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97.

COMPOSITE LIGHTCURVES OF THREE MAIN-BELT ASTEROIDS

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We present composite lightcurves of Koronis family asteroids (2092) Sumiana and (2953) Vysheslavia, and serendipitous observations of main-belt asteroid (2705) Wu. The lightcurve of Sumiana was assembled from seven nights of observations and its period and amplitude are 30.523 ± 0.014 h and 0.38 ± 0.04 mag respectively. Our observations of Vysheslavia and Wu are consistent with previously reported periods.

Our research team at the Union College Observatory (UCO) continues its mission to define Koronis family asteroid spin periods (Wilkin et al., 2023; Zora et al., 2024). We work to increase the sample size of objects to enable larger statistical studies (Slivan et al., 2003; Slivan et al., 2023), with a broader goal of studying the impact of solar radiation on spin via the YORP mechanism (Rubincam, 2000).

Observations were planned with the aid of *Koronisfamily.com* (Slivan, 2003). Four telescopes were used through iTelescope.net (T19, T21, T72) and Telescope.Live (CHI-1). Telescope, camera, and filter information are given in Table I. Observation dates and telescopes are given in the legends in the lightcurve figures. We used *AstrolImageJ* (Collins et al., 2017) to perform photometry on all images. Corrections for light travel time were applied using ephemerides from the JPL Horizons web app (JPL, 2024).

(2092) Sumiana. No published periods or lightcurves for Sumiana were found in the LCDB (Warner et al., 2009) or in the astrophysical literature. We observed on seven nights with four telescopes over two months in spring of 2024. Exposure times were 240 s except for Apr 14, when they were 300 s, and binning was 2×2 . Values for April 14 were averaged in boxes of 4 due to their larger scatter. Despite its lower quality, we retained the photometry from this night because it results in a greater total time span which should increase the precision in the period determination.

Because no single night's lightcurve records a full rotation, we explain in detail how we arrived at our fitted period. For Feb 29, the CHI-1 and T21 observations overlap in time, and the same comparison star was used for photometry. Although the filters used (Sloan r' and Cousins R) are distinct, their bandpasses mostly overlap, so any systematic effect introduced by not allowing a relative shift in magnitudes between the two observing sessions is assumed to be small. By capturing an adjacent minimum and maximum, we derive an approximate amplitude of 0.34 mag. In context of the discussion by Harris et al. (2014), this amplitude is not quite large enough for a quadruply-periodic lightcurve to be a formal geometric impossibility, but for a realistic asteroid shape a doubly-periodic lightcurve is most likely for Sumiana.

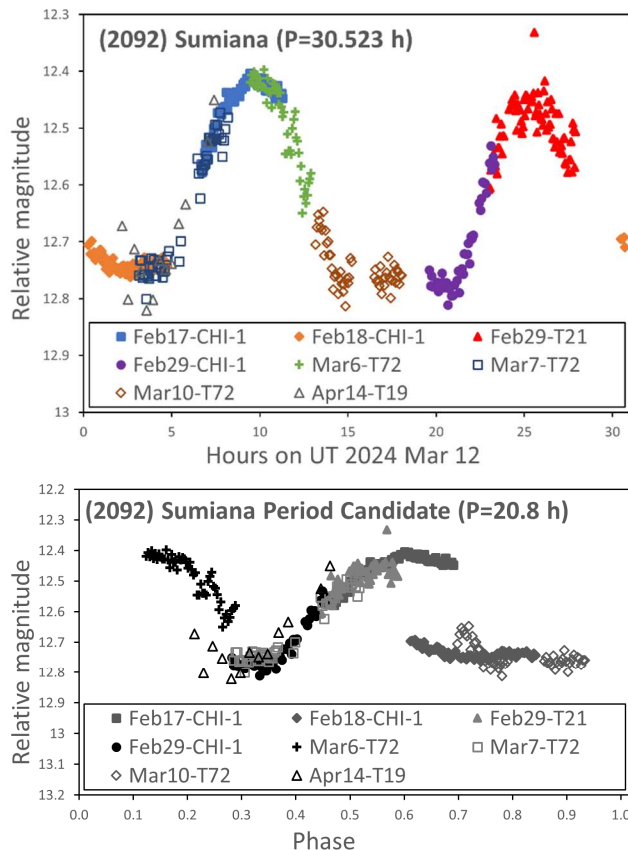
Name	Site	Telescope	Camera	Array	Filter	FOV (')	Scale ("/pix)
T19	Beryl Junction, UT	0.43-m CDK f/6.8	FLI-16803	4096×4096×9μm	Red	43.2×43.2	0.63
T21	Beryl Junction, UT	0.42-m CDK f/4.5	FLI-PL6303E	3072×2048×9μm	R	32.8×29.2	0.96
T72	Rio Hurtado, Chile	0.51-m CDK f/6.8	FLI-ML16200	4500×3600×6μm	R	26.9×21.5	0.36
CHI-1	Rio Hurtado, Chile	0.61-m RC f/6.8	QHY 600M Pro	9576×6382×3.8μm	r'	31.0×20.7	0.39

Table I. Telescopes and Cameras. RC=Ritchey-Chretien; CDK=Corrected Dall Kirkham. Filters: R : Cousins R ; r' : Sloan r' .

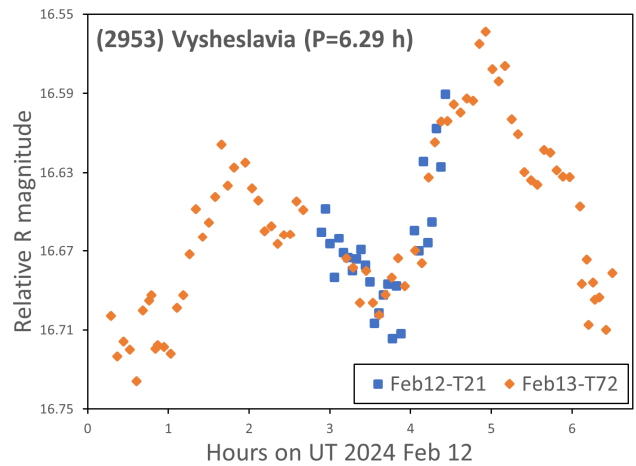
Number	Name	yyyy mm/dd	Phase	L _{PAB}	B _{PAB}	Period(h)	P.E.	Amp	A.E.	Grp
2092	Sumiana	2024 02/17-04/14	1.8, 18.5	145	4	30.523	0.014	0.38	0.04	Kor
2705	Wu	2024 03/06-03/10	20.5, 19.7	41	3	-	-	-	-	MB
2953	Vysheslavia	2024 02/12-02/13	1.6, 2.0	139	-2	6.29	0.02	0.14	0.03	Kor

Table II. Observing circumstances and results. The phase angle is given for the first and last dates. L_{PAB} and B_{PAB} are the approximate phase angle bisector longitude/latitude at mid-date range (see Harris et al., 1984). Grp is the asteroid family/group (Warner et al., 2009).

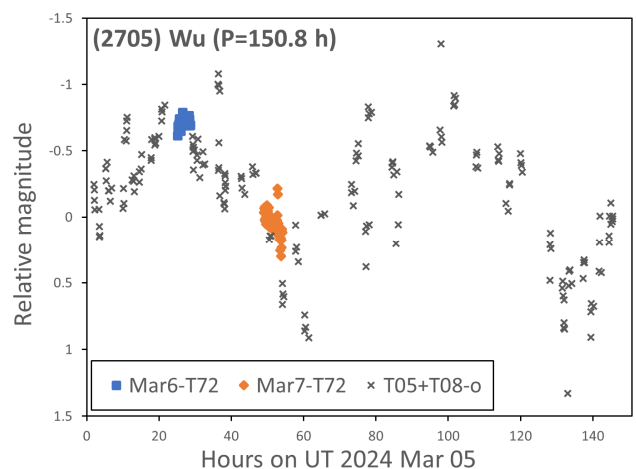
A lower bound of 18 h was estimated as the period of a relatively symmetric doubly-periodic lightcurve by assuming that the elapsed time between the two extrema observed on Feb 29 corresponds to about one quarter of a rotation. To allow for possible significant asymmetry in the lightcurve, adopting a generous factor of 2 gives an estimated upper bound of 36 h for the period. Starting with these constraints, we use the three maxima from Feb 17, Feb 29 and Mar 6 as reference points to create a list of candidate periods with an integer number of half periods between each pair of maxima. The photometry was folded at each of the resulting period candidates, with relative magnitudes of individual nights shifted to attempt to derive a self-consistent composite. Only one period value resulted in a self-consistent composite, yielding period 30.523 ± 0.014 h, and amplitude 0.38 ± 0.04 mag. We also show an example lightcurve from the derived list folded at candidate period 20.8 h, which came closest to, but still did not achieve, self-consistency.



(2953) Vysheslavia. A published period 6.2945 h is given by Vokrouhlický et al. (2006), who provided two spin-axis solutions. Shape models have been published by Vokrouhlický et al. (2006) and Ďurech et al. (2020). We observed Vysheslavia with two telescopes on two consecutive nights in 2024 Feb. Exposure times were 180 s for Feb 12 and 240 s for Feb 13. Both nights used 2×2 binning. The relative magnitude values for the first night were shifted to produce a self-consistent composite, resulting in amplitude 0.14 ± 0.03 mag and period 6.29 ± 0.02 h. The period value is consistent with previous findings.



(2705) Wu. Oey (2010) proposed that this object is a candidate tumbler, and Athanasopoulos (2020) proposed that it is a member of a primordial family, while Athanasopoulos et al., (2022) concluded that it is an interloper. Previously published period values include 150.5 ± 0.5 h (Oey, 2010), 150.8 ± 0.01 h (Ďurech et al., 2020), and 150.78 ± 0.02 h (Athanasopoulos, 2022). Shape models and spin axes based upon sparse-in-time data have been presented (Ďurech et al., 2020; Athanasopoulos, 2022). Our observations were serendipitous in two of our Sumiana fields and used the same telescope and reference star on consecutive nights, for which systematic effects on the relative brightnesses are small enough to neglect for the present discussion. We also accessed sparse-in-time photometry in the σ filter (orange, 560-820 nm) from telescopes T05 and T08 of the ATLAS project (Tonry et al., 2018). We applied corrections for light time, solar phase angle ($G=0.15$), and unit distance (JPL, 2024) and plotted the result as a reference to obtain a partial composite lightcurve. The ATLAS data were taken from the same apparition as our observations and limited to span from 2023 Oct to 2024 Apr. Our observations are consistent with the published period values of ~ 150.8 h.



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