

1368 Numidia, 2113 Erdni, and 1722 Goffin have spectra with prominent UV and 0.9- μ m absorption bands indicating the presence of mafic silicates. Their reflectance increases with increasing wavelength a feature characteristic of the presence of metallic iron analogous to stony-iron meteorites. The spectrum of 495 Eulalia is flat and featureless and that of 908 Buddha increases linearly with wavelength and has a very weak or absent 0.9- μ m absorption band. The spectrum of 908 Buddha is similar to those of D-type asteroids commonly found in the outer asteroid belt. The spectral features of these smaller asteroids do not differ from the larger asteroids in this region and are different from the spectral features of ordinary chondrites. If the numerical and dynamical analyses of Wisdom (1977) and Wetherill (1985) are correct and the 3:1 Kirkwood gap asteroids are the source of the ordinary chondrites, then the surface of these asteroids are somehow spectrally different than the asteroid fragments that collide with the Earth and are recovered as ordinary chondrite meteorites. Laboratory studies of modified ordinary chondrite regoliths will be carried out to investigate possible mechanisms producing variations in reflectance spectra of ordinary chondrites.

*Guest observer at NASA-IRTF #Guest Observer at CTIO.

07.13 Images of Vesta

J. Drummond, A. Eckart, E. K. Hege, R. Watkins (University of Arizona) and J. Morgan (Stanford)

The first glimpses of an asteroid's surface have been obtained from images of 4 Vesta reconstructed from speckle interferometric observations made on November 16 and 17, 1983, using Steward Observatory's 2.3m telescope coupled with Harvard's PAPA camera. From power spectrum analysis of the ten images Vesta is found to have a 'normal' tri-axial ellipsoid shape of $584(\pm 16) \times 531(\pm 11) \times 467(\pm 12)$ km. Its rotational pole lies within 4° of R.A. = 21^h00^m , Dec. = $+41^\circ$ (Ecliptic long. = 336° , lat. = $+55^\circ$). Our observations definitely support a 5hr 20.5min rotational period, and do not fit one twice as long.

Reconstructed images reveal dark and bright patterns, reminiscent of the Moon, which can be followed across the disk as the asteroid rotates. The dark areas so dominate one face of Vesta that a minimum in the lightcurve occurs when the maximum cross-sectional area is visible. Its lightcurve is determined primarily by albedo structure rather than shape, leading to one maximum and one minimum per rotation instead of the expected two of each associated with its triaxial ellipsoid shape.

Further observations of Vesta were obtained with Stanford University's MAMA detector (Timothy and Morgan 1986) at the 2.3m telescope on October 13, 14, and 15, 1986. Preliminary power spectrum analysis of 40 observations lead to the following dimensions in km: $558 \pm 13, 532 \pm 15, 466 \pm 21$. Taking the weighted average between the 1983 and 1986 observations we obtain the following dimensions: $564 \pm 13, 532 \pm 13, 467 \pm 16$. The weighted average position for the adopted pole from the two runs is $(326; +53)$, with a three degree error.

07.14 Infrared Lightcurves of 532 Herculina and 45 Eugenia

L.A. Lebofsky (Lunar and Planetary Laboratory, U. of Arizona), E.F. Tedesco, G.J. Veeder (Jet Propulsion Laboratory, Caltech)

Two papers by Taylor *et al.* have come out recently that have applied the photometric astrometry method to lightcurves of 532 Herculina and 45 Eugenia to determine their poles and sense of rotation. Because of the unusual characteristics of the lightcurves when observed at various aspect angles (single minima and maxima at certain aspects), they concluded that the lightcurve variations were likely to be due primarily to albedo variations on their surfaces.

To test this model, we have made near infrared reflected (J and K) and thermal infrared (N and Q) time-resolved measurements of asteroids 532 Herculina and 45 Eugenia. For both Herculina and Eugenia, we have found that their reflected and thermal lightcurves are in phase with one another. We have generated model lightcurves for Herculina based on the predicted albedo distribution derived by Taylor *et al.* As expected, these reflected and thermal model lightcurves are 90° out of phase with one another. From a comparison of these model and observed lightcurves, we conclude that the lightcurves of Herculina and Eugenia are due primarily to shape rather than to albedo spots on their surfaces.

07.15

Asteroid Pole Determination: Effects of Rotational Phase Shifts

E. Bowell (Lowell Observatory), H. Karttunen, and K. Lumme (University of Helsinki)

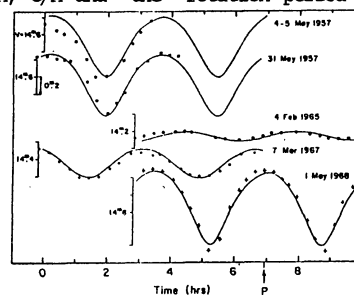
It is difficult to compare asteroid lightcurves obtained at different apparitions because of the unknown shift in rotational phase relative to the line of sight. Even in an ideal case, where the synodic rotation period is known to high accuracy, the unknown pole orientation contributes its own unknown phase shift from one apparition to another. To eliminate such effects we have fitted lightcurves by Fourier expansions and have made use of the amplitudes of various orders rather than the individual sine and cosine coefficients. The inclusion of fundamental concepts due to Russell (*Astrophys. J.* **24**, 1, 1906) makes it possible to solve for the pole and to obtain constraints on body shape from spherical harmonic fits to lightcurves observed at different apparitions. The method and preliminary results from some of the best-observed asteroids will be presented. Research supported, in part, by NASA Grant NSG-7500.

07.16

A New Method for Determining Asteroid Shapes and Rotation Poles from Lightcurves and Its Application to 624 Hektor

K. Uchida (Dept. of Astronomy, Univ. of CA at Los Angeles), and J. D. Goguen (Jet Propulsion Laboratory, California Institute of Technology)

The surface of a model tri-axial ellipsoid is divided into ~5000 plane facets. The incidence and emission angles and the contribution of each facet to the flux are calculated. The total flux is compared to the measured asteroid magnitude. The model parameters are varied until a simultaneous fit to all lightcurves is found. We apply this method to five lightcurves of 624 Hektor from Dunlap and Gehrels (1969), that span a period of 11 years and sample both large and small lightcurve amplitudes. The model rotates about its shortest axis and its surface has a normal reflectance 0.022. The rotation period found is 0.288335 days and the rotation pole direction is ecliptic longitude 314° and ecliptic latitude $+17^\circ$, in good agreement with other estimates. The semi-axes of the ellipsoid are $A = 206$ km, $B = 93$ km and $C = 78$ km. The axes ratios are those of a Jacobi ellipsoid, a special tri-axial ellipsoid that satisfies the condition of hydrostatic equilibrium in a rapidly spinning body of uniform density. If Hektor is assumed to be in hydrostatic equilibrium, the density implied by B/A , C/A and the rotation period is 1.0 g cm^{-3} . This model is stable with respect to binary fission contrary to the conclusions of Weidenschilling (1980) based on the maximum measured lightcurve amplitude alone.



07.17

Convex-Profile Inversion of Asteroid Lightcurves

S. J. Ostro (JPL/Caltech)

Convex-profile inversion (Ostro and Connelly 1984, *Icarus* **57**, 443) has been reformulated, extended, and calibrated as a theory for physical interpretation of an asteroid's lightcurve. Under ideal conditions, one can obtain the asteroid's "mean cross section" $\bar{Q}$, a convex profile equal to the average of the convex envelopes of all the surface contours parallel to the equatorial plane. For an opposition lightcurve, $\bar{Q}$'s odd harmonics are inaccessible, but one can estimate the symmetrized mean cross section, $\bar{Q}_s$. The ideal conditions for estimating $\bar{Q}$ are GEO, that the scattering is uniform and geometric; EVIG, that the viewing-illumination geometry is equatorial; CONVEX, that all of the asteroid's surface contours parallel to the equator are convex; and PHASE, that the solar phase angle $\phi \neq 0$. Condition CONVEX is irrelevant for estimation of $\bar{Q}_s$. Definition of a rotation- and scale-invariant measure of the distance, Ω , between two profiles permits