LIGHTCURVE OF (4507) 1990FV

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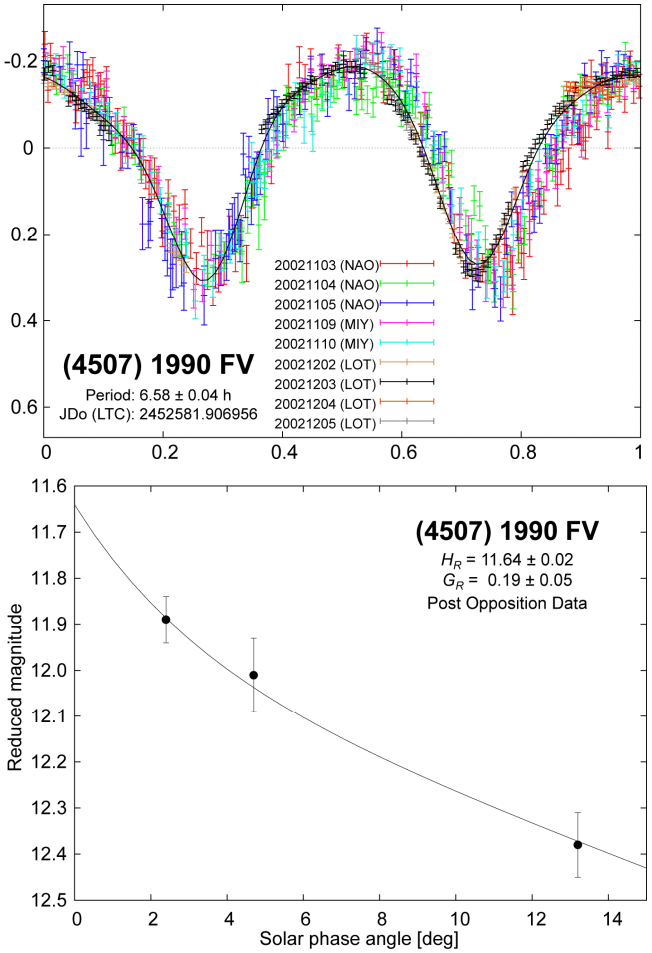
We observed the main-belt asteroid (4507) 1990 FV from 2002 November to December at three observatories in eastern Asia. Its synodic rotation period turned out to be 6.58 ± 0.04 h and its lightcurve amplitude was 0.40 ± 0.03 mag when reduced to zero solar phase angle. Since our observations covered a relatively large solar phase angle range (2.3-13.7 degrees), we were able to make a phase curve to estimate the absolute magnitude (H) and slope parameter (G) in the R band: H_R = 11.64 ± 0.02, G_R = 0.19 ± 0.05.

(4507) 1990 FV is a main-belt asteroid with an orbital period of 4.87 years. It was discovered on 1990 March 19 at Fujieda, Japan (MPC code 898), by Hitoshi Shiozawa and Minoru Kizawa (MPC 16363). This asteroid was once considered a major member of the young Karin asteroid family (Nesvorný *et al.*, 2002). However, later numerical recalculation (Nesvorný and Bottke, 2004) and detailed spectroscopic observation (Vernazza *et al.,* 2006) eliminated the possibility that this asteroid is a member of the Karin family, putting it in the interloper category.

There are two references about this asteroid in the minor planet lightcurve database (Warner *et al.,* 2009; LCDB). One of them is a recent report by Hanuš *et al.* (2013) which uses observational data obtained from Catalina Sky Survey from 2003 November to 2009 May. In Hanuš *et al.* (2013), our presentation abstract at an IAU symposium is cited (Yoshida *et al.* 2005; ACM 2005) as a literature of the rotational period of this asteroid. Another reference in LCDB is our own publication, Yoshida *et al.* (2004). However, Yoshida *et al.* (2004) does not contain any information on the lightcurve or on the rotational period of this asteroid. Also, Yoshida *et al.* (2005) that is cited in Hanuš *et al.* (2013) was published just electronically, and currently the abstract file is not available on the symposium webpage. This kind of confusion is also seen in Harris *et al.* (2012) whose data are summarized on the PSI asteroid database. Our observations for this asteroid were carried out from 2002 November to December, about a year before Catalina Sky Survey's first observation for this asteroid (Hanuš *et al.,* 2013) took place. Therefore we believe that it is worth officially publishing the lightcurve and its period analysis results for this asteroid based on our own observations for rectifying the existing reference records, as well as for aiming at making a new lightcurve reference for future studies.



The photometric observations of this asteroid were made at three different observatories in eastern Asia, just after an opposition of this asteroid. The Mitaka headquarter of National Astronomical Observatory of Japan ("NAO" in the table below), the Miyasaka Observatory in Japan ("MIY"), and the Lulin Observatory in Taiwan ("LOT"). At the Mitaka headquarter of National Astronomical Observatory of Japan (MPC code 388), we used a 0.5-m *f*/1.2 Mitaka Kohki GNF-50 telescope with an SBIG ST-1001E CCD camera. The CCD of this camera has 1024x1024 24x24-μm pixels and 24.6x24.6-mm array dimension. The resulting field of view is 14.0x14.0 arcmin and the plate scale is 0.82 arcsec/pixel. At the Miyasaka Observatory (MPC code 366), we used a 0.25-m *f*/6 Takahashi MT-250 with an SBIG ST-6 CCD camera. The CCD of this camera has 375x242 23x27 μm pixels and 8.63x6.53 mm array dimension. The field of view is 19.8x15.0 arcmin and the plate scale is 3.17x3.72 arcsec/pixel. At the Lulin Observatory (MPC code D35), we used a 1.0-m *f*/8 telescope with an Apogee AP8 CCD camera. The CCD of this camera has 1024x1024 24x24-μm pixels and 24.6x24.6-mm array dimension. The field of view is 10.6x10.6 arcmin and the plate scale is 0.62 arcsec/pixel.

Dates of observations and relative orbital circumstances of the asteroid with respect to the Earth and the Sun are summarized in a table as follows. The Sun-asteroid distance is r while Δ is the Earth-asteroid distance, both in AU. The ecliptic longitude and latitude of the asteroid are λ and β, and α is the solar phase angle (deg). "Obs" denotes the observatory name.

UT Date	r	Δ	λ	β	α	Obs
2002 Nov 03	2.882	1.894	34.4	-0.8	2.28	NAO
2002 Nov 04	2.882	1.896	34.2	-0.8	2.69	NAO
2002 Nov 05	2.882	1.898	33.9	-0.8	3.10	NAO
2002 Nov 09	2.881	1.910	33.1	-0.7	4.73	MIY
2002 Nov 10	2.881	1.913	32.9	-0.7	5.13	MIY
2002 Dec 02	2.879	2.057	29.6	-0.3	12.85	LOT
2002 Dec 03	2.878	2.067	29.5	-0.3	13.16	LOT
2002 Dec 04	2.878	2.075	29.4	-0.3	13.41	LOT
2002 Dec 05	2.878	2.084	29.3	-0.3	13.69	LOT

We used an *R* band filter for our lightcurve observations. All the telescopes were driven at the sidereal tracking rate with the exposure time limited by the moving rate of asteroid as well as by the seeing size during the observing periods. We chose a single exposure time of two to eight minutes so that the asteroid had an appearance of a point source. The brightness of the asteroid was measured relative to that of a field star located on the same frame. We chose the field stars from the USNO-A2.0 star catalogue. We corrected the magnitude of the asteroid using the extinction curve obtained on each of the observing nights, using our own observation result of the Landolt standard stars taken at several air masses.

To construct synthesized lightcurves of the asteroid from the observational data, we followed a sequence proposed by Harris and Lupishko (1989). We employed two different algorithms to examine periodicities in the lightcurve data: Lomb's Spectral Analysis (Lomb, 1976; LSA) and the WindowCLEAN Analysis (Roberts *et al.,* 1987; WCA). After the frequency analysis was done, we fit the lightcurve with a Fourier series. Paying attention to different zero-levels of the lightcurves derived from different observing runs, we combined the lightcurves of multiple observing runs based on these zero-levels, and then obtained final synthesized lightcurve.

Both the WCA and LSA frequency analyses of the lightcurve detected a clear peak at the rotation period of 6.58 ± 0.04 h. We estimated the peak-to-peak variation of the lightcurve reduced to zero solar phase angle, $A(0)$, using the empirical relationship advocated by Zappalà *et al.* (1990): $A(\alpha) = A(0)\ (1+m\alpha)$ where $A(\alpha)$ is raw peak-to-peak variation magnitude of lightcurve when the solar phase angle is α. For S-type asteroids such as (4507) 1990 FV, the parameter m is empirically determined as 0.030. From our observations, the reduced lightcurve amplitude was determined as 0.40 ± 0.03 at α=0.

We fitted our observational results of this asteroid with the *H-G* magnitude system approved by IAU. Absolute magnitude H is usually defined by asteroid brightness in the V band. However, since our observations were carried out in the R band, we calculated and designated H and the slope parameter G as H_R and G_R. Our analysis gave H_R = 11.64 ± 0.02 and G_R = 0.19 ± 0.05.

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