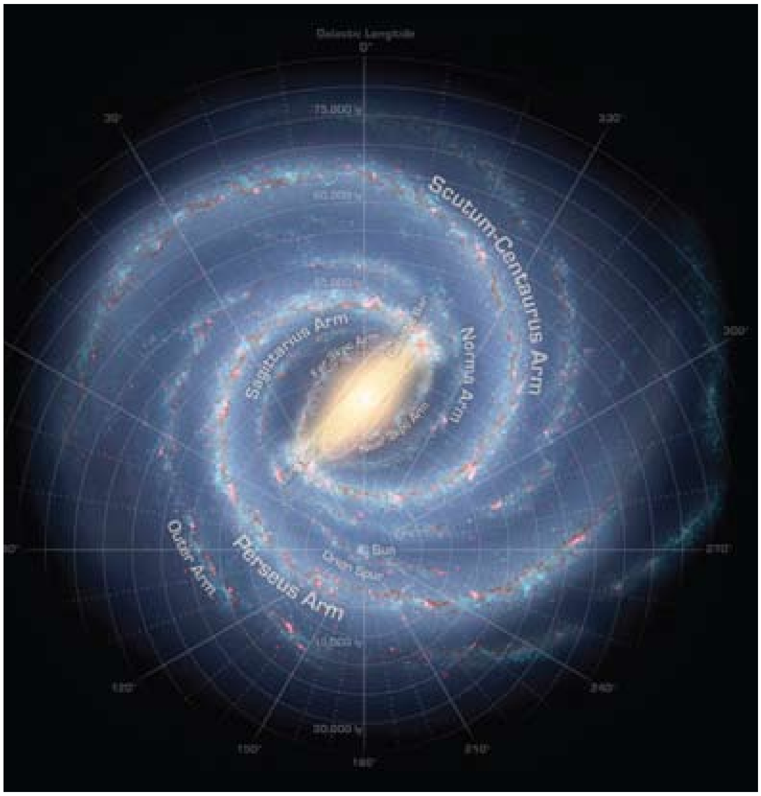
International Year of Astronomy

by Bob Riddle



New model of the Milky Way galaxy

During the year 1608, Hans Lippershey, a Dutch spectacle maker, applied for a patent describing an instrument that could be used to make distant objects appear closer. At about the same time, several others either filed for patents or claimed the rights for inventing what we now know as a telescope. Due to the many disputes, no patent was ever issued for the invention and it did not take much time before others started making their own telescopes, including Galileo Galilei, a mathematics professor at the University of Padua in Italy. In 1609, Galileo apparently became the first to aim a telescope skyward and, among other observations, viewed craters on our Moon, sunspots, the phases of Venus, and moons orbiting Jupiter. With observations such as these, Galileo helped to dispel the belief in a geocentric universe by providing evidence that proved otherwise.

This year marks the 400th anniversary of when a telescope was used for astronomical observations, and 2009 has also been designated the International Year of Astronomy—a yearlong celebration of astronomy through various events and activities both online and in the real world. These include the GLOBE at Night star count program; 100 Hours of Astronomy; Astronomy Day; and Space Week (see Resources).

The ride of your life

On January 4, 2009, the Earth reaches *perihelion*, the closest our planet comes to the Sun. At perihelion the Earth is approximately 0.98 AU from the Sun as compared to July 3rd, when at aphelion the Earth is 1.02 AU distant. While it may seem counterintuitive to be closest to the Sun while you are shivering during the chill of winter, it is the nature of having an elliptical rather than a circular orbit. And keep in mind that it is only winter for us north of the equator. Folks in the Southern Hemisphere are enjoying their summer season.

While you are reading this column and passing closest to the Sun, you are also moving through space in other ways than simply orbiting the nearest star. The obvious ways are the ones we teach our students—rotating with the Earth as it spins on its axis and revolving with the Earth around the Sun. However, our Sun is also moving with the other stars, dust, and gases making up the Perseus Arm of the Milky Way Galaxy as we revolve around the galactic center at a distance of around 28,000 light years. As it revolves around the galactic center, the Sun also oscillates (moves up and down) relative to the galactic plane by about 1% of the galaxy's diameter, or about 1,000 light years. Our Sun, as a disk star (stars in the disk-shaped part of a galaxy), also has its own proper motion that is taking us and the rest of the solar system across the Orion Spur, a short branch off of the main Perseus Arm, in the direction of the star Vega in the constellation Lyra, the Harp.

The orbital motion of the Sun is a result of the gravitational attraction of the mass at the galaxy's center, but this does not mean that distance from the center influences the orbital speed. In other words, stars in the spiral arms closer to the galactic center do not orbit faster than more distant stars. We know this because if the closer stars did move faster, the spiral arms would wrap and twist around

the center. Instead, the stars all move at about the same orbital speed around the galactic center.

The oscillations, or bobbing motion, of a disk star result from its initial position above or below the galactic plane and the gravitational attraction of the galaxy's disk. A star not on the plane is attracted toward the plane, but the density of the disk is not enough to stop the star, and so the star keeps on moving, passing through the disk. However, the gravitational attraction of the disk will slow down the star and pull it back toward the disk, where the star will again pass through the disk. This is repeated several times during a revolution around the galactic center, a galactic year of approximately 200 million years.

Fasten your seat belt

Obviously, we are not sitting still, so how fast are we moving through space and how could we determine this? The answers depend on determining the velocity as well as the distance traveled, which in this case will be the circumference of what is being orbited. Velocity is calculated using the formula $v = d/t$ (velocity equals distance divided by time). The distance or circumference is calculated using the formula $C = 2\pi r$ (circumference equals 2 times pi times the radius). With these formulas and some readily available information, students could calculate the rotational speed of the Earth's equator, and the speed at which our planet (and other planets) revolve around the Sun. The following examples may serve as a guide for completing the calculations. The values used in the examples are rounded off.

Example 1: Rotation speed at the Earth's equator
Circumference of the Earth at the equator: 40000 km
Time for one rotation: 24 hours
Rotation speed at the equator = 40,000 km/24 hours = 1,666.66 km/h

Example 2: Revolution speed around the Sun
Radius (distance from the Sun) 150,000,000 km
Time for one revolution: 365.25 days (8,766 hours)
Circumference of Earth's orbit: (2 × 3.14) × 150,000,000 km = 942,000,000 km
Revolution speed around the Sun = 942,000,000/8,766 = 107,460 km/h

So, if the Earth is rotating at 1,666 km/h, how come we do not feel it? This is an interesting discussion where with some direction, students will realize that they do not feel the Earth's rotation because the Earth rotates at a constant speed. I start with asking how they knew the bus that brought them to the planetarium was moving. Before I listen to their ideas, I have them imagine that they are in a bus with no windows to open or look out or hear outside sounds through. They do not hear the bus engine, and the road is so smooth that there are no bumps. So how do students know the bus is moving? When it slows down or speeds up, their bodies move in the opposite direction (see Questions for Students for follow-up).

Visible planets

Mercury is low over the western horizon at sunset and will be visible for the first two weeks of the month.
Venus is very visible over the western horizon at sunset, setting several hours later.
Mars is still too close to the Sun to be seen.
Jupiter is low over the western horizon near Mercury but is lost in the Sun's glare by the middle of month.
Saturn rises at about midnight local time and is located over the southern horizon at sunrise.

January

1	Start of International Year of Astronomy
3	Quadrantids meteor shower
4	First quarter Moon
	Earth at perihelion
	Mercury at greatest east elongation
10	Moon perigee: 357,501 km
11	Full Moon
14	Venus at greatest east elongation
18	Last quarter Moon
20	Mercury at inferior conjunction
21	Moon near Antares (a.m.)
23	Moon at apogee: 406116 km
24	Jupiter in conjunction with the Sun
26	New Moon
26	Annular solar eclipse
29	Venus near Moon

Resources

100 Hours of Astronomy—*www.100hoursofastronomy.org*
Annular Solar Eclipse—*http://eclipse.gsfc.nasa.gov/SEplot/SEplot2001/SE2009Jan26A.GIF*
Astronomy Day—*www.astroleague.org/al/astroday/astroday.html*
A Two-Armed Galaxy—*www.spitzer.caltech.edu/Media/releases/ssc2008-10/visuals.shtml*
Complete Sun and Moon Data—*http://aa.usno.navy.mil/data/docs/RS_OneDay.php*
Earth's Seasons—*http://aa.usno.navy.mil/data/docs/EarthSeasons.php*
GLOBE at Night—*www.globe.gov*
International Year of Astronomy—*www.astronomy2009.org*

Northern and Southern Hemisphere Star Maps—*http://skymaps.com*
SFA Star Charts—*http://midnightkite.com/starcharts.html*
World Space Week—*www.*worldspaceweek.org
Worldwide Telescope—*www.worldwidetelescope.org*

Questions for students

1. Use the examples and data from the textbook or internet and have students determine the rotational and revolution speeds for the planets. Is there any pattern?
   If there is a pattern, it could be that the terrestrial planets (Mercury, Venus, Earth, Mars) have relatively long rotation rates and short revolution periods compared with the Jovian planets (Jupiter, Saturn, Uranus, Neptune).
2. Involve students in a discussion about how we do not feel these various motions. Use Earth's rotation as a starting point.
   As the Earth rotates we feel no sensation of motion because the rotation does not speed up or slow down—it maintains a steady and constant speed. If the Earth did have a herky-jerky rotation, I'm sure it would be noticed!
3. This month at new Moon there will be an annular eclipse rather than a total solar eclipse. What is an annular eclipse and why is the sun not completely covered?
   The Moon's average apparent size is approximately the same as the apparent size of the Sun. However, the shape of the Moon's orbit is elliptical and its apparent size at new Moon phase varies. As a result, during mid-eclipse the Moon will either entirely cover the Sun or fit within the Sun's disk, leaving a 'ring of fire,' called the annulus, *around the Moon.*
4. The image in this month's column is based on data obtained with the Spitzer telescope, and shows the newest model for the structure of our galaxy. Students could research what we have learned from this mission and others that observe the universe in nonoptical wavelengths and how these have contributed to a better understanding of the structure of our galaxy and the universe.

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