

**PROSPECTS FOR IMPROVING THE MASSES OF (1) CERES AND (4) VESTA PRIOR TO DAWN'S ARRIVAL AT THESE MINOR PLANETS.** J. L. Hilton<sup>1</sup>, <sup>1</sup>Astronomical Applications Department, U.S. Naval Observatory, 3450 Massachusetts Ave. NW, Washington, DC 20392. [jhilton@usno.navy.mil](mailto:jhilton@usno.navy.mil).

**Introduction:** In the interest of mission planning, it is desirable to have the best possible estimate of the masses of 1 Ceres and 4 Vesta prior to Dawn's arrival at Vesta in May 2012 and Ceres in February 2015. Current estimates of the masses of these two bodies have realistic uncertainties  $\sim 1\%$  of their masses.

Due to their small sizes, determination of the masses of minor planets is difficult when they do not possess a known satellite. Instead, the mass is determined by the massive minor planet's perturbation of a passing 'test body', usually another minor planet. The magnitude of the perturbation, even for the closest and slowest approach is quite small. Thus, detection of the perturbation of the test body usually takes several years to decades while the deviation from its orbit prior to its perturbation becomes evident from the accumulated change in longitude resulting from difference between its pre- and post-encounter semimajor axes. This process is difficult enough that the first reliable estimate of a minor planet's mass did not occur until the mass of Vesta was determined in 1966[1].

**Purpose:** This report evaluates, in light of the recent proliferation in main belt asteroid discoveries, if candidate test bodies can be found that pass close enough to Ceres and Vesta at low enough relative velocities that a significant improvement can be made in the estimations of their masses. Further, encounters need to be found such that the improved masses can be provided prior to Dawn's arrival at these two minor planets.

The algorithms developed are not meant to be comprehensive, but only to serve as a method of discovering at least some of those encounters that may lead to a high accuracy minor planet mass determination in a relatively short period of time. Those encounters discovered should be followed up with more accurate, but computationally expensive, work such as numerical integration of the orbits of the test asteroids. Thus, the work reported here is ongoing.

This report first discusses the observational goals that need to be met in order to determine the mass of an asteroid on a short time scale. It then looks at the problem in an analytical way using the assumption of co-planar circular orbits for both massive and test body. The analysis is generalized to the case where both the massive asteroid and the test asteroid are on non-coplanar eccentric orbits by developing a series of limiting metrics. Finally, the realistic restrictions on

the data needed to make such mass determinations are discussed.

**Results:** A survey is performed using the metrics developed to look for suitable candidate asteroids perturbed by Vesta and Ceres. The survey failed to find any encounters with Vesta strong enough to make an improved mass determination prior to Dawn's arrival. On the other hand, three particularly strong encounters were found between Ceres and 2004 BW<sub>137</sub>, 4325 Guest, and 2000 EM<sub>61</sub>, that potentially could lead to Ceres mass determinations with uncertainties well under 1%.

**References:**

[1] Hertz H. G. (1966) *IAUC*, 1983, 3.