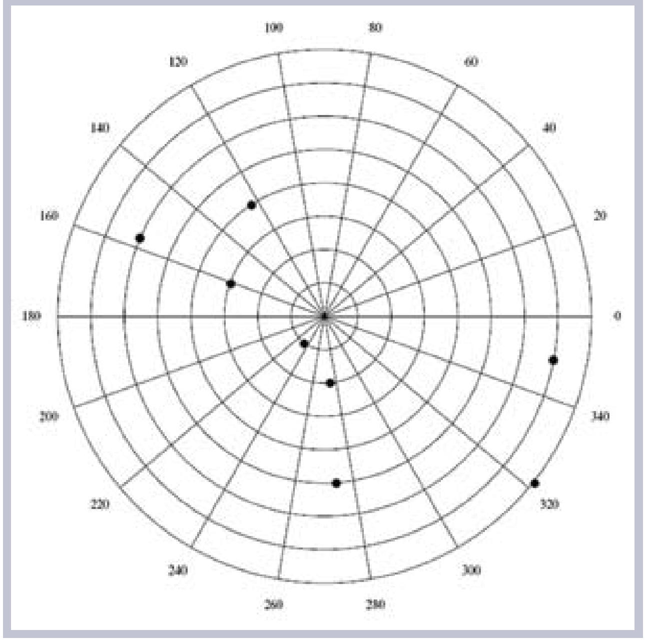
On March 20, 0148 EST (1:48 a.m.), the Sun will reach the astronomical coordinates of 0 hours and 0 degrees. This is one of two days during the year where, in general, the Sun rises due east and sets due west, giving rise to an equal amount of daylight and night, or an *equinox*. This is also the day marking a change of seasons for both the Northern and Southern Hemispheres. Thinking globally, an equinox should be known by the month during which it occurs rather than the traditional and Northern Hemisphere term. Instead of the vernal or spring equinox, we should refer to it as the March equinox.

Visible planets

Mercury will be visible low over the eastern horizon before sunrise. Use the much brighter-appearing Venus to help locate Mercury.

Venus will be visible low over the eastern horizon before the sunrise. Watch for the much dimmer-appearing Mercury to lie to the right of Venus early in the month

FIGURE 3 Heliocentric positions of planets for March 1, 2008



and to the left of Venus by the end of the month.

Mars will be over the southern horizon at sunset and will be visible the rest of the night, setting a few hours after midnight.

Jupiter will rise about two hours before sunrise and will be easily seen shining brightly over the southeastern horizon.

Saturn will rise after sunset and will be visible the remainder of the night. By sunrise, Saturn will be low over the western horizon.

Celestial events

3/2	Moon west of Jupiter
3/3	Moon east of Jupiter
	Mercury at west elongation
3/5	Thin crescent Moon near Mercury and Venus
3/7	New Moon
3/9	Spring forward—Begin Daylight Saving Time
	Uranus in conjunction with Sun
3/12	*Cassini* flyby of Enceladus
	Mars passes M35
3/14	First quarter Moon
	Moon near Mars
3/18	Moon near Saturn and Regulus
3/20	March equinox (0548 UT)
3/21	Full Moon
3/25	*Cassini* flyby of Titan
3/29	Last quarter Moon
3/30	Moon near Jupiter

Questions for students

1. How many degrees does the Earth move along its orbital path each day? Explain how this is different from the amount any of the outer planets move each day. (*The Earth moves nearly 1° [0.9856°] each day in its orbit around the Sun. Because an outer planet, one further from the Sun, takes longer to orbit the Sun than one closer to the Sun, the Earth moves more quickly, and thus travels more along its orbit than a more distant outer planet.*)
2. Using Figure 1, how would you know which of the eight planets has the greatest range in distance from the Sun? (*The eccentricity of an orbiting object is a measure of how circular the orbit is. The values for eccentricity range from circular, 0, to a straight line, 1. Mercury has the greatest eccentricity of the planets with a value of 0.205.*)
3. Use the internet to research Johannes Kepler and the laws of planetary motion he developed. Which of the three Kepler's laws applies to the varying speed that planets have as their distance from the Sun increases? (*Kepler's second law, sometimes referred to as the law of equal areas, is a description of the speed each planet will move as it orbits the Sun. Planets move more quickly when close to the Sun and more slowly when further away.*)

Resources

Daylight Saving Time—*http://geography.about.com/cs/daylightsavings/a/dst.htm*

Heliocentric calculator—*http://nssdc.gsfc.nasa.gov/space/helios/planet.html*

ICE software—*www.astro.uio.no/ita/TNP/ice/ice.html*

Planet watch—*http://currentsky.com*

Polar graph-paper maker—*www.incompetech.com/graphpaper/polar*

Riddle, B. 2006. Scope on the skies: The equinox. *Science Scope* 29 (6): 78–79.

SFA star charts—*www.midnightkite.com/starcharts.html*

Sun Shadow Investigation Project—*http://sunship.currentsky.com*

The Eggquinox—*http://currentsky.com/articles/eggquinox*

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