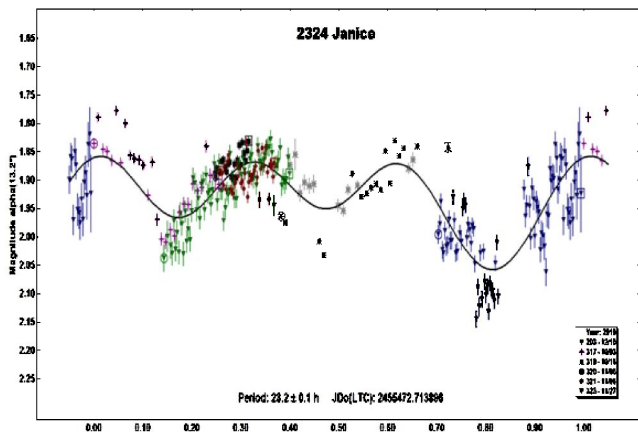




ROTATION PERIOD DETERMINATION FOR 180 GARUMNA: A TRIUMPH OF GLOBAL COLLABORATION

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Previous studies have suggested that 180 Garumna has a very nearly Earth-synchronous rotation period of 23.86 hours, with only a small part of the lightcurve sampled at a single location. A global collaboration among observers from four continents, East Asia, Australia, Europe, and North America produced the first ever lightcurve with full phase coverage that shows a definitive synodic rotation period 23.866 ± 0.001 h, amplitude 0.42 ± 0.02 mag.

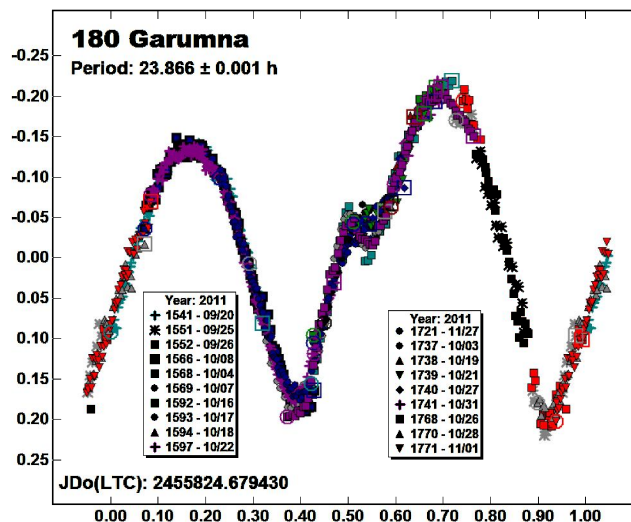
Previously reported rotation periods and lightcurve coverage of the asteroid, 180 Garumna, are by Behrend (2011), 23.859 h, 50%; Clark (2010), 23.32 h, 50%; Stephens (2008), 23.89 h, 35%. To obtain full lightcurve coverage for an object believed to have rotation period very close to Earth-synchronous, it is necessary to have observations from several locations more or less evenly distributed in longitude around the Earth. Vladimir Benishek from central Europe, Shelby Delos, Timothy Barker, and Gary Ahrendts

observing remotely from the Grove Creek Observatory, New South Wales, Australia, Hiromi and Hiroko Hamanowa from Japan, David Higgins from Australia, and Frederick Pilcher from western North America all contributed lightcurves to obtain full phase coverage. *MPO Canopus* software was used for lightcurve analysis and expedited the sharing of data among the collaborators.

Observations made on 19 nights from 2011 Sept. 20 to Nov. 27 show full lightcurve coverage with a period 23.866 ± 0.001 h, amplitude 0.42 ± 0.02 mag. A feature on the rising portion of the lightcurve near rotation phase 0.50 changed shape significantly through the interval of observation. Due to the large number of data points acquired, the lightcurve has been binned in sets of three data points with a maximum of five minutes between points.

References

- Behrend, R. (2011). Observatoire de Geneve web site: http://obswww.unige.ch/~behrend/page_cou.html
- Clark, M. (2010). "Asteroid Lightcurves from the Chiro Observatory." *Minor Planet Bul.* **37**, 89-92.
- Stephens, R.D. (2008). "Asteroids Observed from GMARS and Santana Observatories in Late 2007." *Minor Planet Bul.* **35**, 60-61.



Obs	Telescope	CCD	Sess
Bennishek	40-cm SCT	SBIG ST-10XME	4
Delos, Barker, Ahrendts	25-cm SCT	SBIG ST-1001E	5
Hamanowa	40-cm Newt	SBIG ST-8	3
Higgins	35-cm SCT	SBIG ST-8e	3
Pilcher	35-cm SCT	SBIG STL-1001E	4

Table I. Observers and equipment. SCT = Schmidt-Cassegrain. Newt = Newtonian.

LIGHTCURVE PHOTOMETRY AND H-G PARAMETERS FOR 1151 ITHAKA

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Observers at three observatories worked in collaboration to obtain photometric observations of main-belt asteroid 1151 Ithaka over thirteen nights from 2011 August–October. The resulting analysis found a synodic period $P = 4.93115 \pm 0.00011$ h with an amplitude $\Delta V = 0.12 \pm 0.01$ mag. The measured absolute visual magnitude, $H = 12.94 \pm 0.03$ mag, slope parameter $G = 0.05 \pm 0.03$, and color index $V-R = 0.38 \pm 0.03$ mag are consistent with a low albedo C-type object. The diameter is estimated to be $D = 14 \pm 3$ km.

The main-belt asteroid 1151 Ithaka was reported as a lightcurve photometry opportunity in the *Minor Planet Bulletin* (Warner *et al.*, 2011). As a result, the authors formed a collaboration to observe the asteroid. The observations were carried out from Balzaretto Observatory (A81) in Rome, Italy, Bigmuskie Observatory (B88) in Mombercelli, Asti, Italy, and from Shed of Science Observatory (H39) in Minneapolis, MN, USA, over a period spanning from 2011 August 23 to October 3, or a total of 41 days (Table I). The equipment used for observations is described in Table II.

#	Date 2011	Observer	Phase Angle	Data Points	Filter
1	Aug 23	L. Franco	8.5°	72	C
2	Aug 26	L. Franco	8.6°	89	C
3	Aug 28	L. Franco	8.8°	34	V, R
4	Sep 2	A. Ferrero	10.2°	69	R
5	Sep 5	A. Ferrero	11.4°	77	R
6	Sep 6	L. Franco	11.8°	86	C
7	Sep 6	A. Ferrero	11.8°	81	R
8	Sep 8	R. Durkee	12.3°	33	C
9	Sep 9	R. Durkee	12.7°	38	C
10	Sep 13	A. Ferrero	14.9°	90	R
11	Sep 15	L. Franco	15.8°	38	C
12	Sep 24	R. Durkee	19.6°	69	C
13	Oct 3	L. Franco	23.5°	25	C

Table I. Observations list.

Observer	Country	Telescope	CCD	Filters
Lorenzo Franco	Italy	SCT 0.20-m f/5.5	SBIG ST7- XME	Custom Scientific (Johnson V, Cousins R)
Andrea Ferrero	Italy	RC 0.30-m f/8	SBIG ST9	Astrodon Cousins R
Russell Durkee	USA	SCT 0.35-m f/8.5	SBIG ST10XE bin x2	

Table II. Observers and equipment list.

Each observer's computer clock was synchronized with atomic clock time via Internet NTP servers, giving a timing accuracy of less than one second. All images were calibrated with dark and flat-field frames. Differential photometry was done using *MPO Canopus* (Warner, 2010). The V and R magnitudes were calibrated using the method described by Dymock and Miles (2009) and CMC-14 selected reference stars with color index near solar values using the Vizier Service (VizieR, 2010). The same method was also applied to the clear filter observations after conversion to V magnitude using previously determined transformation coefficients. Observations in V and R band were acquired in alternating sequence (VRVR...).

Period analysis was done using *MPO Canopus*, which implements the FALC algorithm developed by Harris (Harris *et al.*, 1989). Before starting analysis, the sessions were aligned by changing the DeltaComp value for each session in *MPO Canopus* to reach zero-point value. The analysis found a synodic period of $P = 4.93115 \pm 0.00011$ h (Fig.1). The period spectrum (Fig. 2) shows the principal period P and harmonics of $1/2P$, $2/3P$, and $2P$. The bimodal solution of 2.4657 h has a higher RMS error compared to the quadramodal solution at 4.93115 h. In addition, visual inspection of the lightcurve shape shows a left/right axial asymmetry at the 0.5 phase. These suggest that the quadramodal solution is more likely correct.

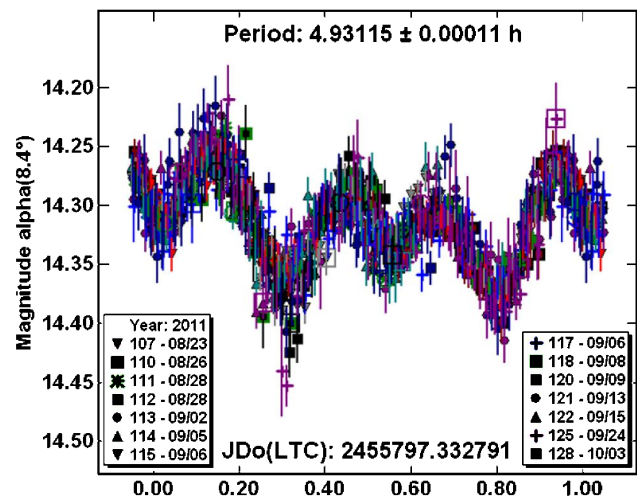


Figure 1. The lightcurve of 1151 Ithaka shows a period of 4.93115 ± 0.00011 h with an amplitude of 0.12 ± 0.01 mag.

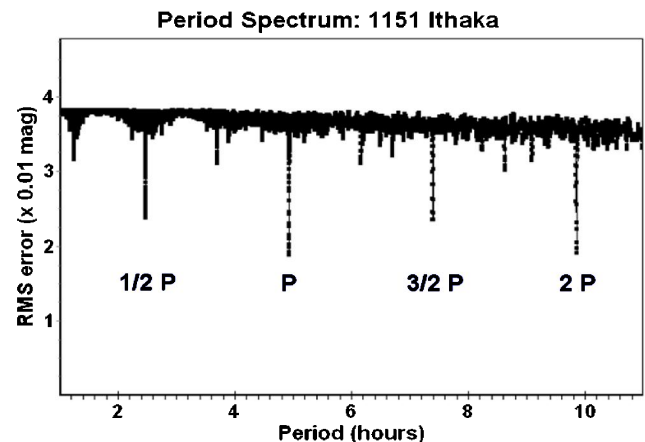


Figure 2. Period Spectrum show the principal period P and harmonics of $1/2P$, $3/2P$, and $2P$.