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5426 SHARP: A PROBABLE HUNGARIA BINARY

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Initial CCD photometry observations of the Hungaria asteroid 5426 Sharp in 2014 December and 2015 January at the Center of Solar System Studies-Palmer Divide Station in Landers, CA, showed attenuations from the general lightcurve, indicating the possibility of the asteroid being a binary system. The secondary period was almost exactly an Earth day, prompting a collaboration to be formed with observers in Europe, which eventually allowed establishing two periods: $P_1 = 4.5609 \pm 0.0003$ h, $A_1 = 0.18 \pm 0.01$ mag and $P_2 = 24.22 \pm 0.02$ h, $A_2 = 0.08 \pm 0.01$ mag. No *mutual events*, i.e., occultations and/or eclipses, were seen, therefore the asteroid is considered a *probable* and not *confirmed* binary.

Observations of the Hungaria asteroid 5426 Sharp were made by Warner at the Center for Solar System Studies-Palmer Divide Station (CS3-PDS) starting on 2014 December 29. These were

follow-up to earlier work by Warner (2012) which found $P = 4.56$ h and $A = 0.25$ mag. The lightcurve was rated $U = 2$ on the asteroid lightcurve database rating system (LCDB; Warner *et al.*, 2009). Based on a high albedo derived from WISE observations (Masiero, 2011), Sharp is a member of the Hungaria *collisional family*, meaning it is a remnant of the parent body and probably of taxonomic type E.

The initial data from CS3-PDS showed attenuations from the general lightcurve that might be attributed to a satellite. A preliminary dual-period analysis by Warner using *MPO Canopus* found a secondary period of about 24 hours, making it nearly impossible to resolve the period with some certainty without observations from stations well removed in longitude.

OBS	Telescope	Camera
Warner	0.35-m f/9.1 Schmidt-Cass	STL-1001E
Benishek	0.35-m f/10 Schmidt-Cass	ST-8XME
Ferrero	0.30-m f/8.0 Ritchey-Chretien	ST-9

Table I. List of observers and equipment.

Obs	Dates (2014/2015)	Sessions
Warner (CS3-PDS)	12/29-01/02 14 19	1-5 8
Benishek (SAO)	01/15 16	6 7
Ferrero (BO)	01/24 26	10 11

Table II. Dates of observation for each observer. The Sessions column gives the session numbers shown in the lightcurve legend.

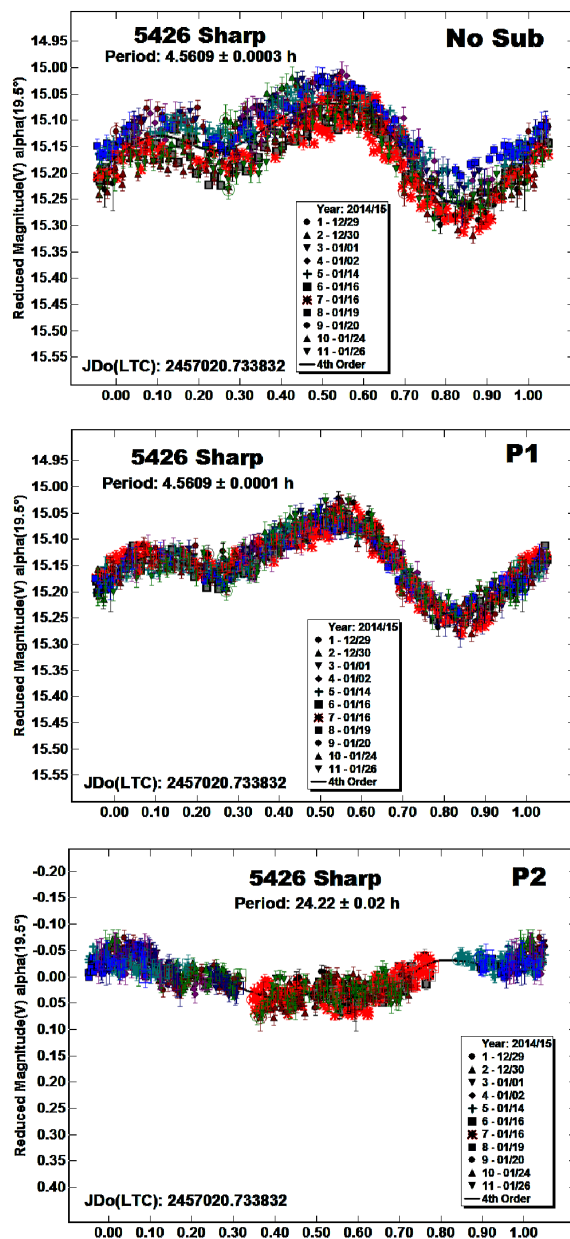
A collaboration was formed with Benishek (working at Sopot Astronomical Observatory) and Ferrero, which eventually allowed resolving the system parameters. Tables I and II list the observers, equipment used, and the dates that each person made observations. All exposures were unfiltered and ranged from 180 to 300 sec.

All three observers used *MPO Canopus* to measure the images. The Comp Star Selector utility found up to five solar-colored stars for each session. The magnitudes for the comparisons were taken from the MPOSC3 catalog, which is based on the 2MASS catalog converted to the BVRc system using formulae developed by Warner (2007). Benishek and Ferrero sent *MPO Canopus* export data sets to Warner for period analysis. This was also done in in *MPO Canopus*, which incorporates the FALC Fourier analysis algorithm developed by Harris (Harris *et al.*, 1989) and modified by Warner to allow subtracting a Fourier model lightcurve from a data set to search for a secondary period.

In the "No Sub" and "P1" lightcurves presented here, the "Reduced Magnitude" is Johnson V corrected to unity distance by applying $-5 \log(r\Delta)$ to the measured sky magnitudes with r and Δ being, respectively, the Sun-asteroid and Earth-asteroid distances in AU. The magnitudes in the "P2" are relative to the average magnitude of the "P1" lightcurve, or $V = 15.15$. The magnitudes were normalized to a phase angle of $\alpha = 19.5^\circ$ using $G = 0.43$, which is the default for type E asteroids in the asteroid lightcurve database (LCDB; Warner *et al.*, 2009). The horizontal axis is the rotation phase, ranging from -0.05 to 1.05 .

The "No Sub" lightcurve shows the entire data set when searching for a single period. The deviations from the average lightcurve exceed the general noise and so prompted the dual period search, which involves finding a single period, primary solution and subtracting that to find a secondary period. The resulting secondary period is subtracted to find a revised primary period. That is used to find a revised secondary period. The process continues until both periods stabilize.

In cases where the initial primary period is not well constrained, some of the alternative periods are used to find the first guess for the secondary period. If this leads to a significantly different result than with the first results, it's an indication that the data set may not be sufficient to find a secure solution. If all initial primary periods lead to about the same secondary period, which then leads to a single primary period, the result is considered as secure as the data set allows.



The “P2” lightcurve shows only a slowly varying amplitude with no significant deviations, which would indicate *mutual events*, i.e., occultations and/or eclipses. Lacking these, it is not possible to give a size estimate of the satellite and to suggest only that the long

period lightcurve represents a satellite that is tidally locked to its orbital period of about 24 hours.

Perhaps future observations will find definitive proof of a satellite. If nothing else, these results strongly recommend a collaboration involving stations located at two widely-separated longitudes. A third station, also well removed from the other two would be better. For example, in this case, having observations from India or Japan would have been a considerable help. Unfortunately, the asteroid was too far north for observers in, for example, Australia or Chile.

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ROTATIONAL PERIOD OF 5685 SANENOBUFUKUI

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The asteroid 5685 Sanenobufukui was observed over eight nights in 2015 March in order to determine its previously unknown rotational period. Lightcurve analysis yielded a bimodal trend with a period of 3.388 ± 0.001 hours.

The main-belt asteroid 5685 Sanenobufukui, also called 1990 XA, was discovered by T. Nomura and K. Kawanishi at Minami-Oda. It is named after the astronomer Sanenobu Fukui. The orbit of 5685 is characterized by a 4.69 year period, an eccentricity of about