SHAPE AND SIZE OF ASTEROID (41) DAPHNE FROM AO IMAGING

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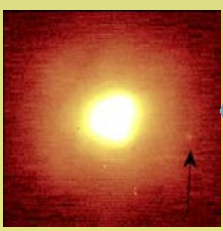
Summary: We present imaging data of main belt asteroid 41 Daphne, taken with adaptive optics (AO) on Keck and VLT. We discovered a satellite and, from its orbit, have determined the mass of Daphne. We determined volume for Daphne's irregular shape using two independent methods: triaxial fit to the AO images, and by combining AO resolved images with data from light curves. Our data provided spectacular shape images revealing flat facets and/or concavities. The two methods produced volume and density estimates that agree to within about 5%. The densities from our two methods are 2.0+/-0.1 and 1.9+/-0.1, somewhat high for Daphne's C-type taxonomy.

Motivation: The physical and statistical study of asteroids requires accurate knowledge of their shape, size, and pole position. Improved size permits improved estimates of albedo, in turn allowing better interpretation of surface composition. In those cases where we have an 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. Of course, density is the single most critical observable having a bearing on bulk composition, porosity, and internal structure.

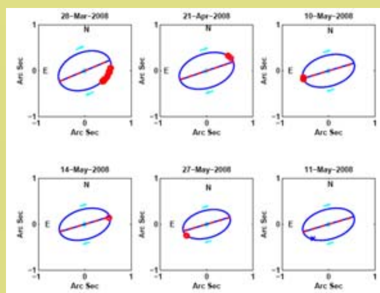
OBSERVATION

As part of our ongoing programs to use adaptive optics to study asteroids for size, shape, and presence of satellites we observed asteroid (41) Daphne during its recent close (1.05 AU) opposition.



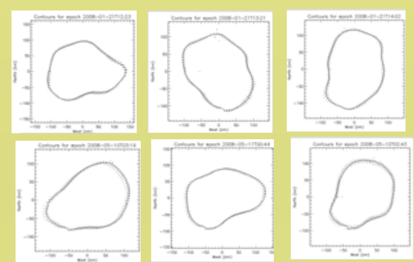
In March 2008, we discovered a small satellite to Daphne at Keck (Conrad et al. 2008, IAUC 8939; Merline et al. 2008, ACM 2008, #8370).

ORBIT



These plots show the position of the satellite relative to the primary (as viewed on the plane of the sky), from our initial observation (Keck, March 2008) and our follow-up observations (acquired at both Keck and VLT, April and May 2008). Our orbit solutions show that the orbit is nearly circular and close to the equatorial plane of the primary.

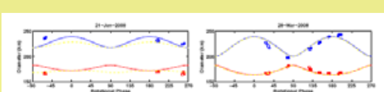
ACCURATE VOLUME



One of Daphne's peculiarities is its highly irregular shape. To be confident of our density estimate, we placed special emphasis on our size and shape determinations. We applied two methods to determine the volume: triaxial ellipsoid fit and detailed shape modeling which included use of existing lightcurve information (e.g., Kaasalainen et al. 2001).

TWO METHODS

Volume and shape were computed using two methods. The volume and pole solutions generally agree.



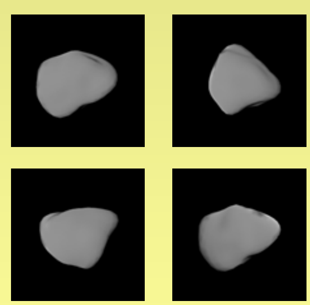
	Triaxial Fit to AO Contours	AO Contours + Lightcurves
Volume (x 10^{21} cc)	3.15	3.36
Pole (λ, β)	199, -32	198, -31

DENSITY COMPARISON

Asteroid	Density gm/cm³	Reference
121 Hermione	1.1±0.3	Marchis et al. 2005
45 Eugenia	1.2 (+0.6,-0.3)	Merline et al. 1999
90 Antiope	1.3±0.4	Merline et al. 2002
253 Mathilde	1.3±0.2	Veverka et al. 1997
762 Pulcova	1.8±0.8	Merline et al. 2002
41 Daphne	**1.95±0.1**	**Carry et al. 2009 (in preparation)**
1 Ceres	2.15±0.1	Carry et al. 2008

The unusually short period of the satellite (~1.1 day) and the estimated size (239x183x153 km) from our observations lead to a density near 1.95 g/cc. This is significantly higher than density measurements for most other C-like asteroids (Merline et al. 2002, Asteroids III, 289).

SHAPE FEATURES



Combining AO contours with lightcurve data produced an exceptional shape model. The model reveals intriguing surface features including flat facets and/or concavities. These global-scale features may have an origin in individual large impacts, as we suggested previously for our similar analysis of (511) Davida (Conrad et al. 2007).

We gratefully acknowledge M. Kaasalainen et al. for producing shape models from our AO contours combined with lightcurve data.

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