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OBSERVATION OF AN OCCULTATION OF THE UCAC4 488-082551 STAR BY ASTEROID (76228) 2000 EH 75 ON 31 MAY 2022

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ABSTRACT. Observations of an occultation of the UCAC4 488-082551 star by asteroid (76228) 2000 EH 75 were carried out on 31 May 2022 at Kryzhanivka observation station of Odesa I. I. Mechnykov National University (the observatory code A85). A set of instruments, which included a Schmidt telescope (the primary mirror diameter D = 271.25 mm; the corrector plate diameter D_k = 223.9 mm; the focal length F = 440 mm), a GPS receiver and Videoscan-415-2001 CCD camera, was used to perform observations. The observing conditions were as follows: clear sky, the star's altitude 49^0 south, the Moon was below the local horizon. The target star from the UCAC4 catalogue (Zacharias *et al.* 2013) has the following photometric parameters: m_B = 14.008; m_V = 12.720; m_r = 12.284; m_i = 11.813. The diameter of the star has not been determined. Asteroid (76228) is a Main Belt asteroid with an orbital period of 4.17178 years. It has an absolute magnitude of 14.93, the visible geometric albedo of 0.123±0.013 and diameter of 5.00±0.23 km (Masiero *et al*. 2011). The time of occultation predicted using ephemerides was 23:52:44±4 sec. The maximum duration of the occultation was 0.4 sec, provided that the observing site was located at the centre of the occultation track (strip). A drop in the star's brightness observed during occultation was about 8^m.

The occultation event was recorded as a sequence of GIF images with the exposure time of 0.5 sec per frame. The system clock of the computer used for the occultation recording was controlled with a GPS receiver in a fashion similar to that described in the paper by Karbovsky *et al.* (2017).

The data processing yielded an estimate of the occultation duration of 0.46±0.04 sec. The uncertainty of the occultation start time within exposure results in the total estimate of accuracy in timing the maximum phase of occultation 23:52:44.06±0.10 sec. The chord length across the asteroid estimated by timing the occultation is L = 9.2±0.8. This chord length is close to the estimates of the asteroid diameter reported in the paper by Masiero *et al.* (2011).

Key words: asteroids, stellar occultation, photometry.

АНОТАЦІЯ. 31 травня 2022 р. були проведені спостереження покриття астероїдом (76228) 2000 EH 75 зорі UCAC4 488-082551 на спостережній станцій в с. Крижанівка (код A85) Одеського національного університету імені І.І.Мечникова. Для спостережень використовувався комплекс з телескопу системи Шмідта (Діаметр головного дзеркала D=271.25 мм, діаметр корекційної пластини Dk=223.9 мм, фокусна відстань F=440 мм),, GPS-приймача і камери «ВІДЕОСКАН-415-2001». Умови спостережень: ясно, висота зорі над горизонтом 49° в південному напрямку, місяць під горизонтом. Зоря з каталогу UCAC4 (Zacharias et.al, 2013), яка має наступні фотометричні параметри mB=14.008, mV=12.720, mr=12.284, mi=11.813. Діаметр зорі не визначався. Астероїд (76228) належить до Головного поясу астероїдів з періодом обертання 4.17178 років. Він має абсолютну зоряну величину 14.93, геометричне альбедо 0.123±0.013, діаметр 5.00±0.23 км (Masiero et. al, 2011). За ефемеридами момент покриття 23:52:44±4 сек. Максимальна тривалість покриття 0.4 сек при умові знаходження в центрі полоси видимості покриття. Падіння яскравості зорі під час покриття приблизно на 8^m.

Був отриманий запис покриття у вигляді послідовності gif файлів з тривалістю експозиції одного кадра 0.5 сек. Системний час комп'ютера, який використовувався для запису, контролювався за допомогою GPS-приймача, аналогічний тому, що описаний в роботі (Карбовський та ін., 2017).

Обробка показала, що оцінка тривалості покриття 0.46±0.04 с. Невизначеність початку покриття в межах експозиції дає сумарну оцінку точності моменту максимальної фази покриття 23:52:44.06±0.10 с. Оцінки хорди астероїда за тривалістю покриття L = 9.2±0.8. Ця оцінка близька до оцінок діаметру з роботи (Masiero et. al,, 2011).

Ключові слова: астероїди, покриття зір, фотометрія.

Table 1: Observations of occultations of stars by asteroids at the observing station of Odesa I. I. Mechnykov National University in Kryzhanivka village (the observatory code A85).

Date	Observation time, UTC	Object (asteroid)	Star	Exposure time, sec	Occultation status: recorded or not recorded
22.11.2021		(585) Bilkis	UCAC4 397-130023	0.5	not recorded
02.12.2021	21:27:00 - 21:30:57	(30512) 2001 HO8	UCAC4 426-009364	0.5	not recorded
31.01.2022	22:19:07 - 22:31:36	(44473) Randytatum	TYC 1366-02390-1	0.5	not recorded
28.03.2022	21:25:53 - 21:26:29	(9691) Zwaan	UCAC4 453-052057	2	not recorded
26.04.2022	02:19:57 - 02:22:56	(107) Camilla	UCAC4 394-075598	5	not recorded
27.04.2022	00:06:00 - 00:07:00	(26512) 2000 CL46	TYC 311-01134-1	0.5	not recorded
31.05.2022	23:52:10 - 23:53:00	(76228) 2000 EH75	UCAC4 488-082551	0.5	recorded
02.05.2022	20:48:14 - 20:50:00	(116228) 2003 YZ4	UCAC4 516-051041	0.5	not recorded
04.08.2022	22:36:48 - 22:50:01	(159342) 2006 JR	TYC 489-02574-1	0.2	not recorded

1. Introduction

Routine observations of asteroid occultations have been performed at the observing station of Odesa I. I. Mechnykov National University in Kryzhanivka village (the observatory code A85). A set of instruments, which includes a Schmidt telescope (the primary mirror diameter D = 271.25 mm; the focal length F = 440 mm), a GPS receiver and Videoscan-415-2001 CCD camera, is used to carry out such observations. An important component of the set of instruments employed to observe occultations is the timing system. For its operation, the computer system clock, which is continuously controlled with a GPS receiver in a fashion similar to that described in the paper by Karbovsky *et al*. (2017), is used.

2. Observations

Observational data are given in Table 1. The majority of observations did not prove that the occultation occurred. This information is still useful though because it can be leveraged to specify the sizes and ephemerides of asteroids more precisely.

Observations of an occultation of the UCAC4 488-082551 star by asteroid (76228) 2000 EH 75 were carried out on 31 May 2022 at the observation station of Odesa I. I. Mechnykov National University in Kryzhanivka village (the observatory code A85). The observing conditions were as follows: clear sky, the star's altitude 49^0 south, the Moon was below the local horizon. The target star from the UCAC4 catalogue (Zacharias *et al*. 2013) has the following photometric parameters: m_B = 14.008; m_V = 12.720; m_r = 12.284; m_i = 11.813. The diameter of the star has not been determined. Asteroid (76228) is a Main Belt asteroid with an orbital period of 4.17178 years. It has an absolute magnitude of 14.93, the visible geometric albedo of 0.123±0.013 and diameter of 5.00±0.23 km (Masiero *et al*. 2011). The time of occultation predicted using ephemerides was 23:52:44±4 sec. The maximum duration of the occultation was 0.4 sec, provided that the observing site was located at the centre of the occultation track (strip). A drop in the star's brightness observed during occultation was about 8^m. The observations resulted in the occultation event recorded as a sequence of GIF images with the exposure time of 0.5 sec per frame. The system clock of the computer used for the occultation recording was controlled with a GPS receiver in a fashion similar to that described in the paper by Karbovsky *et al*. (2017).

3. Processing

A program which enabled to automatically measure intensity of digital images of the target UCAC4 488-082551 star and comparison stars in each frame was employed to process observational data. Main image frames were processed using dark frame subtraction. Seven comparison stars were used as reference ones to improve reliability of photometric estimates for the observed occultation. When performing photometry of the occulted star, its position in each frame was determined by the relevant comparison star positions.

Photometric curves of some reference stars are shown in Figure 1. In order to factor in possible changes in the sensitivity of photometric measurements and in the atmospheric transparency, the resulting photometric curve of the occultation was divided by the weighted average photometric curve for a set of all comparison stars. First, all instantaneous intensities of individual stars were normalised to 1:

$$i_0(t) = i(t)/\overline{i(t)}$$

Then, the root-mean-square error (σ) of the normalised measurements of the comparison stars' intensities was determined. The inverse of this error was assigned as a weight to each k comparison star:

$$w_k = 1/\sigma(i_{ok})$$

The weighted average normalized photometric curve, $I_0(t)$, was determined by the expression:

$$I_0(t) = \sum_k w_k i_{ok}(t) \Big/ \sum_k w_k$$

Photometric estimates of the occulted star were normalized to 1 as well, and then they were divided by the weighted average photometric curve $I_0(t)$. The resulting curve, which is free from the effects of changing sensitivity of photometric measurements and transparency of the atmosphere, is presented in Figure 2.

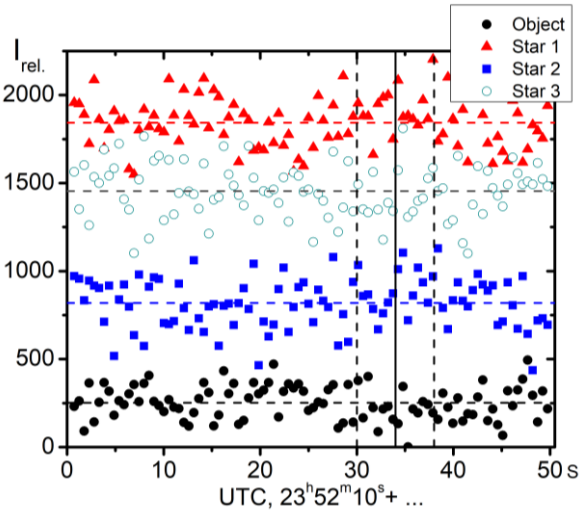

Figure 1: Photometric readings of the target star occulted by asteroid (76228) (denoted as "Object") and several reference stars in the field of view. Horizontal dashed lines depict the mean brightness of the stars. The vertical solid line marks the ephemeris time of the occultation. Vertical dashed lines represent the time range for the occultation start, taking into account prediction errors of ephemerides.

Vertical dashed lines show the limits of predictions of the occultation time using ephemerides. The horizontal dashed line depicts the lower limit of the 2σ range for the photometric curve of the target star. The only photometric reading at the predicted occultation time, which is outside the 2σ range, is marked with a downward arrow.

4. Conclusions

The instant of time which corresponds to the mid exposure time of the frame with captured occultation is 23:52:44.06±0.02 c. The star's brightness in this frame, taking into account statistical signal fluctuations, is 0.08±0.07 in relative units. Since the asteroid is too faint, then it can be assumed that the star disappears completely for the duration of occultation.

It yields an estimate of the occultation duration of 0.46±0.04 sec. The uncertainty of the occultation start time within exposure results in the total estimate of accuracy in timing the maximum phase of occultation of 23:52:44.06±0.10 sec. The chord length across the asteroid estimated by timing the occultation is L = 9.2±0.8. This chord length is close to the estimates of the asteroid diameter reported in the paper by Masiero *et al.* (2011).

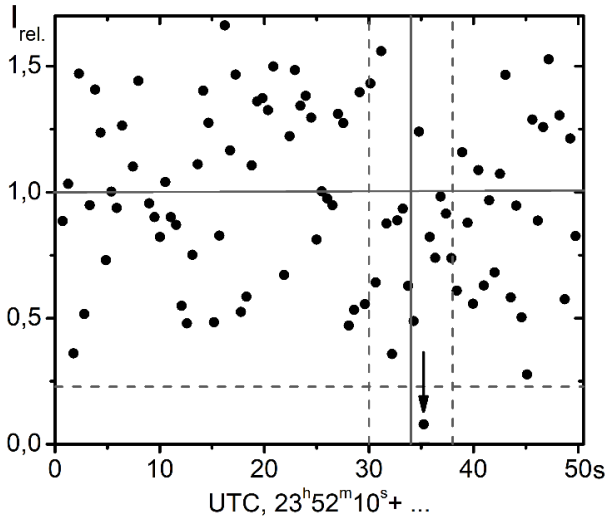

Figure 2: Photometric readings of the UCAC4 488-082551 star normalised to 1, taking into account statistical signal fluctuations, during its occultation by asteroid (76228) 2000 EH 75 on 31 May 2022. The vertical solid line marks the occultation time predicted using ephemerides. Vertical dashed lines represent the time range for the occultation start, taking into account prediction errors of ephemerides. The horizontal dashed line depicts two standard deviations 2σ from the mean intensity of the photometric readings. The downward arrow indicates the photometric reading that corresponds to the occultation.

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