LIGHTCURVE ANALYSIS FOR THREE ASTEROIDS: 4000 HIPPARCHUS, 5256 FARQUHAR, AND 5931 ZHVANETSKIJ

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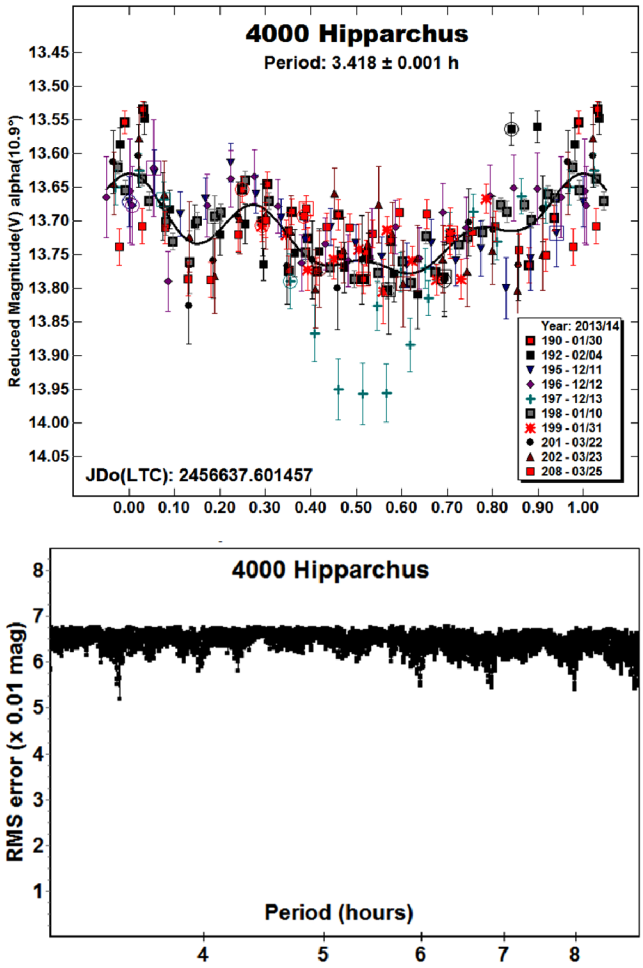
Lightcurves for asteroids 4000 Hipparchus, 5256 Farquhar, and 5931 Zhvanetskij were obtained at the Phillips Academy Observatory (PAO) and HUT Observatory between 2013 October and 2014 March.

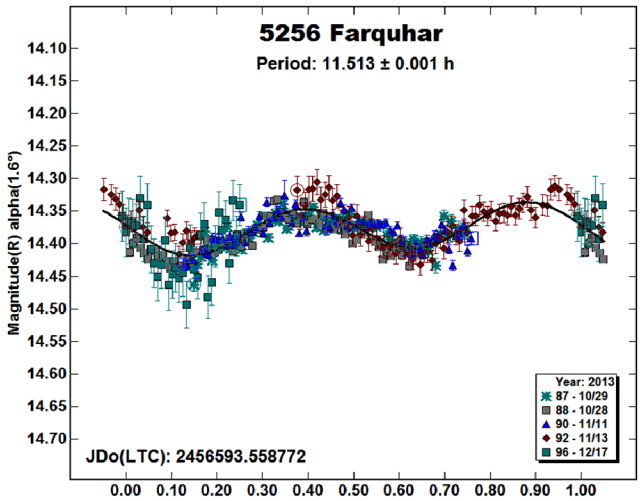
Lightcurves for three asteroids were obtained from Phillips Academy Observatory and HUT Observatory between 2013 October and 2014 March. The two observatories have twin telescopes: 0.40-m *f*/8 Ritchey-Chrétien reflectors by DFM Engineering. Phillips Academy Observatory used an SBIG STL-1301E with a 1280x1024 array of 16-micron pixels. The resulting image scale was 1.0 arcsecond per pixel. Exposures were primarily 300 seconds working at –30°C and unfiltered. All images were dark and flat-field corrected, guided, and unbinned. HUT observations were made with an Apogee Alta U47 CCD. Exposures were 300 seconds working at –40° C. All images were dark and flat-field corrected and binned 2x2 for an effective image scale of 1.65 arcseconds per pixel.

Images were measured using *MPO Canopus* (Bdw Publishing) with a differential photometry technique. All comparison stars were selected to near solar color by using the "comp star selector" tool of *MPO Canopus*. Data merging and period analysis were also done with *MPO Canopus* using an implementation of the Fourier analysis algorithm of Harris (FALC; Harris *et al*., 1989). The combined data sets from both observatories were analyzed collaboratively by high school students enrolled in an astronomy research class taught by Odden at Phillips Academy. The final lightcurves appearing here were contributed by Aggarwal and Yoon. A search of the Asteroid Lightcurve Database (LCDB; Warner *et al*., 2009) and other sources did not reveal previously reported lightcurve results for these asteroids.

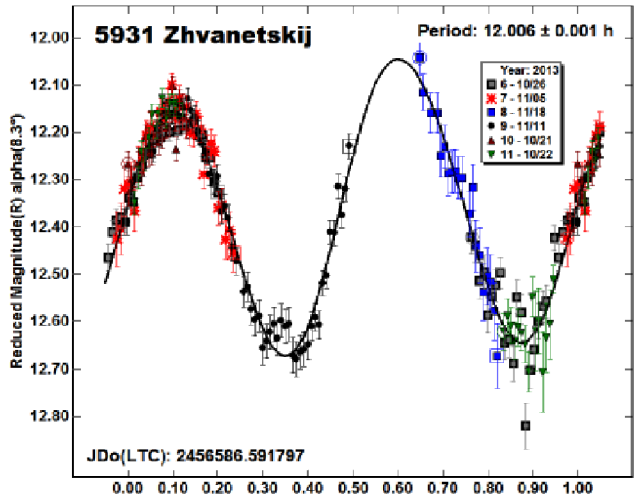
4000 Hipparchus. Astronomers Seiji Ueda and Kaneda Hisroshi discovered asteroid 4000 Hipparchus in 1989 and named it after the famed Greek astronomer. Images were taken from 2013 October to 2014 March at PAO and HUT observatories. To make the graph more legible, data points have been binned in pairs with a maximum of ten minutes between points. The resulting plot consists of 190 data points derived from images taken on ten separate nights. The asteroid was passing through the Milky Way at opposition. Although the authors were careful to eliminate images in which the asteroid was passing near a background star, there is quite a bit of scatter in the resulting plot. Because the field was so dense, there may have been undetected background stars affecting the photometry. A period search of the data favored a period of 3.418 hours, but the period spectrum leaves the possibility open for other solutions. Given the short period of the asteroid and the presence of odd dips in the object's brightness when no adjacent star was obviously present, the authors attempted a dual period search. No strong dual period solution emerged. Follow-up work on this asteroid is warranted.



5256 Farquhar. Astronomers E.F. Helin, C. Mikolajczak, and R. Coker found asteroid 5256 Farquhar in 1998. Images were taken at PAO on 2013 October 28-29 and December 17. HUT observatory imaged the asteroid on 2013 November 11 and 13. The resulting bimodal lightcurve consists of 342 data points. The period spectrum suggests a synodic period P = 11.513 ± 0.001 hours and amplitude 0.07 mag. A second dip in the period spectrum is also noted at 5.755 hours (1/2 P). Although several additional imaging runs were attempted, the asteroid dimmed too quickly for adequate signal-to-noise to be achieved. Thus, further attempts to image the asteroid were not pursued.



5931 Zhvanetskij. This asteroid was discovered in 1976 by Russian Astronomer N.S. Chernykh. Images were taken at PAO on five nights from 2013 October 21 through November 18. HUT Observatory imaged the asteroid on 2013 November 11. The resulting lightcurve consists of 204 data points. The amplitude of the lightcurve is 0.63 mag, sufficient to ensure a bimodal solution. The period spectrum strongly suggests the period of P = 12.006 ± 0.001 hours. Because the asteroid completes its rotation almost exactly twice each day, all of the image runs taken from Andover cover the same portion of the lightcurve. The images provided by HUT extended observations, but a gap remains.



Acknowledgements

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Minor Planet Center Database Search Engine
http://www.minorplanetcenter.net/db_search

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Warner, B.D., Harris, A.W., Pravec, P. (2009). "The asteroid lightcurve database." *Icarus* **202**, 134-146. Updated 2014 February 28. *http://www.minorplanet.info/lightcurvedatabase.html*