ROTATION AND MORPHOLOGY OF ASTEROID 511 DAVIDA.

A. R. Conrad[1], C. Dumas[2], W. J. Merline[3], R. D. Campbell[1], R. W. Goodrich[1], D. Le Mignant[1], F. H. Chaffee[1], T. Fusco[4], S. Kwok[1], R. I. Knight[5], [1]W.M. Keck Observatory, 65-1120 Mamalahoa Highway, Kamuela, HI, 96743, [2]ESO Very Large Telescope (VLT), European Southern Observatory, Alonso de Cordova 3107, Vitacura Casilla 19001, Santiago 19, Chile, [3]Southwest Research Institute, 1050 Walnut Street, Suite 400, Boulder, CO 80302, [4]Office National d'Études et de Recherches Aérospatiales (ONERA), DOTA-E, BP 72, F-92322 Chatillon, France, [5]University of Hawaii, Hilo, 200 W. Kawili St., Hilo, HI 96720-4091

Introduction: We present spatially resolved images of Asteroid 511 Davida, one of ten large main-belt asteroids that we have observed during the course of our Resolved Asteroid Program. We collected images of Davida during 11 phases spaced approximately evenly across a full rotation. We compare the apparent shape, pole orientation, and size with measurements obtained by other methods.

The Resolved Asteroid Program: Adaptive optics on large telescopes allows us to take resolved images of asteroids from the ground. Using diffraction-limited infrared imaging at the W.M Keck Observatory, we have collected spatially resolved images of 10 large main-belt asteroids. For three of these, 511 Davida, 52 Europa, and 12 Victoria, we have phase coverage of a complete rotation. By studying the shape, size, and surface features of these bodies, we hope to learn more about their gross structure and better understand asteroid collisions, the major geological process shaping these objects.

Davida Observations: On December 27, 2002, we took data at 11 epochs across a full, 5.13 hour [3], rotation (Table 1). At each epoch we took 15 images over a 5-minute span. Observations of a nearby star were interlaced with the Davida observations to obtain PSF calibration. The background was removed by subtracting a sky frame and the individual images were then flat-field corrected and combined with a sub-pixel shift-and-add (Figure 1).

Phase	UT	UT$_{\text{REL}}$	θ_{REL}	$\Delta\theta$
1	8:19:24		0.00°	
2	8:39:40	0:20:15	23.37º	23.37º
3	9:06:38	0:47:14	54.50º	31.13º
4	9:44:54	1:25:29	98.64º	44.14º
5	10:03:40	1:44:16	120.31º	21.67º
6	10:32:44	1:53:05	130.47º	10.16º
7	11:03:15	2:43:50	189.05º	58.58º
8	11:23:52	3:04:27	212.83º	23.78º
9	11:47:22	3:27:58	239.95º	27.12º
10	12:25:53	4:06:28	284.39º	44.43º
11	13:01:26	4:42:01	325.41º	41.02º

Table 1. Times and rotation angles for the epochs of the Davida observations. UT$_{\text{REL}}$ gives the elapsed time from the first epoch; θ_{REL} gives the rotation angle since the first epoch; and $\Delta\theta$ gives the rotation angle between epochs.

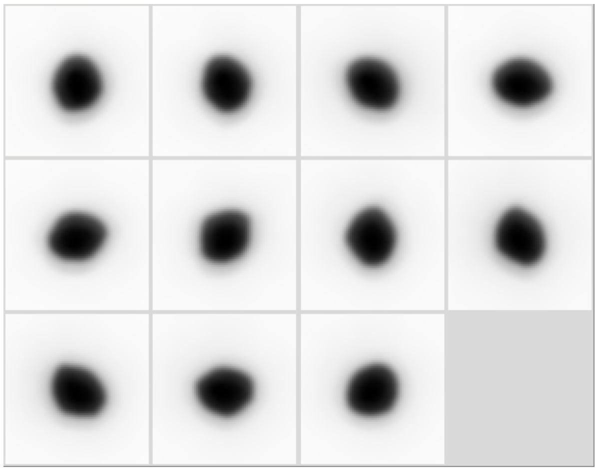

Figure 1. Davida at 11 time steps spanning the full rotation (5.13 h) of the asteroid. Each time step is comprised of 15 K-band (2.1 micron) images that are combined by shift-and-add.

We then deconvolved the images with the MISTRAL* [1] package, to produce a more clearly defined edge (Figure 2). This image restoration method combines raw data with knowledge of the noise statistics, as well as a priori information about the object and the variability of the Point Spread Function. It is particularly useful for reconstructing edges.

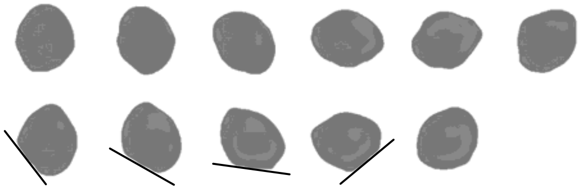

Figure 2. Davida images following deconvolution.

From facets visible in four of the phases (indicated by the line segment accompanying epochs 7-10 in Figure 2) we show that the data are consistent with a prograde rotation, and with the shape and pole orientation obtained by Drummond & Hege [2].

Comparison with Previous Measurements: For a more detailed analysis, we applied a Sobel edge-

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enhancement estimator to obtain a well defined boundary for each of the 11 images (shown as the blue outline in Figures 3a and 3b). We then used IDL™ three-dimensional object graphics to generate an ellipsoid that could be oriented and stretched to match the pole orientation and triaxial ratio measurements obtained by other methods. The well-determined measurements for triaxial ellipsoid dimensions and pole orientation are given in Drummond & Hege [2] (Table II, "Diameters and Poles from Combining SI and Others") as a,b,c = 417±48, 333±25, 292±34 km and λ, β = 299º, +34º ±9 (ecliptic longitude and latitude), respectively.

In Figure 3a we show the ellipsoid with a size corresponding to these lower bounds; in Figure 3b we use the upper bounds.

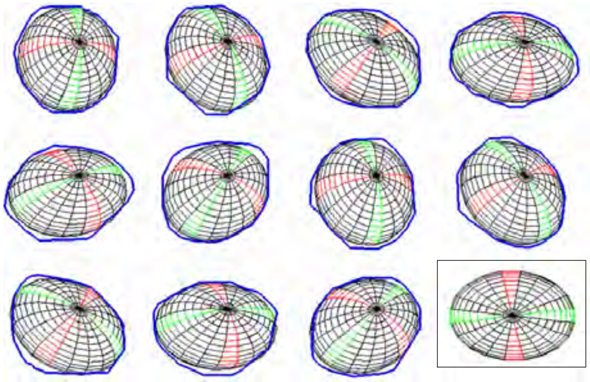

Figure 3a. Comparison of outlines from resolved images (blue outline) to previous measurements (triaxial ellipsoid). The ellipsoid has been scaled and pole-oriented to match the *lower bound* values given in [2]. The green and red longitude bands in the ellipsoid correspond to the long ('a') and intermediate ('b') axes. The short dimension ('c') is aligned with the pole. The inset in the lower right provides a pole-on view of the ellipsoid showing the actual (non-foreshortened) a and b dimensions.

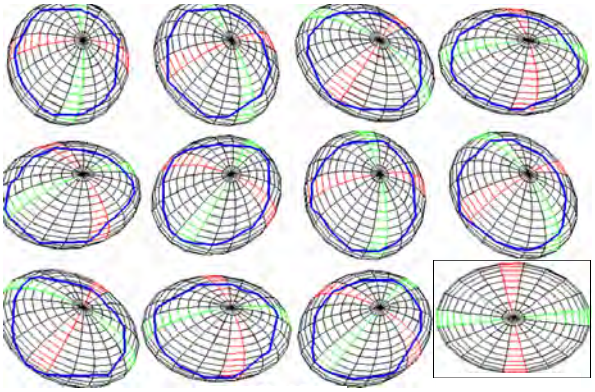

Figure 3b. Ellipsoid shown using *upper bound* triaxial dimensions [2].

From this type of scaling we see that the a and b dimensions are more likely to be near the Drummond & Hege [2] lower bound. Our best estimate is a=377 km and b=281 km.

Observation Details: We observed on a clear night using the H and K filters[†] and the narrow (10 arcsecond field-of-view) mode of the near infrared camera (NIRC2) behind the adaptive optics system on Keck II. The 50 milliarcsecond angular resolution at K corresponds to a resolution of approximately 58 km on the Davida surface, with approximately 6 resolution elements across the diameter (28 pixels in this mode) and 25 resolution elements covering the entire disk (616 pixels). The 40 milliarcsecond angular resolution at H corresponds to a resolution of approximately 46 km, with approximately 7 resolution elements across the diameter and 38 resolution elements covering the disk. Davida was at a distance of 1.617 AU from Earth and within 6 days of opposition (illuminated fraction 99.9%). The next time Davida will come this close will be in the year 2030.

Conclusion: Adaptive optics on large ground-based telescopes now permits more extensive, direct study of rotation, shapes, and sizes of large asteroids than had been possible previously. Our imaging of 511 Davida appears to confirm the sense of rotation and direction of the pole that was determined by Drummond & Hege [2], and puts the size of the asteroid close to their lower limits. Further analysis of our data will refine our estimates of Davida's shape, dimension, and pole solution. These techniques will be used to analyze the other asteroids observed in the Resolved Asteroid Program.

Acknowledgements: The data presented herein were obtained at the W.M. Keck Observatory, which is operated as a scientific partnership among the California Institute of Technology, the University of California and the National Aeronautics and Space Administration. The Observatory was made possible by the generous financial support of the W.M. Keck Foundation. The authors wish to recognize and acknowledge the very significant cultural role and reverence that the summit of Mauna Kea has always had within the indigenous Hawaiian community. We are most fortunate to have the opportunity to conduct observations from this mountain.

References: [1] Fusco, T., et al. (2002) *EAS, 8, 259: 259-271*. [2] Drummond, J. D. and Hege, E. K. (1989) *Asteroids II, 171-191*. [3] Torppa, J., et al (2003) *Icarus 164, 346-383.*

[†] Epochs 6 and 10 were observed at H and K; the remaining nine epochs were observed at K only.