Physical Characterization of Asteroids: Potentially Hazardous Asteroid 2007 MK13

J.A. Shitanishi
California State University Los Angeles, Physics Department, 5151 State University Drive Los Angeles, CA 90032, United States

Physical characteristics of most Near Earth Asteroids (NEAs) are based on photometry and reflective spectroscopy. The 3D shape, period of rotation, and size of an asteroid can be extracted from its light curve. If BVRI data is available, asteroid colors can help constrain the asteroid's spectral classification, from which composition can be derived. Differential photometry alone can provide insight onto the asteroid's rotation period and tri-axial shape. The light curve of one night of relative photometric data of asteroid 2007 MK13 taken with JPL Table Mountain Observatory's 0.6m telescope is presented.

INTRODUCTION/PROJECT GOALS

Near Earth Asteroids (NEAs) are classified as having a distance of less than 1.3 AU at perihelion. This puts them "near earth" and possibly dangerous. Potentially Hazardous Asteroids (PHAs) are a subset of NEAs, and are defined as being less than 0.05 AU away from Earth at their closest approach. Although the chances of an asteroid hitting Earth in the near future is not probable, it is not completely negligible, so it is important to learn more about these asteroids. Other subjects that can be investigated by studying NEAs include learning more about how life formed on Earth (by studying chemical and biological properties of the asteroids), and possibly NEAs as a supply source for materials such as minerals. The predominant way to learn more about these asteroids is to observe them through photometry and reflective spectroscopy.

Photometric data can be in the form of light curves, which describe how an asteroid's magnitude changes with time. Physical properties such as the asteroid's period of rotation, size, and shape can be extracted from light curves. These properties, especially for PHAs, can determine how dangerous the asteroids are to Earth. The overall project goal is to observe NEAs using photometry to get information about those characteristics.

The Near-Earth Asteroid 2007 MK13 was first observed and identified through the Catalina Sky Survey on June 21, 2007 (MPEC 2007-M37). Since its Minimum Orbit Intersection Distance (MOID) = 0.032 AU, it has been identified a PHA. The estimated diameter is 200 m < D < 600 m.[1]

METHODS

Data was obtained using the 1K (1024x1024) CCD camera on the 0.6m Cassegrain telescope at Table Mountain Observatory, a facility of the Jet Propulsion Laboratory. The night of interest was taken on December 27, 2009 (U.T.) by Hicks and Somers.[1] The data comprises of 63 images in the R filter. To reduce the data, Image Reduction and Analysis Facility (IRAF) software package is used. A set bias value was subtracted. 5 flat fields taken in R were used to complete flat-field corrections. Standard photometric analysis is completed in IRAF with the NOAO photometry package APPHOT. The main parameters chosen by the user that affected the measurements were the aperture size and annulus radii. The aperture size for these measurements was chosen to be ~ 4.2''. This was based on where the DN radial profile of the asteroid fell to the background. To sample the sky background, the inner annulus and annulus width were both chosen to be 5.23''. This was set so that little light from the asteroid was in the annulus, as well as no light from other stars in the field. These along with other parameters were used uniformly throughout the asteroid images.

RESULTS

Through aperture photometry data analyzing techniques, the instrumental magnitudes of 2007 MK13 was found as a function of time (Julian date). Figure 1 shows the resulting relative lightcurve, which matches well with Hicks'.[1]

The period of rotation can be estimated by considering that we can see approximately half a period in our data (there are two 'maxima'), and the time between those two maxima is ~ 2hr 25m. Therefore the period can be estimated as being at least 5 hr. This approximation is consistent with Hicks' and Somers' ATel, which used advanced fitting and gave a synodic period of 5.286+/-0.005 hr.

We can estimate the tri-axial ellipsoid ratio (assuming the asteroid has that shape), b/a, by measuring the difference in the maximum magnitude and the minimum magnitude. We can follow the general relation:

$$\Delta m = -2.5 \log\left(\frac{f_1}{f_2}\right)$$

Where Δm is the difference in magnitude, f_1 the flux of one side of the object, say, the smaller flux, and f_2, the flux of the other side of the object, the larger flux. Since flux is related to the area, $f_1 \propto A_1 = \pi bb$, and $f_2 \propto A_2 = \pi ba$, noting that $b < a$, we can rewrite the equation , solving for b/a:

$$\frac{b}{a} = 10^{\frac{\Delta m}{-2.5}}$$

Solving yields a b/a ratio of ~0.3, or a a:b ratio of ~ 3. This is comparable to Hicks' a:b ratio of "at least" 2:1.[1] From this we can suggest that this asteroid is elongated in shape.

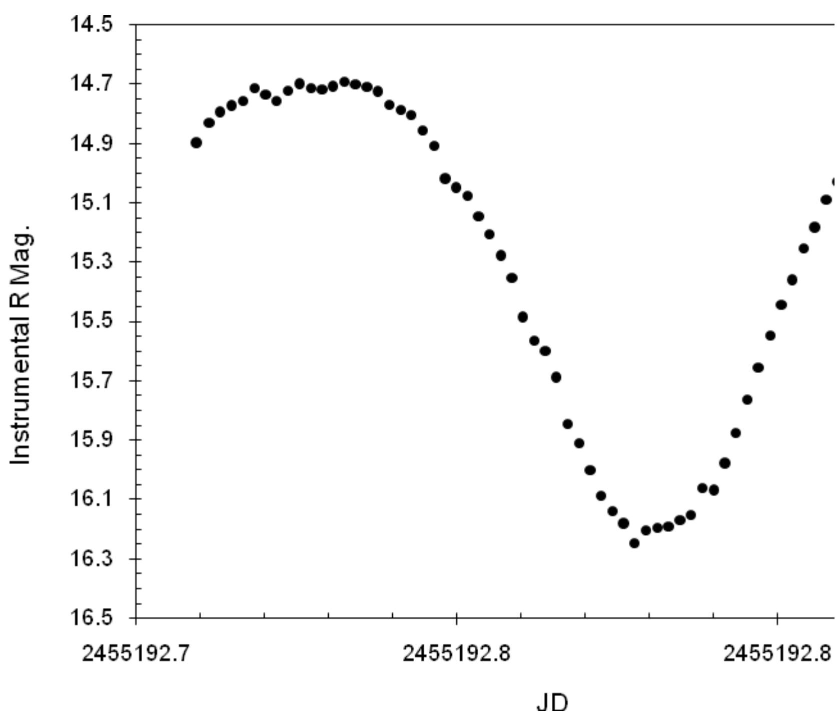

Figure 1: Relative Lightcurve of 2007 MK13 in the R filter.

FURTHER WORK

The next step for this work is to convert these instrumental magnitudes into absolute R magnitudes of the asteroid as a function of time. This requires the use of R filter standard fields at different airmasses, and would use a least-squares-fit to solve for coefficients that depend on the night the observations were held.

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REFERENCES

[1] M. Hicks, J. Somers, 2007 MK13: A Highly Elongated C-type Potentially Hazardous Asteroid, (ATel #2372)