Dawn spacecraft enters orbit around Ceres

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NASA's Dawn spacecraft successfully entered orbit around Ceres on March 6. It is the first spacecraft to successfully orbit two extraterrestrial bodies, enabling it to provide data on two different primordial objects in the solar system.

Ceres was first discovered by Italian astronomer Giuseppe Piazzi in 1801 as part of a broader search for a suspected planet between the orbits of Mars and Jupiter. When first discovered, Ceres was believed to be the "missing planet" being searched for. However, as other objects at approximately the same orbit were discovered, it was realized that Ceres, Pallas and other recently discovered bodies were not planets but something much smaller. To classify them, astronomer William Herschel coined the term asteroids ("star-like").

Despite this, Ceres, Pallas, Vesta and Juno, the first four asteroids to be discovered, were still classified as planets until 1845. They appeared in textbooks across Europe and were even given their own unique symbols. It was only in the late 1840s, starting with the discovery of Astraea and a slew of other asteroids, that it was accepted that they were too small and numerous to be planets. It was around this time that the phrase "asteroid belt" was coined to describe the region between Mars and Jupiter where all these objects were housed. More than 100,000 asteroids have since been discovered.

Since then, asteroids and the larger dwarf planets have been objects of great interest to the astronomical community. Asteroids (and their larger cousins dwarf planets, such as Ceres) do not exist only in the asteroid belt. Some are in Jupiter's orbit, locked very tightly in place by the gas giant's powerful gravity. Others have orbits that take them inside Earth's orbit and there is a possibility for a mission to one of these in the near future.

It is thought that during the solar system's formation, large bodies such as Ceres acted as embryos for the creation of even larger rocky worlds, including the inner solar system planets, the Moon and the larger satellites of the gas giants. That Ceres didn't become a planet is most likely due to the gravitational domination of Jupiter, which either caused planetary embryos to collide with each other or ejected them from the solar system entirely. Ceres escaped both of these fates.

Studies of Ceres, Vesta (Dawn's first target) and other objects in the asteroid belt provide insights into the conditions of the solar system during its formation. Ceres seems geologically unchanged since its formation and its hypothesized rocky core and icy mantle proves true, provide a glimpse of solar system temperatures from 4.6 billion years ago. On the other hand Vesta is more evolved and much more dense, providing insight into the type of primordial material that become the cores of the inner planets, including Earth. By looking at both of these bodies, Dawn allows astronomers to compare the evolutionary history of each and further refine models of the Solar System's formation.

Both objects are also worth looking at in themselves. Vesta has an unusually large rotation rate, possibly caused by the collision that took off about one percent of its mass. It also is not in hydrostatic equilibrium, meaning that its structure is not stable.

Ceres is even more intriguing. It is the smallest known object in the solar system to have enough gravity to be spherical in shape, rather than oblate. There is a possible atmosphere caused by sublimation of ice on the surface or volcanic activity driven by internal radioactivity that spews out ice crystals. In the approach to Ceres, Dawn photographed two bright spots on the dwarf planet's surface, which could be mineral flats, plumes of water vapor, or something else entirely. It is also suspected that Ceres may have an ocean of liquid water under its surface, which makes it

a candidate for the presence of life.

Over the coming months, Dawn will provide a clearer understanding of these phenomena. On approach to Ceres, its three instruments—provided by Germany, Italy and the United States—have already provided image quality exceeding that of the Hubble Space Telescope. No doubt over the coming period, they will continue to uncover more about this rocky and icy world.

It is worth mentioning Dawn's propulsion system. While the launch was done using a conventional chemical rocket, the engines used to propel it through the solar system are somewhat unconventional ion thrusters. Instead of directing the explosion of a chemical reaction, Dawn accelerates a stream of xenon atoms behind it, slowly but steadily changing its velocity using Newton's Third Law of Motion. The effect is similar to pushing someone away while ice-skating. With no friction, both people move away from the original point of contact.

This is what has allowed Dawn to visit both Vesta and now Ceres. If normal rockets were used, the weight constraints needed to keep that much fuel around would have been prohibitive. On the other hand, relatively little atomic material is needed to form the thrust that is needed to maneuver a spacecraft using ion propulsion. This has allowed Dawn to change its velocity over the course of its mission by more than 10 kilometers per second, almost twice the previous record. It also means that Dawn will be able to change the size of its orbit around Ceres, which currently stands at 13,500 kilometers. By November, that orbit will be spiraled down to 375 kilometers.

Ion thrusters have been envisioned by astronomers for more than a century. Robert Goddard first postulated the idea in a notebook in 1906 while Konstantin Tsiolkovsky was the first to publish in 1911. Since then, it was realized that such a system would be ideal in a near-vacuum or vacuum environment. While research into it dropped off somewhat in the ensuing decades, both the US and Soviet Union again looked into this idea in the 1950s and 1960s. While research into this technology dropped off in the US, the Soviet Union realized that such engines were excellent at stabilizing and maintaining orbits and so deployed more than 100 throughout the Cold War. It was only in 1992 and the introduction of Soviet science into the Western world that ion thrusters were again seriously considered.

Dawn is a remarkable achievement. After more than two centuries of study, internationally organized effort has made the study of some of the oldest objects in the solar system possible. The coming months will see a dramatic increase in our understanding of how the planets came to be.