NASA SPACE MISSIONS TO ASTEROIDS

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This short report summarizes the current NASA missions to study NEOs. This discussion is limited to missions that are actually successfully launched, and it does not deal with other potential missions currently under study.

The first mission to study asteroids was Galileo. Although the asteroids visited by Galileo were in the main–belt, they may tell us something about NEOs as well. The primary objectives of Galileo are the study of the jovian system, where a probe was deployed directly into the jovian atmosphere in December 1995, and the spacecraft is currently in the midst of a 2–year orbital tour of the jovian satellites. On the way to Jupiter, Galileo achieved close flybys of the asteroids Gaspra and Ida, passing each within less than 100 radii of the asteroid. Both Gaspra and Ida are S–type asteroids. Gaspra is an irregular "potato–shaped" object about 15 km across, roughly the size of the impactor that killed the dinosaurs 65 million years ago. Ida is a highly–elongated object 53 km in length. Detailed imaging and spectra of both objects are being used to infer their surface composition and impact history. In addition, both Ida and Gaspra were found to have very small intrinsic magnetic fields. However, probably the most exciting discovery was the presence of a natural satellite, called Dactyl, in orbit around Ida. The satellite can be used to calculate the mass and density of Ida, showing that it is a primitive object perhaps similar in bulk composition to the ordinary chondrite meteorites. It also suggested that both Gaspra and Ida have some internal voids, and neither is likely to represent a single monolithic body.

The informational equivalent of a first mission to NEOs has been provided recently by radar studies of three Earth–approaching asteroids, carried out with high–powered NASA radar systems at Arecibo, Puerto Rice, and at the Goldstone Tracking Station in California. Imaging studies carried out by Steven Ostro and his colleagues show that of the three objects observed in imaging mode, only one (Geographos) appears to be a single coherent object. Castalia is bifurcated and dumbbell shaped, and Toutatis is extremely elongated with the suggestion of three separate components. Toutatis has also been shown to have a rotation state that does not correspond to equilibrium solid–body rotation. With the just–completed upgrade of the Arecibo radar, the power of this system has increased by factor of 20. We can therefore expect to obtain high–resolution images of several NEOs per year, approaching the resolution of spacecraft encounters. We will also be able to determine their spin states.

The third element of the current NASA missions to study asteroids is provided by the small Discovery mission launched in February 1996 called the Near Earth Asteroid Rendezvous, or NEAR mission. This half–ton spacecraft carries 56 kg of scientific instruments and is dedicated to asteroid studies using visible and infrared spectral imaging, x–ray and gamma–ray spectral analyses of bulk composition, plus magnetometer and high–resolution laser altimetry. On the way to its primary objective, the NEAR spacecraft will achieve a flyby of the main–belt asteroid Mathilda (June 1997), the largest asteroid and the first of the C class to be investigated. NEAR will reach its primary target, asteroid Eros, in January 1999, when it will match trajectories with the asteroid and begin a one–year orbital investigation. Eros is one of the largest of the NEOs. This comprehensive study of a single NEO will perfectly complement the previous flybys of Gaspra, Ida, and Mathilda, as well as the radar studies being made of NEOs that pass close to the Earth.

As a result of these studies, we will have a much better understanding of asteroids by the end of the present decade, with information that can be used to plan for possible NEO defense systems as well as increase our understanding of the role of these objects in the history of the solar system and of our own planet Earth.