

Exploring the Asteroids

By Colin Johnston, Science Communicator

Between Mars and Jupiter lies the Asteroid Belt. Relics of the Solar Nebula, these asteroids are the leftovers of the Solar System. Churned by giant Jupiter's gravity, they are stuff that never had the chance to become a planet. There are about a million asteroids with a diameter of 1 km or more.

Only 200 or so of the asteroids in the Belt are more than 100 km across. The biggest object in the asteroid belt member is Ceres, so large it was recently up-graded from asteroid to Dwarf Planet. The three largest asteroids (Vesta, Pallas and Hygiea) plus Ceres together make almost half the total mass within the main belt. Ceres alone accounts for one-third of that total mass. Note that if Ceres and all the asteroids in the Belt combined into one lump the resulting body would be less than a twentieth the size of our Moon.

Asteroids are 'living fossils' from the earliest days of the Solar System

As they are 'living fossils' from the earliest days of the Solar System, asteroids are fascinating to astronomers. The largest bodies out there have, entirely through chance, survived billions of years of possible collisions and have remained intact ever since they formed. As they are the largest, Ceres and Vesta are especially interesting. Surprisingly Vesta and Ceres are chalk and cheese, or more aptly rock and ice. Observations of Vesta suggest it has a complex geology suggesting an intriguing history. Its surface features include basaltic lava flows – implying that it once had a molten core – and a deep impact crater near its southern pole. Vesta seems to be bone-dry. In a complete contrast, Ceres has a simple primordial surface with evidence of water

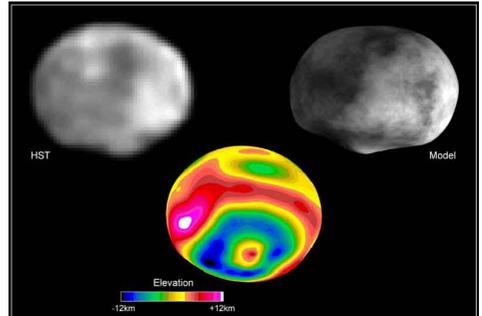


Image Credit: NASA

Three faces of Vesta? Image at top left is an actual Hubble Space Telescope image of Vesta, the groovily-coloured image is a relief map based on the first image and the top right image is a model of Vesta approximating a close-up view of the asteroid. Vesta orbits about 2.4 AU from the Sun (1 AU = 150 million km)

ice. Ceres seems to possess frosty polar caps and a tenuous atmosphere. Vesta in many ways resembles the inner planets like Mars and Earth, while Ceres is more like one of the icy moons of the outer planets, such as Callisto. Clearly both worlds were created by very different processes.

Think of an asteroid. You have probably imagined an irregularly shaped lump. Ceres is not like that. It is almost spherical, but not perfectly so, like the Earth its rotation means that it is slightly flattened at the poles. Recent research has suggested that this is a clue to its internal structure. If Ceres' interior was a uniform mix of ice and rock it would be flatter still, instead the more modest flattening indicates the presence of a core, presumably composed of rock, surrounded by an icy mantle. If it is made of ice, Ceres' mantle contains more water than all the oceans of Earth. Someday this may make Ceres one of the most valuable locations in the Solar System to space colonists.

While Ceres is more or less spherical in shape, at half the size Vesta is potato-shaped. Hubble Space Telescope images show Vesta to be ir-

regular. At widest it is about 580 km across (only slightly more than the distance from Belfast to London) but about 460 km from pole to pole. Vesta has probably enjoyed a more eventful life than Ceres. In fact Vesta has had huge fragments splintered off itself. How do we know this? Astronomers can use a technique called reflection spectroscopy to identify the presence of chemical elements on an astronomical body by the 'fingerprints' they leave in the sunlight reflecting off the surface. Spectroscopic analysis indicated that several small asteroids have surfaces which are highly similar or identical to Vesta's. The best explanation is that they are indeed fragments blasted off Vesta by an ancient collision, possibly the very one which left the great crater near the asteroid's south pole. But that is not all, the visible and near-infrared reflectance spectra of Vesta and the basaltic achondrites, a class of meteorite which fall on Earth, are so similar they must be connected. Presumably these are fragments from the massive impact that have found their way to our world. We almost certainly already have samples of Vesta here on Earth!

Ceres and Vesta are two fascinating worlds, worthy of further study. All being well on 26 September 2007 an explorer will leave Earth visit both Vesta and Ceres in the next decade. Dawn is the first probe designed specifically to visit main belt asteroids. It has been a troubled mission, delayed by financial and technical problems; in fact the whole Dawn mission has been cancelled and resumed twice.

“Dawn will cruise under continuous thrust from its ion engines”

There is seldom a true sense of scale in artist's impressions and computer-generated renderings of space probes. It is easy to visualise our robot explorers to be dinky little machines, no bigger, say, than a small car. This usually is not the case, and Dawn is especially big. Its solar panels span 19.7 meters (65 feet) from tip to tip, almost as long as a cricket pitch. Its science payload includes a pair of cameras, a gamma ray and neutron spectrometer used to pin down the

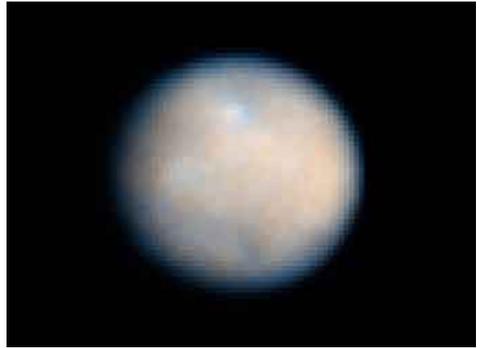


Image Credit: NASA

Ice Dwarf Ceres as viewed by the Keck Observatory at Mauna Kea, Hawaii. Ceres is 980 km across its equator. Its average distance from the Sun is about 2.8 AU

elements making up the outer part of its targets and a mapping spectrometer which operates in the visible and infrared wavebands to reveal how minerals are distributed across the surfaces of Ceres and Vesta. Dawn's most innovative feature is its propulsion system.

Most preceding interplanetary probes, after an initial rocket boost coast gradually across the Solar System to their destinations. Dawn, instead, will cruise under continuous thrust from its ion engines. In these devices electric energy is used to accelerate xenon fuel, applying a very gentle but continuous thrust. As a result the spacecraft eventually attains speeds much greater than possible with chemical rocket mo-



Image Credit: NASA

Dawn in flight as portrayed by a NASA artist, showing the plume of ionised xenon from its engines. The stylised background shows Vesta (left), Ceres (right), numerous small asteroids and the Solar Nebula which gave rise to them all.

tors. It is a very fuel efficient propulsion system, so the spacecraft can be smaller without massive fuel tanks. Ion propulsion has been applied before, notably to the Deep Space 1 and SMART 1 vehicles, but the Dawn mission its most creative application so far. After launch in September 2007, the probe will move away from Earth in a slow, lazy spiral until it receives a gravity assist as it flies by Mars in March 2009. It will cruise onwards until it goes into orbit around Vesta in October 2011. Dawn will spend six months scrutinizing the asteroid before firing

up the ion drive and proceeding to a February 2015 arrival at Ceres. At the moment the plan is to spend the rest of the mission at the dwarf planet, but there is always the chance that the mission could be extended to permit visits to other members of the Asteroid Belt.

So in less than a decade we will have explored two new worlds and possibly learned more about the origin of the Solar System. We live in great days.