Rocks, robots, and ices

by Bob Riddle

Solar system exploration in November includes flybys of Saturn's moons, a comet, and the next-to-last launch of a space shuttle before the shuttle program ends. In addition, on November 1 and 29 before sunrise, the waning crescent Moon will be close to asteroid 3 Juno (see Figures 1a and 1b). In fact, by observing the Moon and using some of the stars in the background for reference, you may notice after your November 1 viewing that the Moon returns to the same location relative to asteroid 3 Juno 28 days later on November 29; however, its waning crescent phase appearance is not the same as it was on November 1.

The Moon-phase cycle

Our Moon orbits the Sun with the Earth. As they do so, the Moon goes through a regular cycle of phase changes that take approximately 28 days. So 28 days after a first quarter Moon, the Moon would again be at first quarter—but only if the Earth were not revolving during that 28-day period. Pause in your orbit for a moment and think about this. In order for the Moon to show the same phase appearance, it would have to be in the same physical arrangement with the Earth and the Sun, which takes approximately 28 days. However, the Earth is also moving in its orbit as the Moon goes through its phase cycle. At the end of 28 days, they are not in the same physical arrangement as they were 28 days before. It takes an additional two to three days of Earth revolution for that same physical arrangement to happen, which is why the Moon may be back to where it was 28 days before, close to the location of asteroid 3 Juno in this example, but not yet at the same waning phase. (See September 2006 "Scope on the Skies" for additional information about the Moon cycle.)

Rock on

Asteroid 3 Juno is the 10th-largest asteroid, measuring about 230 km in diameter at its greatest dimension. Originally known as a minor planet, asteroid 3 Juno was the third object (now known as an asteroid) discovered

FIGURE 1a 0600 EDT November 1, 24.23 days old, waning crescent

FIGURE 1b 0600 EST November 29, 22.8 days old, waning crescent

orbiting between Mars and Jupiter. It is classified as an S, or stony, type of asteroid and is composed of nickel, iron, and magnesium silicates. Asteroid 3 Juno is a relatively bright asteroid, and with a highly eccentric orbit it becomes binocular bright when at perihelion. Unfortunately, this year is not a perihelion year for 3 Juno, so it will not become bright enough to be seen with binoculars. However, on November 1 and 29, the stars just above the location of the waning crescent Moon and 3 Juno will be bright enough to be used for this observation. The stars belong to Leo the Lion, with the brighter Regulus above to the right or west of the Moon, and the tail of the lion Denebola above and to the left or east.

STS-133 Discovery

Tentatively scheduled for launch on November 1 is the *STS-133 Discovery* mission to the International Space Station (ISS). This will be the next-to-last shuttle mission before the shuttle program ends with the launch of *STS-134 Endeavour* during February of next year. *STS-133* is the 35th mission to the ISS, and during the 11-day mission the shuttle crew will deliver and help install several final components that include a permanent multipurpose module and an express logistics carrier. The multipurpose module will add additional rack space for mounting experiment packages and equipment. The logistics carrier, when attached to the exterior of the ISS, will provide rack space and electricity for experiments intended to be done outside the ISS in space. Having a space-exposed platform for conducting experiments will eliminate some need for satellite-based experiments.

A particularly exciting aspect of this shuttle mission is that one of the passengers on board will become the first permanent resident of the ISS. Nicknamed R2, this passenger is a 300-pound robot known properly as Robonaut 2 (see Figure 2). Developed by General Motors and NASA, this space-faring robot has been built from the waist up to be able to work side-by-side with astronauts or to work independently on tasks designed specifically for the robot. Robonauts are not intended to be replacements for human astronauts; however, these next-generation robots have the dexterity and speed to accomplish many of the

FIGURE 2 Robonauts with tools

repetitive tasks done by humans during space walks, or extra-vehicular activity.

Rendezvous with a comet—again

On November 4, the *Deep Impact* spacecraft will coast past comet Hartley 2, a periodic comet with an orbital period of about six years and three months. The *Deep Impact* spacecraft gained some notoriety in July of 2005 when it slammed a 370 kg copper mass into comet Tempel 1. The resulting impact allowed instruments on board the *Deep Impact* spacecraft to analyze the subsurface composition of the comet. Following that comet encounter, the spacecraft was repurposed to serve in another mission to study a different comet. *Deep Impact/EPOXI* is a joint mission and named after two scientific studies, Extrasolar Planet Observation and Characterization (EPOCh) and the Deep Impact Extended Investigation (DIXI). In November, *Deep Impact* will employ the same instruments used in its Tempel 1 mission to study Hartley 2.

According to predictions, comet Hartley 2 is estimated to reach fifth magnitude this month, making it bright enough to be seen with the naked eye or binoculars, providing the sky is dark enough. The comet will be passing across the stars of the constellation Cygnus the Swan. This constellation, also known as the Northern Cross, will be nearly straight overhead during the evening hours. Its brightest star, Deneb, at the top of the cross shape, will be the uppermost star in the familiar fall star pattern, the Summer Triangle. (See Resources for more information about comet Hartley 2.)

Leonid meteor shower

A discussion of periodic comets would not be complete without mentioning the connection between comets and meteor showers. Debris left behind by comets that lie along the Earth's orbital path becomes the source for the annual meteor showers we experience each month on about the same dates. The Leonids, named for the location of the sky the meteors appear to radiate from (see Resources for more viewing information), will reach their peak on November 17. This will be a good time to view the Leonids, despite the early hours, because the Moon will have set by the time Leo and the meteor shower radiant rise in the east. ■

November

1 Launch of *STS-133 Discovery*
Moon near Regulus (Leo)
2 Moon near asteroid 3 Juno
3 Moon at perigee: 364,191 km
4 Moon near Saturn
Deep Impact/EPOXI flyby of comet Hartley 2
6 New Moon
7 Daylight Saving Time ends
Moon near Mars
Neptune ends retrograde
11 *Cassini* flyby of Titan
13 First quarter Moon
14 Moon near Neptune
15 Moon at apogee: 404,631 km
Mercury near Antares (Scorpius)
Moon near Jupiter
17 Leonid meteor shower peak
Venus near Spica (Virgo)
18 Neptune at east quadrature
19 Jupiter ends retrograde
20 Mercury near Mars
21 Full Moon
Moon near Pleiades
28 Last quarter Moon
29 Moon near asteroid 3 Juno
30 Moon at perigee: 369,430 km
Cassini flyby of Enceladus

Questions for students

1. In addition to the S-type, or stony, asteroids, what other types of asteroids are there? *(When students investigate this question, they will find out that asteroids are classified into types based on their composition as determined by spectra and by location within the solar system.)*
2. Does the Moon revolve around the Earth? *(From our perspective, it appears that the Moon revolves around the Earth; however, the two actually rotate around the balance point, or* barycenter, *of the Earth and Moon system, and together they both revolve around the Sun.)*
3. What is a *barycenter* and where is it for the Earth–Moon system? *(A* barycenter *is the balance point or center of mass for two objects; for the Earth–Moon system the barycenter is located below the surface of the Earth.)*

Visible planets

Mercury will be visible, but low above the southwestern horizon, all month at sunset.
Venus will be visible above the eastern horizon at sunrise.

Mars will be very low above the southwestern horizon at sunset and will set within an hour after sunset.
Jupiter will be visible above the southern horizon at sunset and will set after midnight.
Saturn will be visible above the eastern horizon before sunrise.

Resources

Asteroid information—*http://nssdc.gsfc.nasa.gov/planetary/planets/asteroidpage.html*
Cassini Mission—*http://saturn.jpl.nasa.gov*
Comet Hartley 2—*http://cometography.com/pcomets/103p.html*
Deep Impact/EPOXI Mission—*www.nasa.gov/mission_pages/epoxi/index.html*
Earth–Moon barycenter—*http://prisms.mmsa.org/review.php?rid=534*
Leonid meteor shower—*http://meteorshowersonline.com/leonids.html*
Riddle, B. 2006. Scope on the skies: Luna. *Science Scope* 30 (1): 76–78.
Robonaut 2 home—*http://robonaut.jsc.nasa.gov*
Robonaut 2 fact sheet—*www.nasa.gov/pdf/464887main_Robonaut2FactSheet.pdf*
STS-133—*www.nasa.gov/mission_pages/shuttle/shuttlemissions/sts133/index.html*
Where is the barycenter?—*www.astronomycafe.net/qadir/q665.html*

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