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UCLA-Led Project Will Send Spacecraft to Study the Origins of the Solar System

Dawn Mission to Study Ceres and Vesta, the Largest Asteroids

The Office of Space Science at NASA has approved the "Dawn Mission," a UCLA-led project that will develop a spacecraft to orbit and study Ceres and Vesta, the two largest asteroids (minor planets) in our solar system.

The Dawn Mission marks the first time that a spacecraft will orbit two planetary bodies on the same mission.

Christopher T. Russell, professor in the Department of Earth and Space Sciences at UCLA, will direct the Dawn mission.

According to current theories, the differing properties of Vesta and Ceres are the result of these minor planets being formed and evolving in different parts of the solar system. By observing both minor planets with the same set of instruments, Dawn will provide new answers to questions about the formation and evolution of the early solar system.

The Dawn mission will launch in May 2006. It will study Vesta beginning in July 2010, and Ceres beginning in August 2014.

This Web page contains general background material about the Dawn mission. For the Web site of the Dawn science team, visit **http://www-ssc.igpp.ucla.edu/dawn**.

The Dawn Mission is part of NASA's Discovery Program, an initiative for lower-cost, highly focused, rapid-development scientific spacecraft. The Discovery Program is managed by NASA's Jet Propulsion Laboratory, for the Office of Space Science, Washington, D.C. For more information about the Discovery Program, visit **http://discovery.nasa.gov**.

The Discovery Program is part of NASA's initiative for lower-cost, highly focused, rapid-development scientific spacecraft. The Discovery Program is managed by NASA's Jet Propulsion Laboratory, for the Office of Space Science, Washington, D.C.

This Web site contains background material about the Dawn mission. The sections include:

The Dawn Mission

The goal of the Dawn mission is to understand the conditions and processes during the earliest history of our solar system. To accomplish this mission, Dawn will explore the structure and composition of Ceres and Vesta, two minor planets that have many contrasting characteristics and have remained intact since their formation more than 4.6 billion years ago.

The Dawn mission will launch from Cape Canaveral on May 27, 2006. After more than four years of travel, the spacecraft will rendezvous with Vesta on July 30, 2010. Dawn will then orbit Vesta for almost a year, studying its basic structure and composition.

On July 3, 2011, Dawn will leave orbit around Vesta for a three-year cruise to Ceres. Dawn will rendezvous with Ceres and begin orbit on August 20, 2014, and conduct studies and observations until July 26, 2015. After the exploration of Ceres, and more than nine years of space travel, Dawn may continue with additional exploration of the asteroid belt.

The Dawn mission is led by UCLA space scientist Christopher T. Russell. Team members include scientists from the German Aerospace Center (DLR), The Institute for Space Astrophysics in Rome, the Jet Propulsion Laboratory, Los Alamos National Laboratory, University of Hawaii, University of Maryland, University of Tennessee (Knoxville), Brown University, NASA Goddard Space Flight Center, University of Arizona and Massachusetts Institute of Technology.

Orbital Sciences Corporation will construct the spacecraft, and the Jet Propulsion Laboratory will provide the ion engines and management of the overall flight system development. The German Aerospace Center will provide the framing camera, and the Institute for Space Astrophysics in Rome will provide the mapping spectrometer.

Educators from New Roads School in Santa Monica, Calif., and Mid-continent Research for Education and Learning (McREL), Aurora, Colo., will develop standards-based learning materials for people of all ages, helping to bring the mission into classrooms and homes across the nation.

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The Dawn Mission: Why Ceres and Vesta?

The Dawn mission focuses on two of the first bodies formed in our solar system, the minor planets Ceres and Vesta.

Studies of meteorites believed to be from Vesta that were found on Earth suggest that this body formed from dust in the solar nebula within 5-15 million years of the time the solar system evolved about about 4.6 billion years ago. Although no meteorites from Ceres have yet been found, this body also formed during the first 10 million years of the solar system's existence. Today Ceres and Vesta represent two of the few large protoplanets that have not been heavily damaged by collisions with other bodies.

Ceres and Vesta feature striking contrasts in composition. Scientists believe many of these differences stem from the conditions under which Ceres and Vesta formed, with Ceres forming wet and Vesta dry. Evidence of water -- frost or vapor on the surface, and possibly liquid water under the surface -- still exist on Ceres; this water kept Ceres cool throughout its evolution. At the same time, Vesta was hot, melted internally and became volcanic early in its development. As a result of these two different evolutionary paths, Ceres remains in its primordial state, while Vesta evolved and changed over millions of years.

Because these bodies lie near the plane of the Earth's orbit, they can both be studied with a single mission. The Dawn mission will help us understand the evolution of the interior structure and thermal history of Ceres and Vesta -- information that provides keys to the secrets of the creation of our solar system.

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Dawn Mission: The Minor Planets - Ceres

Ceres, the largest asteroid in our solar system, is a roughly round object about 600 miles in diameter. It orbits the sun in the asteroid belt between Mars and Jupiter approximately 258 million miles from Earth.

The year 2001 marks the 200th anniversary of the discovery of Ceres by Giuseppe Piazzi in 1801 with a small telescope atop the royal palace in Palermo. At first Piazzi believed he had found the missing planet expected to be in the region we now call the asteroid belt. However this minor planet turned out to be very small indeed, only one-quarter of the diameter of the Earth's moon.

Ceres was the first asteroid to be discovered in our solar system. Additional observations by Piazzi were cut short due to illness. Carl Friedrich Gauss, at the age of 24, was able to solve a system of 17 linear equations to allow Ceres to be rediscovered, a remarkable feat for this time. Within one year of its initial discovery, both H. Olbers and Franz von Zach were also able to re-identify Ceres.

Ceres was named after the Roman goddess of agriculture. It circles the sun in 4.6 terrestrial years.

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Dawn Mission: The Minor Planets - Vesta

Vesta is the brightest asteroid in our solar system, and is the only one visible with the unaided eye; its oval, pumpkin-like shape has an average diameter of about 320 miles. Vesta is the second most massive minor planet. Found on March 29, 1807, by Heinrich Wilhelm Matthäus Olbers, it was the fourth minor planet to be discovered.

Named for the ancient Roman goddess of the hearth, Vesta is approximately 220 million miles from Earth. It circles the sun in 3.6 terrestrial years.

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Dawn Mission Overview

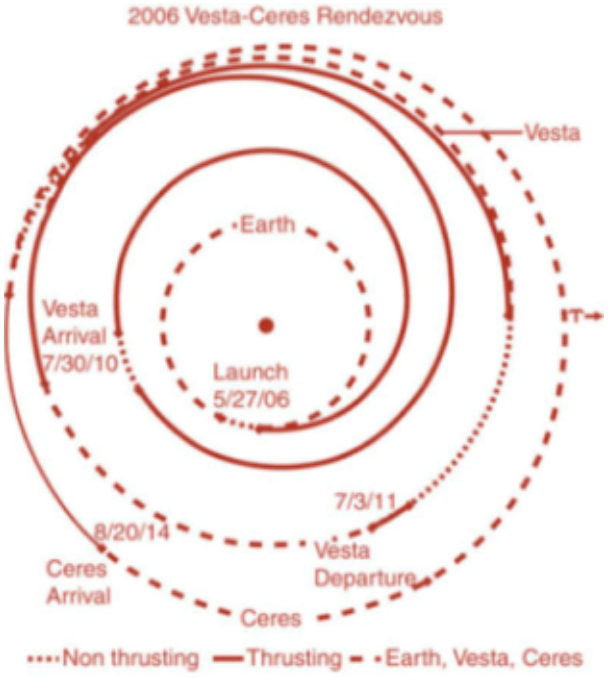
- May 27, 2006:
  - Launch from Cape Canaveral on a Delta 7925H rocket

- July 30, 2010 - July 3, 2011:
  - Rendezvous with Vesta (nine month study)
  - Orbit at 420 and 80 miles

- July 3, 2011 - August 20, 2014:
  - Cruise to Ceres

- August 20, 2014 - July 26, 2015:
  - Rendezvous with Ceres (nine-month study)
  - Orbit at 530 and 80 miles

- July 26, 2015:
  - Observation of Ceres concludes
  - Possible continuing exploration in the asteroid belt



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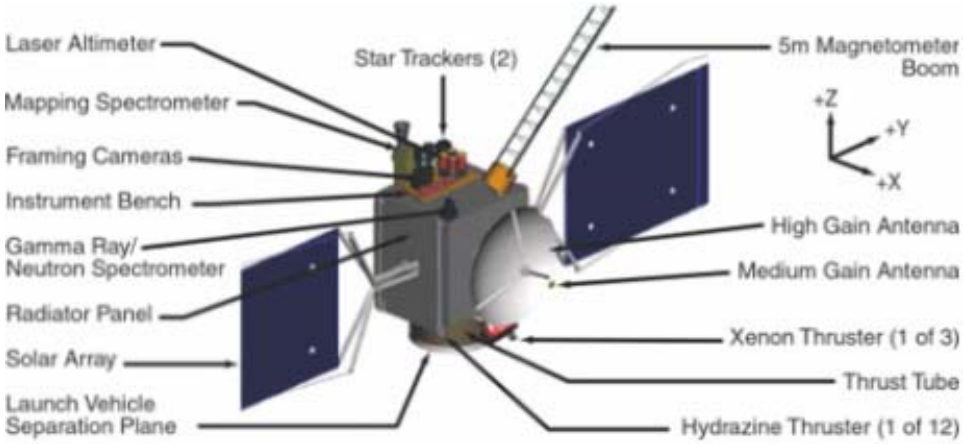
The Dawn Spacecraft



With a two-stage, nine-year journey to study the minor planets Ceres and Vesta, Dawn will become the first spacecraft to orbit two planetary bodies during the same mission.

To accomplish its mission to study the physical structure and evolution of asteroids Ceres and Vesta, Dawn would carry:

- A framing camera provided by the German Aerospace Center (DLR), Institute of Space Sensor Technology and Planetary Exploration
- A mapping spectrometer provided by the Institute for Space Astrophysics in Rome
- A laser altimeter provided by the NASA Goddard Space Flight Center
- A gamma ray spectrometer from the Department of Energy's Los Alamos National Laboratory
- A magnetometer provided by UCLA

The Dawn spacecraft will be built using construction methods and components that have been used successfully in many other satellites, including Deep Space 1, Orbview, the Topex-Poseidon ocean topography mission and the Far Ultraviolet Spectrum Explorer. The Dawn spacecraft will also be the first fully scientific space mission to use ion propulsion to power the spacecraft's journey.

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Dawn: Mission Management

UCLA:
Science lead -- Science operations, data products, archiving and analysis

German Aerospace Center (DLR),
Institute of Space Sensor Technology and Planetary Exploration:
Framing camera and mapping spectrometer: Integration, testing, sequencing and analysis

Jet Propulsion Laboratory (JPL):
Project management, systems engineering, mission assurance, payload, SEP, navigation, mission operations, level zero data

Orbital Science Corporation:
Spacecraft design and construction

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Dawn: Science Team

A. Coradini	Institute for Space Astrophysics (IAS), Rome
W. C. Feldman	Los Alamos National Laboratory (LANL)
R. Jaumann	Institute of Space Sensor Technology and Planetary Exploration, German Aerospace Center (DLR)
A. S. Konopliv	Jet Propulsion Laboratory (JPL)
T. B. McCord	University of Hawaii
L. A. McFadden	University of Maryland
H. Y. McSween	University of Tennessee, Knoxville
S. Mottola	DLR
G. Neukum	DLR
C. M. Pieters	Brown University
C. A. Raymond	JPL
C. T. Russell	UCLA (project director)
D. E. Smith	NASA Goddard Space Flight Center
M. V. Sykes	University of Arizona
B. Williams	JPL
M. T. Zuber	Massachusetts Institute of Technology

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Ion Propulsion

The Dawn spacecraft would be the first purely scientific mission to be powered by ion propulsion, an advanced technology now being used by NASA's Deep Space 1 mission.

The principle behind the ion engines is much the same as the phenomenon you experience when you pull hot socks out of the clothes dryer on a cold winter day. The socks push away from each other because they are electrostatically charged, and like charges repel. The challenge in electric space propulsion is to charge a fluid so its atoms can be expelled in one direction, and thus propel the spacecraft in the other direction.

Unlike chemical rocket engines, ion engines accelerate nearly continuously, giving each ion a tremendous burst of speed. The fuel used by an ion engine is xenon, a gas also used in photo flash units, that is more than 4 times heavier than air.

When the ion engine is running, electrons are emitted from a hollow tube called a cathode. These electrons enter a magnet-ringed chamber, where they strike the xenon atoms. The impact of an electron on a xenon atom knocks away one of xenon's 54 electrons. This results in a xenon atom with a positive charge -- a xenon ion.

At the rear of the chamber, a pair of metal grids is charged positively and negatively. The force of this electric charge exerts a strong electrostatic pull on the xenon ions. The xenon ions shoot out the back of the engine at a speed of 68,000 mph.

At full throttle, the ion engine consumes 2,500 watts of electrical power, and produces 1/50th of a pound of thrust -- about the same pressure as a sheet of paper resting on the palm of a hand. That is far less thrust than is produced by even small chemical rockets. But an ion engine can run for months or even years, and despite the almost imperceptible thrust, this engine, for a given amount of fuel, can gradually increase a spacecraft's velocity 10 times more than can a conventional rocket powered by liquid or solid fuel.

The ion propulsion system on NASA's Deep Space 1 spacecraft won Discover Magazine's Award for Technological Innovation.

For more information about NASA developments in ion propulsion, visit **NASA's site**.

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The Discovery Program

NASA's Discovery program offers the scientific community opportunities to accomplish frequent scientific investigations using innovative and efficient management approaches. It seeks to keep performance high and expenses low by using new technologies and strict cost caps. Proposals require careful tradeoffs between science and cost to produce investigations with the highest possible science value for the price.

Discovery solicits mission proposals that are assembled by a team from industry, small businesses, government laboratories and universities. The goal is to launch these smaller missions every 12-24 months at a cost of less than $299 million.

The Discovery Program is managed at NASA's Jet Propulsion Laboratory, a division of the California Institute of Technology, Pasadena, for the Office of Space Science, Washington, D.C. More information on the Discovery Program is available at **http://discovery.nasa.gov**.

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Attempting to Answer the Fundamental Questions

The Space Science Enterprise Strategic Plan published by NASA in November 1997 addresses the concept of cosmic origins, evolution and destiny -- how the universe began, how life on Earth originated and what fate awaits our planet and our species. All that we do in space science is part of a quest to understand our cosmic origins and destiny, and how these are linked by cycles of evolution. In response, the space science community has formulated the following fundamental questions that lie at the core of gaining this understanding:

- How did the universe, galaxies, stars and planets evolve? How can our exploration of the universe and our solar system revolutionize our understanding of physics, chemistry and biology?
- Does life in any form exist elsewhere than on planet Earth? Are there Earth-like planets beyond our solar system?

How can we use knowledge of the Sun, Earth and other planetary bodies to improve the quality of life on Earth? What cutting edge technologies must we develop to conduct our research in the most productive, economical and timely manner?

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The Discovery Program Objectives

The Discovery Program's prime objective is to enhance our understanding of the solar system by providing answers to these fundamental questions. Discovery missions explore the planets, their moons and other small bodies within the solar system, either by traveling to them or by remote examination. Discovery also studies planetary systems beyond our solar system.

Discovery also offers a Mission of Opportunity program which allows investigators to participate in a non-NASA mission, typically sponsored by non-U.S. governments, other U.S. government agencies or private sector organizations. This participation could include providing a complete science instrument, hardware components of a science instrument or expertise in critical areas of the mission.

Eight Discovery Missions have been chosen to date, including the Near Earth Asteroid Rendezvous, the Mars Pathfinder Mission, the Lunar Prospector, the Stardust spacecraft, the Genesis spacecraft, the Comet Nucleus Tour, the MESSENGER mission and the Deep Impact Mission.

More information about the Discovery program and its missions is available at **http://discovery.nasa.gov**.

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Asteroids, Discovery Program and the Dawn Mission: More Information

Dawn Mission -- online media information:
http://www.college.ucla.edu/dawn

Dawn Mission -- technical background:
http://www-ssc.igpp.ucla.edu/dawn

Interviews with Dawn team members:
UCLA: Harlan Lebo, (310) 206-0510
Stuart Wolpert, (310) 206-0511

JPL contact:
Martha Heil, (818) 354-0850

Information about the Discovery Program and the NASA Office of Space Science:
NASA: Don Savage, (202) 358-1727

Asteroids -- An Introduction:
http://www.solarviews.com/eng/asteroid.htm

Ceres:
See the paper "Bode's Law and the Discovery of Ceres" by Michael Hoskin, at
http://www.astropa.unipa.it/versione_inglese/Hystory/BODE'S_LAW.htm

Vesta:
http://www.solarviews.com/eng/vesta.htm

Ion Propulsion -- Background:
http://www.science.nasa.gov/newhome/headlines/prop06apr99_2.htm

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