DISCOVERY OF AN EXTREME MASS-RATIO SATELLITE OF (41) DAPHNE IN A CLOSE ORBIT.

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Introduction. We report the discovery of a small satellite to large C-type asteroid (41) Daphne, using adaptive optics on Keck II. The satellite appears to have the most extreme mass ratio (10^6) of any binary known. It is also in a particularly close orbit for this class of binary. We consider how difficult is such a detection for large asteroids in the Main Belt, and what consequences it may have for the main-belt binary population and frequency. Because these observations were taken with the intention of not only a deep satellite search, but also rotationally resolved imaging of the primary, we are able to also determine accurately the shape, size, and pole position of the primary. The resulting volume estimate, coupled with the mass from the satellite orbit, will allows us to determine an exceptionally accurate density for this object

Background. This was a combined effort of two programs, one to determine the shape, sizes, and poles of large main-belt asteroids and one to search for companions to main-belt asteroids. Our main objective in the particular run was to acquire good sizes and shapes for asteroids already known to have companions, and thus improve the volume and hence the densities. Improved size permits improved estimates of albedo, in turn allowing better interpretation of surface composition. If we have a good estimate of the mass, e.g. from the presence of a satellite, uncertainty in an asteroid's volume is the overwhelming uncertainty in attempts to derive its density [1]. Of course, density is the single most critical observable having a bearing on bulk composition, porosity, and internal structure [1,2]. We can also achieve good surface maps if the objects is large enough, e.g. for our observations of Ceres [4]. Our resolved-asteroid technique is described in [3,5].

Observations. Our observations were made with the Keck II adaptive-optics imaging system NIRC2/AO on 2008 Mar 28 UT. At this time, asteroid (41) Daphne was approximately 1.09 AU from Earth, and had an angular size of about 0.22". The presents the most favorable size until the year 2031. A small satellite was discovered very close to the primary. The pair was tracked for over 3 hours, resulting in a surprisingly long (0.3") orbital track of the satellite.

Characteristics. Because this discovery was made only a few days before the deadline for this abstract, we have only been able to make preliminary estimates of the system parameters. From the single arc of the orbit, we had at first estimate a semi-major axis of about 443 km, but revised estimates put it at closer to 405 km. The orbital period estimate on our first report was 1.6 days, but this may be revised downward. The most unusual aspect is that this object appears to have the most extreme size ratio of any known binary. The brightness difference of the pair is about 10 magnitudes, giving a size of less than 2 km, and a mass ratio of about 1 million, significantly exceeding typical binaries (cf [1]). In addition, for this class of binary (large main-belt asteroid, with small secondary), undoubted produced via the SMAT (Smashed Asteroid Target) mechanism of Durda et al. [7], it is also the closest known pair (5.5 primary radii, while most known are at about 10, see [1]).

Discussion. Such objects may be common, but undetected. With a very high eccentricity, this main-belt object was exceptionally close during these observations. It is possible that many more such close, small satellites exist, and indeed with a typical size distribution and the collision results of [7], one might expect many more. This may affect the previously claimed binary frequency for the larger main belt objects [1], which is much lower than in other populations. In addition, some benefit has been gained by the substantially improved AO system at Keck, providing higher Strehl and contrast, allowing us to detect such faint satellties close to a bright object.

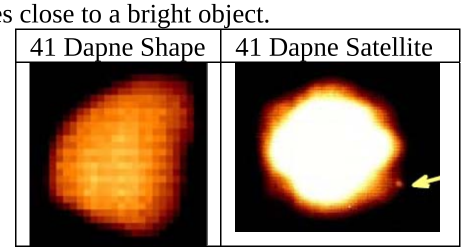

Figure 3. 41 Daphne Shape and Satellite

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