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## PHOTOMETRY OF NEAR EARTH ASTEROID FLORENCE (3122)

**Purpose.** The purpose of this work is investigation of asteroid period of own rotation in moment of its close approach to Earth. Increased brightness of the object create an opportunity to find hidden new aspects of asteroid surface based on higher signal noise ratio and better precision of photometry.

**Methods.** In this work we use methods of CCD photometry. Observations were made on two telescopes with diameter 40 and 35 cm at different observatories.

**Results.** Photometry of near Earth asteroid Florence (3122) is performed during two nights in August and two nights in September 2017 from observatories in west of Ukraine — Laboratory of space research of Uzhhorod National University and amateur observatory in Ternopil. Brief overview of Florence period determination by other authors is given. Light curves obtained from observation data are presented. Periods of asteroid rotation were defined by MPO Canopus software.

**Conclusions.** Determined periods of rotation confirm previously published values. Presented period precisions are better than published before. Two different periods obtained on two observation sessions. Reasons of these results are described. No hidden aspects of asteroid surface were identified because of too fast phase angle change, also two light curves is not enough for such task salvation.

**Key words:** asteroid, photometry, light curve, period.

### Introduction

Florence (3122) is a stony asteroid, classified as near-Earth potentially hazardous asteroid. It was discovered on 2 March 1981 by American astronomer Schelte J. Bus at Siding Spring Observatory. Its provisional designation was 1981 ET<sub>3</sub>. Asteroid was named in honor of Florence Nightingale, the founder of modern nursing [1].

On 1 September 2017, Florence passed 0.047237 AU from Earth, approximately eighteen times the average distance of the Moon. As seen from Earth, it has brightened to apparent magnitude 8, and was visible in small telescopes. This was the asteroid's closest approach since 1890 and the closest until after 2500. Its most recent flyby was on August 29, 1930, at a distance of 0.05239 AU and the next one will be on September 2, 2057, at 0.049952 AU [2].

Size of asteroid is approximately 5 kilometers in diameter. It orbits the Sun at a

distance of 1.0–2.5 AU with period 2 years and 4 months (859 days), the orbit has an eccentricity of 0.42 and an inclination of 22° with respect to the ecliptic. Based on last radar images obtained at Arecibo Observatory on September 4 two moons orbiting Florence asteroid was discovered.

### Observation and light curve analysis

Photometric observation of asteroid Florence (3122) was planned at the period of its close approach to Earth and weather conditions provide us an opportunity to observe this target over 2 nights. Photometric CCD data were obtained on 30–31 of August 2017 at Derenivka observational station of Laboratory of space research Uzhhorod national university (LSR UzhNU) using a 0.4-m f/3.5 Newton telescope ChV-400. Also in this article we analyze data obtained on 31 August and 1 September 2017 on telescope situated near Ternopil city in amateur private

observatory. Telescopes and mounts used in this observation campaign are manufactured in Ternopil under the “Wight Swong” trademark. All main characteristics of involved telescopes are presented in Table 1.

All images were reduced using flat and dark frames. Photometry analysis of data was performed through MPO Canopus software, period analysis is also done using MPO Canopus, which implements the FALC algorithm developed by Harris [3].

**Table 1.** Parameters of telescopes used in observation

Telescope	MPC code	CCD	Focus, Diameter, FOV	Filter
<b>ChV-400 Uzhhorod</b>	K99	FLI PL9000, 12x12 micron pixel	F = 1750 mm D = 400 mm 73.3 x 73.3 arcmin	R filter
<b>Ternopil telescope</b>	-	SBIG, 9x9 micron pixel	F = 1800 mm D=350mm 47.5 x 62.8 arcmin	No Filter (Clear)

Earlier photometric observations of asteroid Florence shows period around 2.35 hour, in Table 2 periods obtained by different authors are presented [4]. Most precise period value is obtained by Pravec at all. in work [5]. Periods determined from our observation are presented in Table 3. Phased light curves of asteroid are showed on Fig. 1-2, phase angle at the middle of observation date is showed

on graphs as alpha value. Observations made from Ternopil have bigger error value. This fact is caused by shorter exposition of asteroid that was chosen by observer (0.5 second). In case of observational data from Derenivka station we can see much smaller error value because in this case 30 seconds exposition time was chosen.

**Table 2.** Periods of Florence (3122)

Reference	Date of Obs	Phase (°)	Period (hour)	Period Error (hour)	Amp Max (mag)	AmpErr (mag)
Warner 2018a	2017-09-01	23.8	2.362	0.005	0.16	0.02
Pravec 2003web	2003-10-31	49.4	2.3581	0.0001	0.22	-
Radar Team 2017c	2017-09-01	23.8	2.4	0.1	-	-
Pravec 2002web	2002-03-12	4.6	2.3581	-	0.15	-
Behrend 2010web	2010-12-18	33.8	2.3582	0.0003	0.18	0.01
Warner 2018a	2017-09-02	29.9	2.386	0.005	0.21	0.01
Wisniewski 1997	1986-03-19	15.1	5.	1.	0.15	0.02
Pravec 1998b	1996-1997	-	2.35812	0.00002	0.18	-
Elenin 2012	2010-10-28	57.9	2.359	0.003	0.27	0.02
Linder 2013	2011-01-03	25.7	2.359	0.001	0.15	0.05
Warner 2016j	2016-01-24	17.5	2.3580	-	-	-

**Table 3.** Our observation of Florence (3122)

Station	Date of Obs	Phase (°)	Period (hour)	Period Error (hour)	Amp Max (mag)
Derenivka	30-08-2017 31-08-2017	19.8	2.355377	0.000001	0.22
Ternopil	31-08-2017 01-09-2017	29.4	2.357623	0.000001	0.23

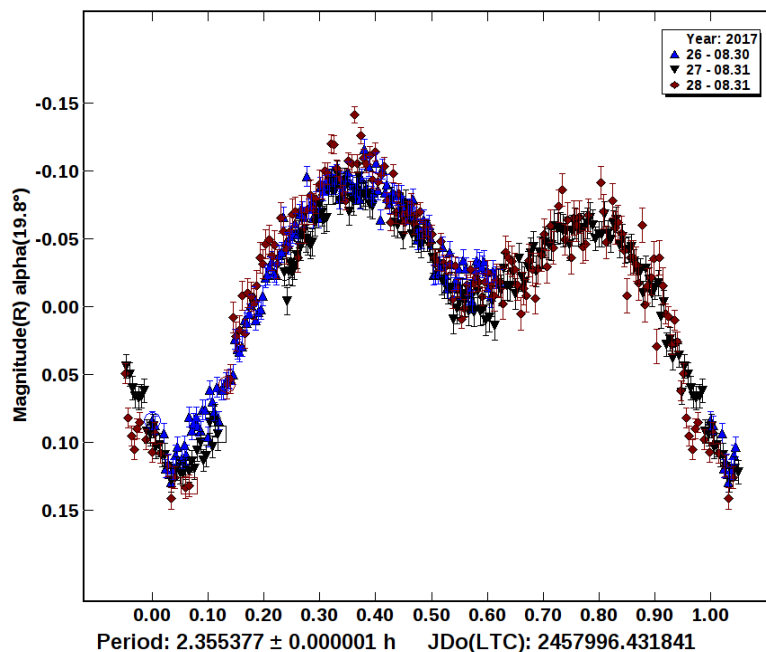


Figure 1. Photometry of asteroid Florence (3122) from Derenivka station on 30-31 Aug 2017.

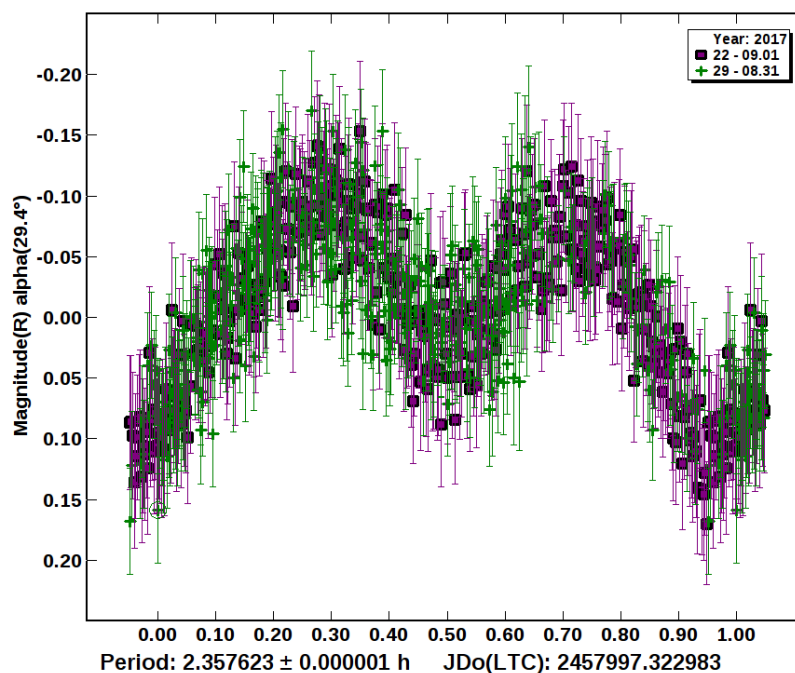


Figure 2. Photometry of asteroid Florence (3122) from Ternopil city on 31 Aug and 01 Sep 2017.

### Conclusion and discussion

Obtained results of asteroid rotation period are in good agreement with data obtained in previous years by other authors. Taking into account fast change of object phase angle we can explain small deviation of rotation period. Fact of second period existence also can be explained with some hidden aspects of asteroid shape that cant be identified due to fast phase angle change. For detection of such aspects better precision of photometry is also needed.

Despite that facts that light curve obtained from Ternopil amateur observatory has a bigger error it was processed and period value obtained from these data are in good agree with well known period.

All obtained observation will be send to Asteroid Light Curve Photometry Database. Such photometry observation of close approach asteroid can give us new knowledge about shape of object or better define period of asteroid rotation value because object is much brighter as it is usually (15<sup>m</sup> compared to 8<sup>m</sup> in close approach).

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## ФОТОМЕТРІЯ БЛИЗЬКОГО ДО ЗЕМЛІ АСТЕРОЇДА FLORENCE (3122)

Фотометрія астероїда Florence (3122), що наближався до Землі, виконувалася протягом двохночей у серпні та двох ночей у вересні 2017 р. з обсерваторій на заході України - Лабораторії космічних досліджень Ужгородського національного університету та аматорської обсерваторії поблизу міста Тернопіль. Представлено короткий огляд визначення періоду астероїда Florence (3122) іншими авторами. Наведена крива блиску, отримана з даних спостережень. Період обертання астероїдів визначався програмою MPO Canopus. Отриманий період обертання підтверджує раніше опубліковані значення. Описано причини що привели до визначення двохдещо відмінних періодів впродовж двохсеансів спостережень.

**Ключові слова:** астероїд, фотометрія, крива блиску, період.

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## ФОТОМЕТРІЯ БЛИЗКОГО К ЗЕМЛІ АСТЕРОЇДА FLORENCE (3122)

Фотометрія астероїда Florence (3122), приближающийся к Земле, выполнялась в течение двухночей в августе и двухночей в сентябре 2017 из обсерваторий на западе Украины - Лаборатории космических исследований Ужгородского национального университета и любительской обсерватории близ города Тернополь. Представлены краткий обзор определения периода астероїда Florence (3122) другими авторами. Приведенная кривая блеска, полученная по данным наблюдений. Период вращения астероїдов определялся программой MPO Canopus. Полученный период обращения подтверждает ранее опубликованные значения. Описаны причины, приводящие к определению двухнесколько отличных периодов в течение двух сеансов наблюдений.

**Ключевые слова:** астероїд, фотометрія, крива блеска, період.