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Travel through time to the beginnings of the solar system: Nasa Mission Dawn to Ceres and Vesta commences with German cameras

4 July 2007

Spacecraft Dawn

It will be a journey to the origins of the solar system: Spacecraft Dawn will commence its trip between 7th-11th July from the American spaceport Cape Canaveral in Florida aboard a three-stage Delta II-7925H launch vehicle to explore the asteroids Ceres and Vesta. It will be the first time that a single craft has circled two different bodies in the solar system in one orbit.

And it is the first time that no American cameras are being used on a NASA mission into the depths of the solar system: the two identically built photographic systems aboard Dawn are the result of collaboration between the German Aerospace Center's (DLR) Institute of Planetary Research and the Max Planck Institute for Solar System Research (MPS) in Katlenburg-Lindau, which led this camera experiment.

"Dawn will become a very unusual mission", revels Professor Ralf Jaumann from the DLR Institute of Planetary Research and member of the Dawn scientific team. "With this project we will be able to take a sort of 'journey through time' to the dawn of the solar system. Both bodies – Ceres and Vesta – were formed during the birth of the solar system within a few million years of each other, but then developed in very different ways. The cameras that we developed together with the Max Planck colleagues will help us to gain a detailed picture of the two asteroids."

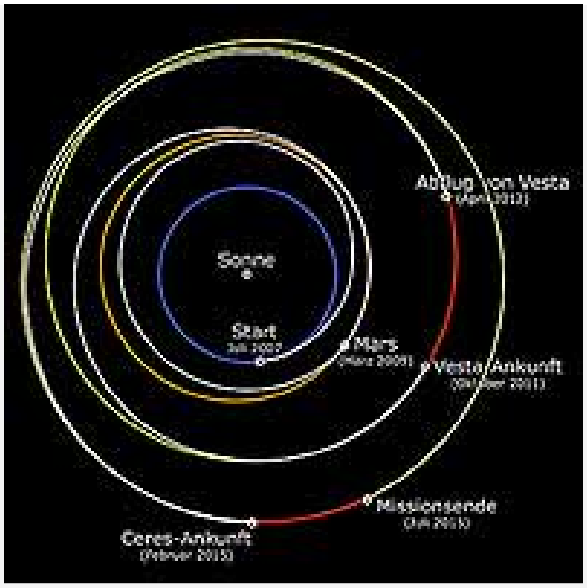
In addition to the DLR and the MPS, the Technical University of Braunschweig's Institute of Data Technology and Communications Networks also contributed to the development of the camera. At present the launch of the mission is planned for Saturday, 7th June at 16:09 local time (22:09 CEST) from launch pad 17B. Should bad weather in Cape Canaveral lead to delays the countdown can be repeated daily in a launch window of approximately half an hour until 11th July.

Dawn's Schedule	
Launch window:	7. up to 11th July 2007 Second half of September, 2007
Launch system:	Delta II 2925 H (3 stages)

Spaceport:	Cape Canaveral, Florida, USA
Launch complex:	17B
Test phase:	60 days in earth orbit
Inter-planetary orbit:	Commences 81 days after launch
Mars swing-by manoeuvre:	March 2009
Arrival at Vesta:	October 2011
Continuation flight to Ceres:	April 2012
Arrival at Ceres:	February 2015
End of mission (tentative):	July 2015

Two hundred years after the doctor and astronomer Heinrich Olbers of Bremen tracked Vesta with his telescope in 1807, a spacecraft is now for the first time bound for two of the three largest asteroids. The American missions Galileo, NEAR, Deep Space-1 and Stardust and the Japanese craft Hayabusa have already previously investigated several smaller bodies in the asteroid belt between Mars and Jupiter. Ceres, the largest body in the main asteroid belt which was discovered by Giuseppe Piazzi in 1801, was originally even thought by him to be a planet. With diameters of 909 to 975 kilometers, Ceres has an almost spherical shape and was last year shifted to the category of "dwarf planet", as was Pluto, by the general assembly of the International Astronomical Union in Prague.

First results in October 2011



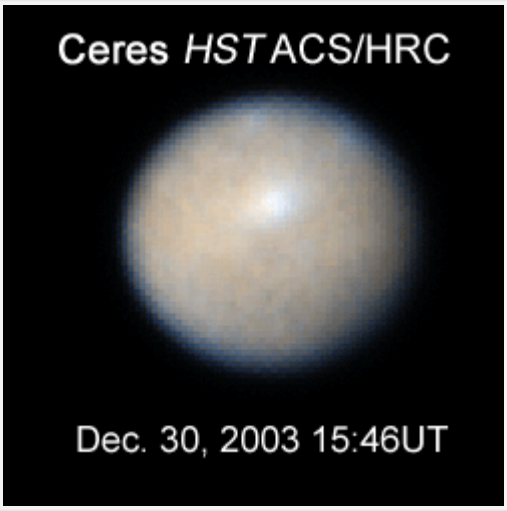
Flight path of the Dawn spacecraft

24 minutes after the launch Dawn will be separated from the third stage of the launch vehicle and first brought into an orbit of the earth. A little later the two solar sails, which are each over eight meters in length, will be unfolded to create a total of 10 kilowatts of energy to both sides of the 1.217 kilogram-heavy spaceship and then the spacecraft's ion engines will be fired up for the first time.

Dawn is already on a spiral-shaped course through the inner solar system on which the craft at first very slowly but at a continuously accelerating pace is distancing itself from the earth. During the first 60 days the functions of all systems and instruments will be checked before Dawn is finally placed into a "travel mode" shortly thereafter. In March 2009 the spacecraft will pass by Mars and use the interaction with the planet's gravitational field for additional acceleration.

The craft will arrive at Vesta in October 2011. Dawn will observe the asteroids for a little over half a year from orbits of differing heights. Due to its relatively close proximity to of 322 to 385 million kilometres from the sun Vesta, named after the Roman goddess of holy fire, is regarded as a relatively "dry" and also "developed" asteroid. Because of its nearness to the sun Vesta has already lost most of its volatile components. Vesta is the brightest asteroid and is occasionally visible to the naked eye in the night sky.

Ceres and Vesta: born at the same time 4.6 billion years ago – yet still so different



Rotation von Ceres. Zusammengesetzt aus Aufnahmen des Hubble-Weltraumteleskops im ultravioletten und sichtbaren Licht. Animation: *HST* ACS/HRC.

Shortly after the birth of Vesta approximately 4.6 billion years ago, streams of red-hot iron and magnesium-rich "basaltic" lava, such as that which also covered the earth's ocean floors, supposedly flowed across the surface of the body. Telescopic observations show that Vesta's crust must comprise rock with a range of compositions. On its south pole the collision with another asteroid has left behind a massive crater and significantly changed Vesta's external shape. Planetary scientists assume that due to their spectral characteristics, the impact created at least 50 smaller asteroids which are now orbiting the sun as "vestoids". Parts of these have even landed on earth as meteorites.

After observing Vesta, Dawn will be brought to Ceres on a transfer path. The craft will arrive here in February 2015 and conduct experiments and make recordings until the end of the mission in July 2015. Due to the large distance between the asteroid and the sun of 380 to 450 million kilometers and the resulting lower temperatures when the body was being formed in this zone of solar fog a larger part of Ceres comprises light and volatile elements.

For this reason Ceres has a lower specific weight than Vesta and, having a substantial portion of ice and possibly also water in its interior, also displays some of the characteristics of a comet.

The percentage of water on the dwarf planet is estimated at 15 to 25 per cent, which is why Ceres, named after the Roman goddess of agriculture, is regarded as a "wet" asteroid. The possibility that under the crust in Ceres' mantle there may exist a layer of water or ice that is perhaps as vast as one hundred kilometers has not been ruled out. For Ceres it is probably more so the case than for Vesta that here one can encounter the original and unchanged conditions of the early solar system.

Five billion kilometers through the universe on an ion beam

The Dawn spacecraft’s camera system

On arrival at Ceres, Dawn will have travelled over five billion kilometers thorough the inner solar system using its three ion beam engines. Large distances can be covered much more efficiently using these propulsion systems than by using conventional combustion engines. In the inner solar system the electrical current required for an ion engine is easily generated using appropriately designed solar sails, leading to the term "solar electric" ion engine.

In this process atoms in the inert gas Xenon are activated using electric current so that they are "ionized" through the loss of an electron.

An electrical field is used to accelerate the positively charged Xenon ions to up to six or ten times the speed of a chemical jetwash and the ion beam is focused on the final nozzles. This allows a rebound effect of a maximum of 91 millinewtons to be achieved. This is only as much as a wavering piece of paper exerts on the surface of a desk, however this allows the thrust to be maintained over months and years despite relatively low amounts of Xenon, allowing considerable acceleration.

A spaceship can attain higher speeds with an ion engine than with the combustion engines that have generally been used to date. In so doing only 3.25 milligrams of Xenon are required per second; in Dawn’s tank there are 425 kilograms of the inert gas. Dawn is the first purely scientific mission which will reach its destinations by way of "patient acceleration", as it is referred to by Dawn Project Manager Keyur Patel from NASA’s Jet Propulsion Laboratory in Pasadena (California), meaning with an ion engine. The maximum electricity consumption of the ion beam engine is 2.5 kilowatts, the equivalent of the capacity of a household vacuum cleaner.

Sizes of Ceres and Vesta

Two cameras constructed in the same way – also called "framing cameras" (FCs) because image reproduction takes place on a right-angled surface sensor – are the German contribution to the Dawn mission. Both systems can fulfil the same tasks and will record Ceres and Vesta through a color-neutral filter as well as through seven color filters for relatively narrow wavelength bands in visible light and close infra-red (430 to 980 nanometers). The wavelengths of the individual filters have been selected such that the surfaces of Ceres and Vesta are not only pictured in "real color" but also in such a way as to allow conclusions to be made about the composition and physical properties of the outermost layer of these celestial bodies, the regolith.

The light signals meet on a CCD (charge-coupled device) surface sensor with 1,024 by 1,024 light-sensitive semiconductor elements (pixels), each with an edge length of 14 micrometers. The sensor and the attached electronic parts used to select signals and forward them to the data storage unit were developed at the DLR, where the parts of the camera were also calibrated.

The schedule for the two fly-bys, the planning of which is partly being done on site at the mission control center in Pasadena, California, provides for pictures to be taken from various heights in order to be able to fulfil as many scientific tasks as possible. Detailed pictures with a resolution of up to ten meters per pixel are expected from the lowest orbit around Vesta at a height of 200 kilometers. In addition to gaining a complete geological characterization of Ceres and Vesta and creating a geodetically precise picture cartography of at least 80 per cent of the surface of each of the two asteroids, determining the topography and the landscape profile is also a priority.

Not least, the DLR Institute of Planetary Research also possesses many years' expertise in the field of stereo image data processing as a result of the 3D mapping of the surface of Mars using the high resolution stereo camera on the spacecraft Mars Express. A majority of the image data processing and archiving will be performed during the course of the mission at the DLR Institute of Planetary Research Berlin.

Ceres and Vesta

In addition to the German cameras, two other scientific instruments are located on board: the spectrometer provided by the Italian Space Agency ASI, which will be used for mapping the mineralogical composition of the surface of the asteroid in visible light and close infra-red, and the gammy ray and neutron detector GRaND from National Laboratories in Los Alamos (New Mexico, USA). Furthermore, the radio traffic between the craft and the earth, which is barely influenced by the gravitational field of the two massive bodies, will be analyzed for tiny changes to obtain information about the gravitational field of the two bodies.

Asteroids: witnesses of the dawn of the solar system

Through comparative observation of Ceres and Vesta, two asteroids which developed in different ways despite forming at the same time, participating researchers hope to obtain new knowledge about the process in which planets and planet-like celestial bodies are created. It is assumed that there are at least 100,000 asteroids: remnants from a time in which planets were formed, which can be found in a wide belt between the orbits of Mars and Jupiter.

Due to the enormous gravitational pull exerted by Jupiter, the largest planet in the solar system, the asteroids are not only kept in their own orbit, but also steered onto a collision course among one another. As a result, fragments sometimes find their way into orbits which lead to the inner solar system where these small bodies can also collide with the earth. In the history of the solar system the impacts of asteroids have significantly influenced the development of various forms of life on our planet.

The planetoid Eros

Thanks to carbon dating of meteorites we know that asteroids were formed almost 4.6 billion years ago in a period of less than ten million years out of the same solar fog from which the planets were also formed. Unlike these, most asteroids have hardly experienced any change to their interior as a result of dynamic processes; only their surfaces have been affected in the course of 4.5 billion years by solar wind and the impacts of meteorites of all sizes. With diameters of a few hundred meters to a hundred kilometers, most of the bodies are too small for enough warmth to have been able to be generated in the bodies to supply volcanism, for example. Asteroids, together with comets – which have originated much farther from the sun – therefore represent the earliest material in the solar system.

Dawn is a Discovery" mission: low-priced and fast

Mission logo

Dawn is a part of the so-called "Discovery" program launched by NASA in 1992 which gives science the opportunity to solve the riddles of our solar system with relatively low-priced and innovative missions. Dawn is the ninth Discovery mission, which the Mercury craft Messenger and Stardust, Deep Impact, Mars Pathfinder and Lunar Prospector were also a part of.

The total cost for Dawn including launching and operating costs is approximately Euro 320 million, and the German contribution amounts to three per cent of this sum. In the creation of the Dawn camera the DLR's Space Agency and the DLR's Basic Financing for Research and Development used funds from the federal government's National Space Travel Program, as well as – for the most part – funds from the Max Planck Society.

The mission is being carried out by NASA's Jet Propulsion Laboratory in Pasadena (California) in cooperation with the University of California in Los Angeles (UCLA). The scientific head of the project is Professor Christopher Russell of the UCLA. In Germany, scientists from the DLR's Institute of Planetary Research in Berlin-Adlershof, the Max Planck Institute for Solar System Research in Katlenburg-Lindau and the Free University of Berlin are taking part in the evaluation of the Dawn data.

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