LIGHTCURVE AND ROTATION PERIOD OF THE TUMBLING ASTEROID 1513 MATRA

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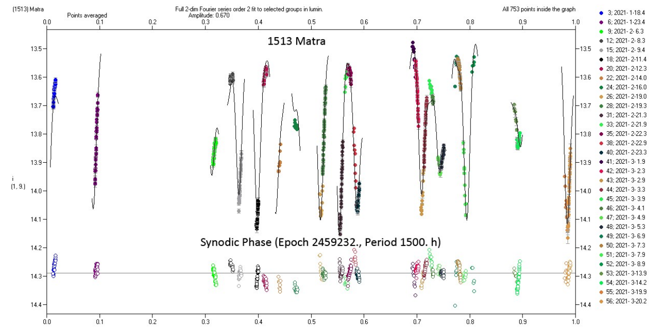
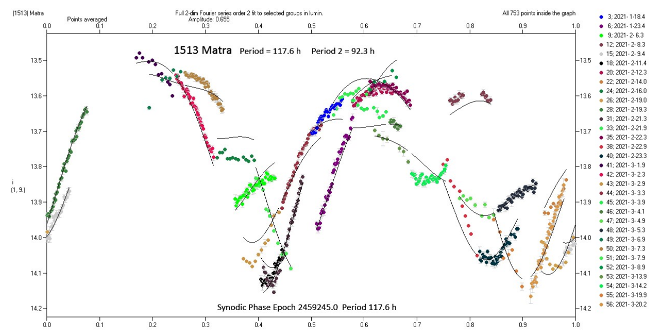
Minor planet 1513 Matra is tumbling with a main period of 117.6 ± 0.1 h, maximum amplitude 0.67 ± 0.02 mag, and second period near 92.3 h.

To obtain the data for this investigation, Pilcher at the Organ Mesa Observatory used a Meade 35-cm LX200 GPS Schmidt-Cassegrain, SBIG STL-1001E CCD, clear filter, 120 second exposure times, unguided. Benishek used a Meade 35-cm LX 200 Schmidt-Cassegrain telescope with SBIG ST-8XME and SBIG ST-10XME CCDs, exposure times from 120 to 240 seconds, clear filter, unguided. Image photometric measurement and lightcurve construction were done by *MPO Canopus* software. Calibration stars of near solar colors were selected from the CMC15 catalog. Because the internal consistency of magnitudes in the GAIA 2 catalog is better than in the CMC15, the magnitudes of all calibration stars were converted to the G magnitude system in the GAIA 2 catalog as presented on the VizieR web site.

Previously published periods of 1513 Matra are by Binzel and Mulholland (1983, >24 h) and by Rowe (2019, 34.8 h). After the first several sessions by Pilcher, it became clear that the lightcurve did not repeat with any one period and, therefore, that 1513 Matra was tumbling. At this time Benishek kindly accepted Pilcher's invitation to collaborate. A total of 32 sessions 2021 Jan. 18 - March 20 were obtained by the two observers. Petr Pravec kindly analyzed the data with simultaneous dual-period software that includes the ability to find both the axial rotation period and the precession period for tumbling asteroids. His analysis is the conclusion of this report:

It is definitely a tumbler. The main period of 117.6 h is well determined (uncertainty about 0.1 h), but the second period is less secure. It is likely 92.3 h, but not entirely certain. So, I rate this NPA rotation solution as PAR -2 tending to -3 (see the scale in Pravec et al, 2005). Note that there remain systematics in the residuals, which is because only the Fourier order 2 could be fitted to the data. Higher orders would be needed to explain some small features of the lightcurves, but there are not enough data for a robust fit of higher order 2-period Fourier series.





Acknowledgements

The authors thank P. Pravec for permission to publish his unphased and phased lightcurves in this paper.

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VizieR web site. *vizier-u.strasbg.fr/viz-bin/VizieR*

Number	Name	yyyy/mm/dd	Phase	L_{PAB}	B_{PAB}	Period(h)	P.E.	Amp	A.E.
1513	Matra	2021/01/18-2021/03/20	*16.9,17.9	148	1	117.6 92.3	0.1	0.67	0.02

Table I. Observing circumstances and results. The phase angle is given for the first and last date. An asterisk before the phase values indicates that a maximum or minimum was reached during the period. LPAB and BPAB are the approximate phase angle bisector longitude and latitude at mid-date range (see Harris *et al.*, 1984).

DETERMINING THE ROTATIONAL PERIOD OF MAIN-BELT ASTEROID 282 CLORINDE

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Based on CCD photometric observations of the main-belt asteroid 282 Clorinde, we report the results of the lightcurve analysis: $P = 49.353 \pm 0.004$ h, $A = 0.26$ mag.

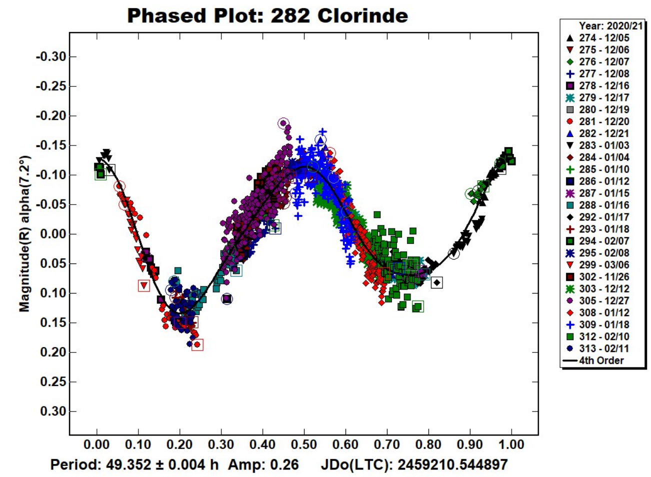
In the framework of the asteroid scientific project that is called "Investigating the most ancient asteroids" (*http://users.uoa.gr/~kgaze/research_asteroids_en.html*), we obtained time resolved photometry of the asteroid 282 Clorinde.

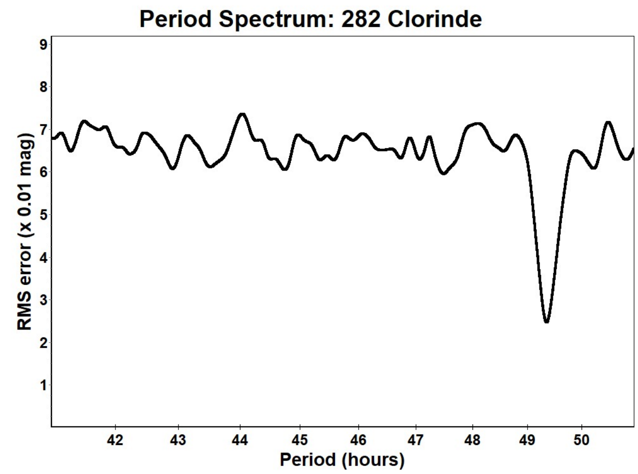
Thanks to the integration of the data obtained from the measurements obtained at two astronomical observatories: Astronomical Observatory BSA and Lowell Observatory Anderson Mesa, it was possible to observe Clorinde for a long interval, namely from 26 November 2020 to 06 March 2021. From all of these data sessions, we obtained almost complete coverage of the phase angle range between 9.6 and 27.3 degrees. The equipment and the respective sessions by each author are reported in Table I. The calibration stars were: For Astronomical Observatory BSA; catalog CMC15; for Lowell Observatory Anderson Mesa; from the Panstarrs_transformed catalog.

Sessions from the several individual observers were adjusted vertically for best fit. The resulting period becomes $P = 49.352$ h and the lightcurve amplitude $A = 0.26$. These results differ substantially from previous published ones: Behrend (*http://obswww.unige.ch/~behrend/page_cou.html*) $P = 12.142$ h, and Binzel and Mulholland (1983) $P = 6.42$ h.

Observer Observatory (MPC code)	Telescope	CCD	F	Sessions
Roberto Bonamico Osservatorio Astronomico BSA (K76)	0.30-m NRT f/5	ATIK 314L+	C	302, 313
Gerard van Belle Lowell Observatory Anderson Mesa (688)	PW1000 1-m CDK	FLI ML16803	C	274, 299

Table I. Observing equipment and sessions. NRT: Newtonian Reflector, CDK: Corrected Dall Kirkham.





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Number	Name	yyyy mm/dd	Phase	L_{PAB}	B_{PAB}	Period(h)	P.E.	Amp	A.E.	Grp
282	Clorinde	2020/11/26-2021/03/06	9.6,27.3	81.1	-9.0	49.352	0.004	0.26	0.01	

Table II. Observing circumstances and results. The phase angle is given for the first and last date. If preceded by an asterisk, the phase angle reached an extrema during the period. 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).