2012 QG42: A SLOW ROTATOR NEA

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(Received: 7 October)

CCD photometric observations of the near-Earth asteroid 2012 QG42 were made by a collaboration of observers in the U.S. and Europe. The asteroid was found to be a slow rotator, having a synodic period of 24.22 ± 0.01 h based on a data set spanning nearly two weeks. The amplitude of the lightcurve was 1.18 ± 0.03 mag.

The near-Earth asteroid 2012 QG42 was discovered by the Catalina Sky Survey on 2012 Aug 26. Based on its spectral colors in the S- to Q-type range for which 0.24 is a typical albedo (Binzel, personal communication), the H magnitude of 20.8 suggests a diameter of about 200 meters. A few days after discovery, Michael Busch (private communications) contacted Warner to request photometry to determine a preliminary period to help plan radar observations. Observations were made on 2012 August 31 and showed a steady ascent of about 0.35 mag over three hours, suggestive of a period in excess of 12 hours. This was sufficient evidence for radar planning but it did not end the observing campaign.

Once the elongation of full moon became sufficient, observations were started again at PDO on September 6; that run covering more than six hours and showing an increase of more than 0.5 mag with indications of an approaching maximum. These results were sent out as part of discussion of the asteroid on the Minor Planet Mailing List (*http://tech.groups.yahoo.com/group/mpml/*), which prompted the other co-authors to contact Warner regarding data that they obtained. Some of the observers were in the Eastern Hemisphere and had observations on dates when PDO did not observe, which proved critical since the asteroid's period appeared to be commensurate with an Earth day, the PDO data alone suggesting 16-18 hours.

Table I shows a list of the team leads who contributed to the campaign and the equipment that was used. PDO observations were unfiltered with exposures starting at 120 sec in August but going down to 30 sec as the asteroid's motion increased and it brightened considerably. Exposures at Indian Hill (IHO) were 12-15 sec. Those at Poznan were 15 sec and those at San Marcello Pistoiese were 20 sec. With fast moving objects, a compromise must be found to avoid excessive trailing while trying to keep the exposure at or more than 10 seconds so that scintillation noise does not start to dominate.

Lead	Code	Telescope	Camera
Warner	PDO	0.5-m f/8.1	FLI-1001E
Baker	IHO	0.3-m f/5.1	ST-402ME
Bacci	SMPO	0.60-m f/4.0	Alta U6
Bartczak	POZAN	0.7-m, 0.4-m	iXon3, ST-8
Vorobjov	ISAC	0.61-m f/4.5	STL-1001E

Table I. Observers and Equipment.

Table II shows the observing circumstances for the dates within the campaign, which extended to mid-September. By that time, the phase angle had exceeded 50°. To avoid issues with evolving amplitude and lightcurve shape, and with the period well-established, the campaign was closed. The synodic period was found to be 24.22 ± 0.01 h with an amplitude of 1.18 ± 0.03 mag. A long period was confirmed by preliminary analysis of radar data as well (Benner, private communications).

The lightcurve has a somewhat asymmetric shape but this is probably due to the lack of complete coverage. The line is the 4th order Fourier fit to the data. To complete the curve would have required observations from longitudes equal to Australia or Japan. This might have changed the period slightly, but not significantly. The lightcurve data will be made available to the radar team

Code	Date	UT	Phase	L_{PAB}	B_{PAB}
PDO	Aug 31	05:03 08:36	16.1 15.9	346.5	-4.3
IASC	Sep 04	04:30 04:52	9.4	346.5	-2.6
IASC	Sep 06	04:50 05:10	4.4	346.0	-1.1
PDO	Sep 06	03:40 10:02	4.6 3.8	346.6 .45.9	-1.1 -0.9
IASC	Sep 07	04:41 05:10	1.3	345.5	-0.1
SMPO	Sep 07	22:25 23:23	1.6 1.7	345.0 344.9	0.7
SMPO	Sep 08	20:46 22:23	5.8 6.1	344.0	2.0 2.2
IASC	Sep 08	20:25 23:49	5.7, 6.4	344.0 343.9	2.0 2.3
SMPO	Sep 08	22:24 23:19	6.1 6.3	344.0 343.9	2.2
POZAN	Sep 08/09	21:47 00:55	6.0 6.7	344.0 343.8	2.1 2.3
PDO	Sep 09	02:27 09:31	7.0 8.7	343.7 343.3	2.5 3.0
IASC	Sep 09/10	19:42 01:18	11.3 12.9	342.7 342.3	3.9 4.4
POZAN	Sep 09/10	18:56 00:53	11.1 12.8	342.7 342.3	3.8 4.4
IASC	Sep 10	03:13 03:28	13.5 13.6	342.1	4.6 4.7
PDO	Sep 10	05:16 10:10	14.1 15.7	341.9 341.5	4.8 5.4
IASC	Sep 10/11	18:37 00:45	18.6 21.0	340.7 340.0	6.4 7.2
IHO	Sep 11	01:11 04:00	21.2 22.3	340.0 339.6	7.2 7.6
IASC	Sep 11	03:55 04:09	22.3 22.4	339.7 339.6	7.6
IASC	Sep 12	03:26 03:44	33.7 33.9	336.2	11.5 11.6
IHO	Sep 13	00:55 02:22	47.4 48.5	331.8 331.4	16.3 16.7

Table II. Observing circumstances. The UT column gives the earliest and latest UT time of observation. Phase is the solar phase angle at the two UT times. L_{PAB} and B_{PAB} are, respectively, the phase angle bisector longitude and latitude at the two UT times. If a single value is given, the value did not change during the range of observations.

headed by Marina Brozovic at JPL, who can create a combined data set with the radar data and so generate a better model for the asteroid.

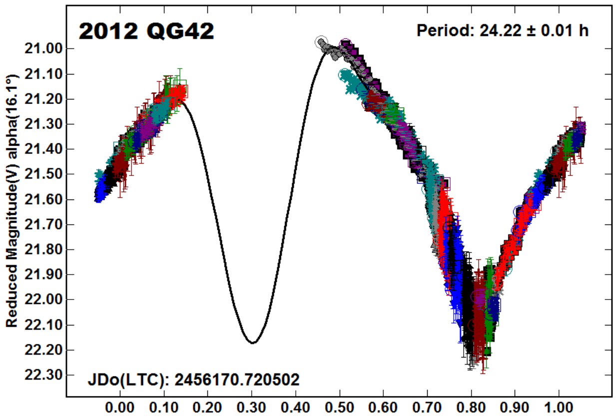

Figure 1. The lightcurve for 2012 QG42. More than 3100 data points were used, covering 2012 August 31 – September 13.

Acknowledgements

Funding for observations at the Palmer Divide Observatory is provided by NASA grant NNX10AL35G, by National Science Foundation grant AST-1032896. TV thanks Richard Miles for his assistance with measuring the images taken by RH. Funding for observations at the Astronomical Research Observatory is provided by NASA grant NNX10AG50G; additional funding has been provided by the Planetary Society Gene Shoemaker NEO Grant. The work was supported by grant N N203 404139 from the Polish Ministry of Science and Higher Education.

ASTEROID LIGHTCURVE ANALYSIS AT THE PALMER DIVIDE OBSERVATORY: 2012 JUNE - SEPTEMBER

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(Received: 28 September)

Lightcurves for 10 asteroids were obtained at the Palmer Divide Observatory (PDO) from 2012 June to August: 1025 Riema, 1685 Toro, 3022 Dobermann, 6403 Steverin, 9564 Jeffwynn, (11904) 1991 TR1, (13186) 1996 UM, (23715) 1998 FK2, (53530) 2000 AV200, and (86257) 1999 TK207. Analysis of data from 2007 revised the previously reported period for (11904) 1991 TR1.

CCD photometric observations of 10 asteroids were made at the Palmer Divide Observatory (PDO) from 2012 June to September. See the introduction in Warner (2010) for a discussion of equipment, analysis software and methods, and overview of the lightcurve plot scaling. The "Reduced Magnitude" in the plots is Johnson V or Cousins R (indicated in the Y-axis title) corrected to unity distance by applying –5*log (rΔ) with r and Δ being, respectively, the Sun-asteroid and Earth-asteroid distances in AU. The magnitudes were normalized to the phase angle given in parentheses, e.g., alpha(6.5°), using G = 0.15 unless otherwise stated.

For the sake of brevity in the following discussions on specific asteroids, only some of the previously reported results are referenced. For a more complete listing, the reader is referred to the asteroid lightcurve database (LCDB, Warner *et al.*, 2009). The on-line version allows direct queries that can be filtered a number of ways and the results saved to a text file. A set of text files, including the references with Bibcodes, is also available for download at *http://www.minorplanet.info/lightcurvedatabase.html*. Readers are strongly encouraged to obtain, when possible, the original references listed in the LCDB for their work.

<u>1025 Riema.</u> This Hungaria asteroid was previously worked by Shevchenko (2003), who found a period of 6.557 h. Subsequent work by Stephens (2003) found 3.580 h. Warner (2009) reported a period of 3.566 h. The latter data set was relatively sparse, which may explain the discrepancy with the Stephens period. The latest set of 195 data points gives a period of 3.581 h. The period spectrum included here, covering 3-7 h, indicates a strong preference for the 3.58 h solution over that from Shevchenko.

<u>1685 Toro</u>. Observations of this near-Earth asteroid (NEA) were made in July and August to support radar modeling. The period of about 10.195 h had been previously established on several occasions, e.g., Dunlap (1973) and Higgins (2008). The observations in late July were made at a phase angle of about 75°. At that time the amplitude of the lightcurve was 1.38 ± 0.02 mag and the synodic period was 10.226 ± 0.002 h. Additional observations in late August were at phase angle 97°, when the synodic period had decreased to 10.188 ± 0.002 h but the amplitude increased to 1.80 ± 0.02 mag. These are not unexpected changes with the increasing phase angle and will help the modeling process more than having just one curve or the other.

<u>3022 Dobermann</u>. This was the third apparition at which observations of this Hungaria asteroid were made. The period was found to be 10.32 h in 2004 (Warner, 2005) and 10.330 h in 2011 (Warner, 2011). Angeli (2001) found a period of 10.49 h, but none of the three data sets from PDO can be made to fit this solution. The results from the 2012 campaign were in close agreement with the two previous results from Warner.

<u>6403 Steverin</u>. This is a Eunomia family member that was worked by Warner (2005), who found a period of 3.485 h. The period of 3.4903 h found in 2012 is in good agreement with that result.

<u>9564 Jeffywnn</u>. This Mars-crosser was a "full moon project", meaning it was bright enough while the moon was near full and other in-progress targets too faint. There were no previous results found in the LCDB.

<u>(11904) 1991 TR1</u>. This Hungaria asteroid was originally reported to have a period of 9.123 h (Warner, 2008) based on a monomodal curve and despite an amplitude of 0.31 mag. Harris (2012) has shown that at relatively low phase angles (6° in 2008), this combination is almost physically impossible and that a bimodal solution was the right solution. Another analysis of the 2007 data found a bimodal lightcurve with a period of 18.233 ± 0.003 h. The data in 2012 were of considerably less quality, being much fewer and noisier due to the asteroid being in crowded star fields. What data were available were forced to a period near the revised period. The result is not at all convincing. Observations at future apparitions are planned at PDO and encouraged elsewhere.