# Astrodynamics

This has been a year of exciting encounters. On February 15, NASA's Stardust-NExT probe 're-encountered' Tempel-1 and observed the changes in the impact crater created by the Deep Impact mission during its encounter in 2005. After the flyby, Stardust-NExT performed a 'burn-to-depletion' sequence to gather engineering data to be used for future spacecraft design.

Launched in August 2004 and followed by six gravity assists at Earth, Venus, and Mercury, the MESSENGER (Mercury surface, space environment, geochemistry, and ranging) spacecraft entered orbit around Mercury on March 17, becoming the first spacecraft to orbit our solar system's innermost planet.

After nearly four years of solar electric propulsion cruise, on July 15 Dawn became the first spacecraft to orbit Vesta. More important, it is the first to use a low-thrust system to spiral in at an asteroid. Dawn will observe Vesta's surface composition and interior structure until it spirals out in 2012 and departs for its second science target, the dwarf planet Ceres.

After complex mission operations, the two ARTEMIS (acceleration, reconnection, turbulence, and electrodynamics of the Moon's interaction with the Sun) probes reached lunar orbit in July and will observe the Sun-Moon interaction for the next 7-10 years. China's second lunar probe, Chang'e-2, departed the Moon after completing its primary objective and reached the Sun-Earth L2 point. This made China the third country to have visited L2.

On December 7, 2010, Japan's Akatsuki spacecraft failed to enter its planned orbit around Venus due to underthrusting of its main engine. Akatsuki will attempt another orbit insertion burn when the probe returns to Venus in about six years. Launched from the same vehicle, the Japanese spacecraft IKAROS (interplanetary kite-craft accelerated by radiation of the Sun), the first successful interplanetary solar sail mission, accomplished all the mission objectives and has been extended to gather engineering data for future missions of this kind. The USAF's advanced extremely high frequency (AEHF) satellite had a major problem with its primary liquid apogee engine soon after launch in 2010. As an emergency plan, the satellite used its 5-lb Hall current thrusters to recover from the failure and to achieve its expected orbit altitude over a year's transfer time.

The shuttle Atlantis landed at the Kennedy Space Center on July 21, ending its final mission. This also ended the U.S. space shuttle program, after 30 years and 135 missions. For the next-generation program, NASA is designing and building the multipurpose crew vehicle and the heavy-lift SLS (Space Launch System) for future human exploration of the solar system.



*Vesta's south pole was captured by the Dawn spacecraft's framing camera from a distance of about 1,700 mi. Courtesy NASA/JPL-Caltech/UCLA/MPS/DLR/IDA.*

Two historic observations took place this year. One was the discovery of an Earth Trojan asteroid, designated 2010 TK7. First detected by NASA's WISE (wide-field infrared survey explorer) mission, with follow-up observation by researchers at Athabasca University in Canada, the asteroid was shown to be stable for at least the next several thousand years. Farther away in the outer planet system, the Hubble space telescope discovered a tiny new moon orbiting Pluto, making it the fourth moon of the icy dwarf planet. This is an invaluable discovery for the New Horizons mission for planning close-up observations scheduled in 2015. On November 7 a near-Earth asteroid passed within 0.85 lunar distances from the Earth. Measuring 400 m across and named 2005 YU55, it presented an excellent opportunity for ground-based observations.

Finally, Moscow State University hosted the fifth global trajectory optimization competition. The objective of this international contest was to "make a rendezvous mission to a given asteroid most worthwhile by visiting the largest number of other asteroids on the way." This year's winner was a JPL team whose tour design consisted of 18 asteroid visits. Å

by **Ryan S. Park**