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Exploring the smallest terrestrial planet: Dawn at Vesta

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Abstract

The Dawn mission is designed to map Vesta and Ceres from polar orbit for close to one year each. The ion-propelled Dawn spacecraft is illustrated in Figure 1. Dawn carries a framing camera with clear and color filters, a visible and infrared mapping spectrometer, a gamma ray and neutron spectrometer, and obtains radiometric data on the gravity field. The camera obtains stereo imagery from which a global shape and topography model are derived. The mapping spectrometer determines the mineral composition of the surface and the gamma and neutron spectrometer determines the elemental composition. As Dawn approaches Vesta, as illustrated in Figure 2, it measures the rotational characteristics of the body to determine the orientation of the rotation axis. This in turn determines when solar illumination reaches the north pole and when mapping can be completed. As shown in Figure 3, there are three science orbits: Survey at a radial distance of 3000 km and a period of 69 hr; high-altitude mapping at a radial distance of 950 km and a period of 12.3 hr; and low-altitude mapping at a radius of 465 km and a period of 4 hours. Vesta is the ultimate source of the HED meteorites from which much has been learned about their parent body. By the time of this presentation we will have surveyed the region around Vesta for moons, determined a much more accurate mass and rotation axis for Vesta, and have preliminary information on surface features and composition from the survey orbit.

1. Why Vesta

Vesta was formed, according to dating information gained from the HED meteorites, in the solar system's first 5 million years. Thus its surface should be much older than that of the Moon and of those of the terrestrial planets. We believe that Vesta accreted close to the time of a supernova explosion and so contained short-half-life radionuclides that provided sufficient heat to melt Vesta, drive off the water and allow differentiation and formation of an iron core. The existence of an abundant source of meteorites on Earth that came from Vesta or Vesta-derived material allows us deep insight into geochemistry of this body, albeit without geologic context. The images of Vesta's surface provide that missing geologic context for the Howardite, Eucrite and Diogenite (HED) meteorites. These meteorites indicate that Vesta's crust and interior are significantly different and its evolutionary history is different from those of the Moon.

As Figure 4 shows, Vesta is larger than previously visited asteroids. It is the second most massive asteroid in the main belt. Its roundness reveals that it is close to hydrostatic equilibrium. It is one of the fastest rotators of the large asteroids with a period of 5.342 hours. Based on HST imagery, Vesta is thought to have a large impact structure surrounding its south pole. Initial observations with Dawn are not inconsistent with this hypothesis, but the surrounding terrain is unlike other impact basins. Away from the south pole Vesta has a very old heavily cratered surface.

Vesta is a bright object with a higher albedo than most of the other asteroids and higher than those of the Moon and Mercury. Color images reveal prominently colored units, more so than on other asteroids. It has a diversity of composition similar to the diversity on the Moon and Mercury. Its spectral features due to ferrous iron near 1 micron are prominent globally on Vesta, not just locally as on other airless bodies, and in stark contrast to Mercury where they are absent.

In this talk and the following talks, we discuss our current understanding of this complex body and what it is teaching us about the earliest days of the solar system.

2. Figures

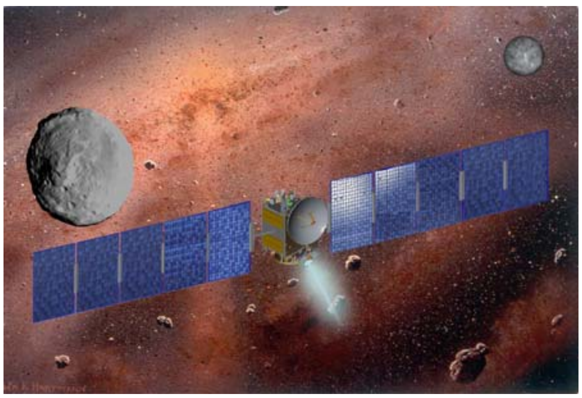

Figure 1. An artist’s conception of the Dawn spacecraft firing one of its ion thrusters on the way to Vesta (left) with Ceres in the background (right).

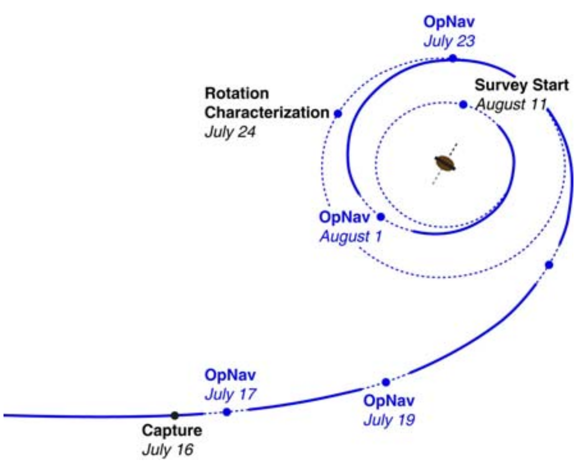

Figure 2. Dawn’s approach trajectory.

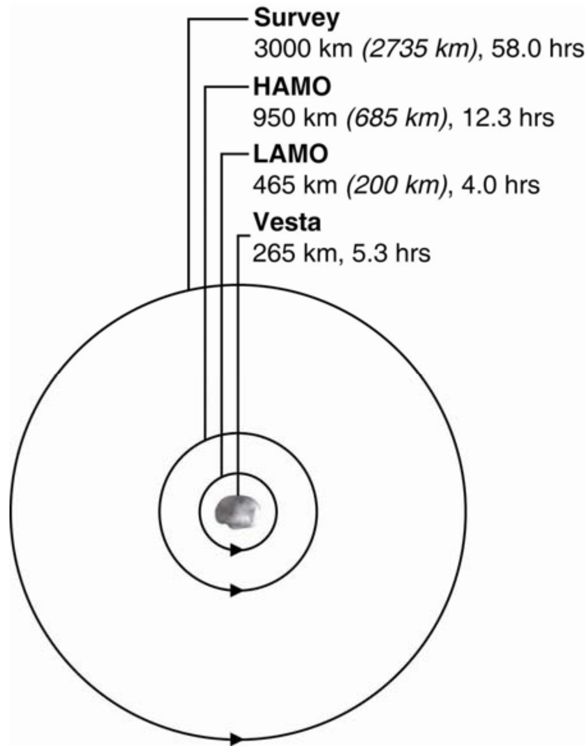

Figure 3. Dawn’s three mapping orbits. Vesta radius used is the mean radius. Radial distances (altitudes) given for each of the 3 orbits.

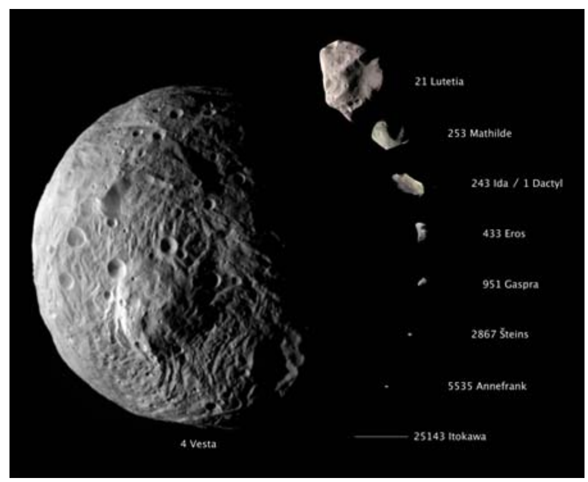

Figure 4. Vesta seen from over its south pole in comparison with other asteroids visited to date