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Photometric Observations of Fast Move and Fast Rotate Asteroids

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Abstract

I present the results from my short-exposure ($t_{exp} \leq 10$ s) photometric observations of faint asteroids, including fast-rotate and fast-move NEA. I introduce deep data analysis method to get quality outcome using small telescopes equipped with quick camera, widely available today even for amateurs. I show how I use statistical analysis of big amount of frames to compensate SNR deficiency. Light curves and determined period of 2018 UY1 (NEA super-fast rotator and fast-mover; P = 98.05±0.04 s) and (3040) Kozai (Mars Crosser; P = 4.5133±0.0002 h) are presented.

1. Introduction

Among asteroids NEO group has a significant importance for 2 reasons at least: a) they are considered to be hazardous and b) there is potential for future space mining projects. The study of spin rotation provides us with knowledge about interior structure of the object. It's admitted that fast-rotators should be coherent bodies to keep its consistence [1], hence its impact is more dangerous than if it was a rubble pile.

Despite of their importance there is still bias in NEO studies: only for 262 asteroids with H ≥ 24 period has been determined so far (as of May 6th, 2019) and for only 84 of which with LCDB quality code "3-" or better [2]. This is because of difficulties in observation of such objects: when they are close enough to be measured with proper SNR they are usually moving fast on the sky, rapidly changing geometry and observation window is relatively small (single nights).

2. Telescopes & setup

Observations have been done using 3 telescopes: 0.65m Roman Baranowski Telescope (RBT) located in Winer Observatory (Arizona) equipped with Andor iXon X3 888 EMCCD camera, 0.43m Corrected Dall-Kirkham Astrograph (CDK) located in Nerpio (Spain) with FLI ProLine 16803 CCD and 0.28m Rowe Ackremann Schmidt Astrograph (RASA) located in Lusowko (Poland) with ZWO ASI290-MM camera. FLI ProLine 16803 is a classic CCD camera while Andor iXon X3 888 represents scientific standard electron-multiplying CCD and ZWO ASI290-MM is a CMOS camera of amatour level. The last two have high quantum efficiency, low read noise and short readout time thus are apropriate for making fast photometry.

3. Observations

Table 1: Following observations has been done. For CDK sloan r' filter has been used. For RBT and RASA - luminance filter applied.

Asteroid H (mag)	Dates	V(mag) Speed("/s)	#Frames Exp. (s)	Telescope
2018 UY1 24.1	2018-10-29 2018-10-30 2018-10-31	17.6 - 17.1 0.17 - 0.28	6070 10,8,7,6,5	RBT
(3040) Kozai 13.8	2019-02-26 2019-02-27 2019-03-30 2019-03-31 2019-04-01 2019-04-05 2019-04-06	15.6 - 16.8 0.03 - 0.005	11909 10	RASA
	2019-03-28 2019-03-29 2019-04-03 2019-04-04	16.6 - 16.8 0.010 - 0.006	44 300	CDK

4. Data reduction

Because of high number of data collected for single object it was necessary to implement a tool to pipe all the reduction process. Huge number of frames together with quality alghoritm to uncertainty estimate lead to trustworthy results.

The main features of the pipeline process:

- each raw frame has been calibrated to 32-bit data FITS;

- each frame has been plate solved to get asteroid's position on the frame, even if it's not noticeable;

- no frame has been rejected because of low asteroid's SNR or image quality; instead uncertainty of each asteroid measurement has been determined;

- stars' brightness transformation function of airmass has been determined; for fast movers this still ensures reference brightness and known uncertainty;

- aperture photometry parameters (aperture, annulus) were determined using genetic algorithm for frame series; each frame serie covers 15 minutes timeframe. Parameters were optimized for sources of brightness similar to the asteroid (± 1 mag);

- for asteroids with P ≥ 600s, frames were stacked into 60s sets with sideral-, asteroidal- and half-asteroidal speed; stars' photometry has been taken from the first, asteroid photometry - from the second. However this was not applied for highly crowded fields; in this case half-asteroidal speed is usually used;

- period was determined using Fourier series approximation based on weighted points.

5. Results

Table 2: In table below I present results of the observations. The reduction is ongoing and more results will be presented during the Congress.

Asteroid	Date	Period	Amp. (mag)
2018 UY1	2018-10-29	98.05 s ±0.04	0.28
2018 UY1	2018-10-30	98.01 s ±0.02	0.22
2018 UY1	2018-10-31	98.08 s ±0.04	0.42
(3040) Kozai	2019-02-26 - 2019-02-27	4.516 h ±0.002	0.27
(3040) Kozai	2019-03-28 - 2019-04-06	4.5133 h ±0.0002	0.32

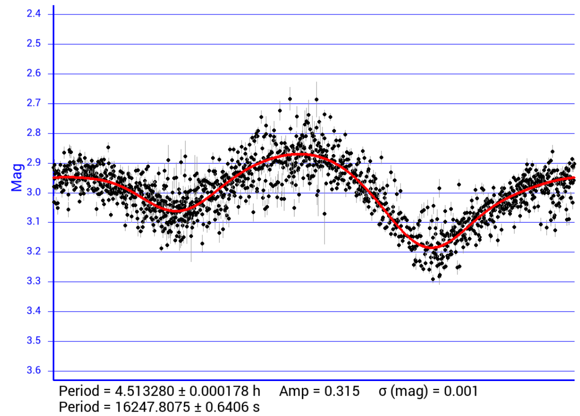

Figure 1: Lightcurve of (3040) Kozai. Data collected between 2019-03-28 and 2019-04-06. It's worth to notice that determined period is fully consistent with the ones given by Pravec and Stephens and cited in LCDB [2].

6. Conclusions

Fast photometry combined with statistical analysis can be strong technique for obtaining quality photometric data. For faint asteroids including fast rotators and fast movers it's possible to determine high quality rotation data even if SNR of single observation is very low. This enables small telescopes and amateur observatories to deliver valuable scientific input and overcome biases, especially in our knowledge of very small NEAs (D < 0.15 km).

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References

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