Asteroid 4769 Castalia: Interpretation of Optical Lightcurves Using a Radar-Derived Shape Model

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A 167-parameter, 3-D shape model of Castalia (Hudson & Ostro 1994, *Science 263,* 940), obtained from inversion of delay-Doppler images, constrained the object's subradar latitude on the date (Aug. .22, 1989) of the observations by defining an annular sky region that contains Castalia's pole. We have used the shape model and nominal Hapke parameters for S asteroids (RHF) to model Castalia lightcurves obtained at Table Mountain Observatory on Aug. 23-25, 1989, at solar phase angles ranging from 58° to 900 This investigation defines the projected pole's azimuthal orientation around the radar line of sight and therefore yields a least-squares estimate of the orientation of Castalia's north or south pole; there is insufficient geometric leverage to distinguish the rotation sense or to estimate values of Hapke parameters. The model lightcurves match the TMO data surprisingly well, given the modest number of shape parameters in the model and the fact that part of the asteroid was not seen by the radar.

Visual comparison of the. lightcurves with the fran~c-by-frame geocentric appearance of the sun-illuminated shape model reveals tbc detailed relationship between the asteroid's visible, illuminated, projected surface area and its disc-integrate.d brightness. Hence, one immediately and completely understands, for example, why one lightcurve minimum is deeper and sharper than the other, and why one maximum is weaker and flatter than the other -- small asymmetries in the overall shape and character of concavities at various scales all play a role in determining the form of a lightcurve under any given viewing/illumination geometry. The availability of a detailed shape model clearly enhances the interpretability of lightcurves, especially for very small (and hence potentially very irregular) objects observed at large phase angles.

In their inversion of the radar images, Hudson and Ostro presented models corresponding to lower and upper bounds on Castalia's bifurcation. The lightcurve data clearly favor the more bifurcated model. Our experience suggests that optical lightcurves may enhance the accuracy of future radar reconstructions of small asteroid shapes, to a degree that would depend on the geometrical circumstances encountered in the radar and optical observations as well as on the asteroid's shape and spin state. 1/or example, optical determination of a target's the spin vector would shrink the parameter space for the radar inversion. In some cases, lightcurves might provide extra leverage in splitting the N/S anlb]guit yinsinglc.d elay-l)oJ~plcri n~agcs.