

## LIGHTCURVES FOR THREE KORONIS FAMILY ASTEROIDS

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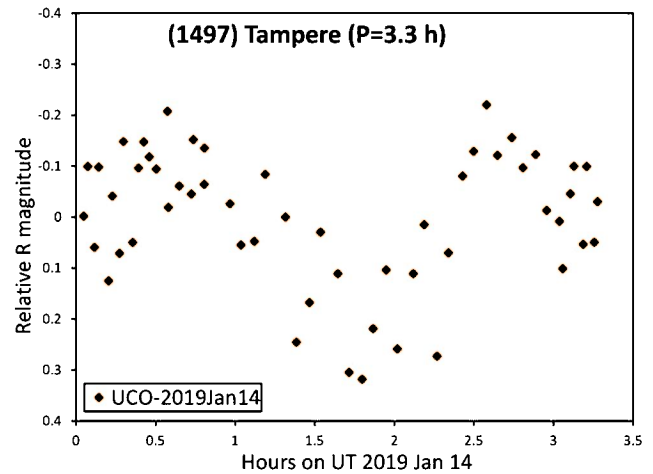
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We present photometry for three Koronis family asteroids, with new synodic rotation periods for two objects with no previously published dense lightcurves: (2470) Agematsu:  $2.7952 \pm 0.0007$  h; and (3856) Luts kij:  $7.992 \pm 0.0002$  h. The lightcurve for (1497) Tampere is consistent with the previously published period.

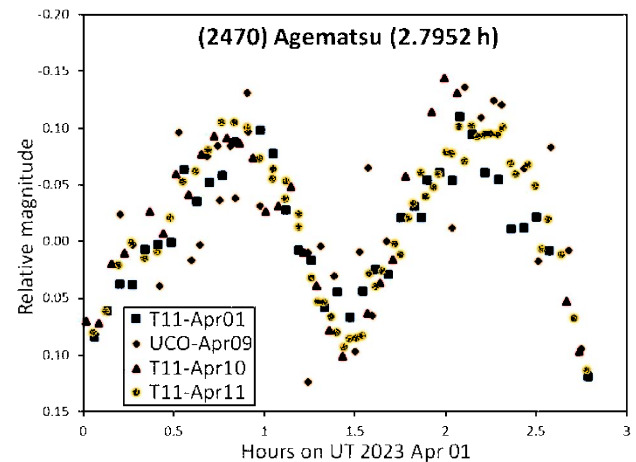
Members of the Koronis family have been shown to possess strongly anisotropic spin vectors clustered in two directions (Slivan, 2002). Thermal radiation torques by the YORP mechanism (Rubincam, 2000) may dominate collisional evolution of asteroid spins for sufficiently small objects of diameter  $\lesssim 30$  km in the main asteroid belt. Because YORP torques are more relevant for smaller objects, we continue our project (Wilkin et al., 2022; Wilkin et al., 2023) to increase the sample of known spins for koronis family objects (Slivan et al., 2003; Slivan et al., 2023b). Targets were chosen using the Koronis family web tool (Slivan, 2003), specifically, from the shape/spin list: (1497) Tampere, and from the quality  $Q < 3$  list needing more accurate periods: (2470) Agematsu and (3856) Luts kij.

Imaging observations were obtained using four telescopes including the Union College Observatory (UCO) and remote access through the networks iTelescope.net (T11, T21) and Telescope.Live (SPA-2; see Table I). Observation dates and telescopes used are given by the figure legends. All observations used a red filter but specific filters varied by observatory due to availability. Exposure times were 240s and binning  $2 \times 2$  on all cameras. Images were processed for bias, dark, and twilight flat field corrections. We used *AstroImageJ* software (Collins et al., 2017) to process the Union College images and to perform photometry on all images. NASA Horizons ephemerides (NASA, 2024) were used to apply light-time corrections and to obtain parameter values for phase and phase angle bisector appearing in Table II.

**1497 Tampere.** Rotation period and lightcurves were published by Slivan et al. (2023a), who obtained synodic period of  $3.30237 \pm 0.00015$  h. Our single night in 2019 yielded a lightcurve consistent with the previous period and amplitude  $0.45 \pm 0.06$  mag in R.



**2470 Agematsu.** No published periods or lightcurves were found in the lightcurve database (LCDB, Warner et al., 2009). We performed imaging observations on two telescopes and four nights in April, 2023. Relative magnitudes for a given night were shifted to produce a self-consistent composite. The composite lightcurve results in an estimated period of  $2.7952 \pm 0.0007$  h.



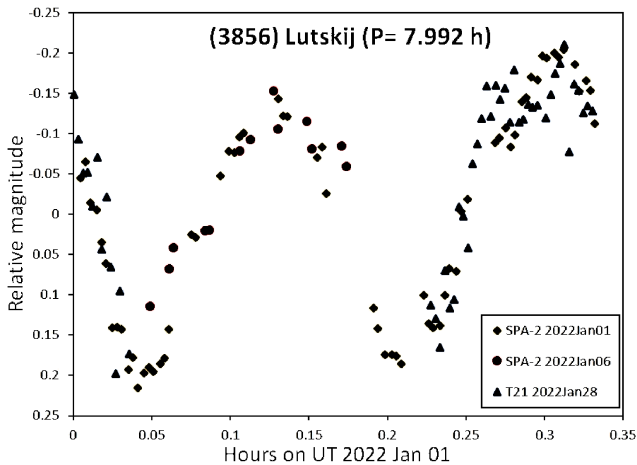
**3856 Luts kij.** No published periods or lightcurves were found in the lightcurve database (LCDB, Warner et al., 2009). We observed remotely on three nights in early 2022 using two telescopes. Relative magnitudes for a given night were shifted to produce a self-consistent composite. The lightcurve is doubly-periodic at a period of  $7.992 \pm 0.002$  h. The amplitude,  $0.42 \pm 0.03$  mag, is sufficiently large that we may exclude the possibility of a singly-periodic lightcurve at one half that period, or a quadruply-periodic lightcurve at double the given period (Harris et al., 2014). Recently, a sparse-survey period has been given by Ďurech and Hanuš (2023) using GAIA DR3 photometry. Their result, 7.9934 h, with unspecified error, is consistent with ours.

| Name  | Site               | Telescope        | Camera          | Array         | Filter | FOV(') | Scale(''/pix) |
|-------|--------------------|------------------|-----------------|---------------|--------|--------|---------------|
| UCO   | Schenectady, NY    | 0.51-m RC f/8.1  | SBIG STXL-11002 | 2004×1336×9μm | R      | 30×20  | 0.93          |
| T11   | Beryl Junction, UT | 0.50-m CDK f/6.8 | FLI-PL11002M    | 4008×2672×9μm | R      | 36×54  | 0.81          |
| T21   | Mayhill, NM        | 0.43-m CDK f/6.8 | FLI-PL6303E     | 3072×2048×9μm | R      | 33×49  | 1.92          |
| SPA-2 | Oria, Spain        | 0.70-m RC f/8    | FLI-PL16803     | 2048×2048×9μm | r'     | 29×29  | 0.86          |

Table I. Telescopes and Cameras. UCO = Union College Observatory; RC=Ritchey-Chrétien; CDK = Planewave Corrected Dall-Kirkham Astrogaph. The primary and secondary mirrors of UCO were shifted in early 2021 along with a resurfacing, yielding a slightly altered image scale. Prior to 2021, the image scale was 0.87''/pix.

| Number | Name     | yyyy mm/dd       | Phase     | L <sub>PAB</sub> | B <sub>PAB</sub> | Period(h) | P.E.   | Amp  | A.E. | Grp |
|--------|----------|------------------|-----------|------------------|------------------|-----------|--------|------|------|-----|
| 1497   | Tampere  | 2019 01/14-01/29 | 1.7       | 118              | 0                | 3.3       | 0.3    | 0.45 | 0.06 | Kor |
| 2470   | Agematsu | 2023 04/01-04/11 | *2.6, 2.6 | 196              | 4                | 2.7952    | 0.0007 | 0.15 | 0.02 | Kor |
| 3856   | Lutskij  | 2022 01/01-01/29 | 4.7, 14.7 | 90               | 2                | 7.992     | 0.002  | 0.42 | 0.03 | Kor |

Table II. Observing circumstances and results. The phase angle is given for the first and last dates. If preceded by an asterisk, the phase angle reached an extremum during the period. LPAB and BPAB are the approximate phase angle bisector longitude/latitude at mid-date range.



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