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LIGHTCURVE AND ROTATION PERIOD OF 40 HARMONIA

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RESUMEN

Se ha estudiado, mediante observaciones fotométricas, la curva de luz del asteroide 40 Harmonia. A partir de 3 fragmentos de curva observados en mayo de 1986, se determinó un periodo de ajuste de 8h 54.6m ±0.6m y una amplitud máxima de 0.14 mag. Dicho periodo resulta ser algo menor que aquel adoptado en el Catálogo TRIAD, aunque está en buena correspondencia con algunas observaciones previas.

ABSTRACT

We have studied photometrically the lightcurve of the asteroid 40 Harmonia. From three fragments of curve observed in May 1986, we have determined a period of 8h 54.6m ±0.6m and a maximum amplitude of 0.14 mag. Such a period turns out to be somewhat shorter than that adopted in the TRIAD Catalogue but it is in good agreement with previous observations.

Key words: **ASTEROIDS – PHOTOMETRY – ROTATION**

I. INTRODUCTION

The precise determination of rotation periods of asteroids enables us to infer some important physical parameters of these objects, such as the orientation of their spin axes and their shapes (Taylor 1971; Magnusson 1986). All these data give us important clues to the origin and evolution of the asteroid belt. The asteroid 40 Harmonia presents a not well defined period, owing to the few available observations. For that reason we have included it in our observing program.

According to the Asteroid Lightcurve Catalogue (Lagerkvist *et al.* 1985), 40 Harmonia has been photometrically observed by Gehrels and Owings (1962) and Lagerkvist (1978). After that, it has been observed by Mc. Cheyne, Eaton, and Meadows (1985).

From the January 29, 1958 observations, Gehrels and Owings derived an approximate period of 9h 06m ±3m. By dividing the interval between their January 14 and 29, 1958 observations by a number of 39 cycles they obtained a synodic period of 9h 08.15m ±0.04m in close agreement with the previous one. However, they did not rule out other number of cycles, e.g., they obtained a period of 8h 54m for 40 cycles, one of 9h 23m for 38 cycles. The maximum amplitude was found to be 0.22 mag.

From a 6 hours observing run, Lagerkvist (1978) obtained a rotation period of 8h 52.8m, with a maximum amplitude of 0.28 mag.

Mc. Cheyne *et al.* (1985) observed 40 Harmonia in color V during three consecutive nights (6–7, 7–8, 8–9 October 1983). They found a discontinuity in their composite lightcurve for a rotational phase of 0.55. We will try to explain it as one of the outcomes of our own photometric study of this asteroid.

II. OBSERVATIONS

We observed 40 Harmonia during three nights in the May, 1986 opposition. The observing conditions of the asteroid are shown in Table 1. The ephemeris have been calculated from the orbital elements of the Ephemeris of Minor Planets (1986).

The observations were made with a 76-cm Cassegrain telescope of the station "El Leoncito" belonging to the Observatorio Astronómico "Felix Aguilar", San Juan, Argentina. A digital photoelectric photometer with a photomultiplier tube RCA 31034 and a pulse counting system were used. The cooling of the tube was done by Peltier effect. A diaphragm with a 30″ field and an integration time of 10 sec was used for all measurements.

We practiced differential photometry in the standard B and V colors of the Johnson system.

The star SAO 159318 was chosen as a comparison star due to its closeness to the asteroid and its spectral type, which is G0, $m_V = 9.2$, according to the SAO Catalogue.

If we call ΔV the difference in magnitude between the asteroid and the comparison star (Va – Vc) corrected for differential extinction, then we have:

$$\Delta V\,(1,2.9^\circ) = \Delta V - 5 \log (r\Delta) + F(\alpha),$$

where

$$F(\alpha) = -2.5 \log \frac{[(1-Q)\ \ \phi(2.9^\circ) + Q)]}{[(1-Q)\ \ \phi(\alpha) + Q)]} .$$

The expression was deduced from the formula proposed by Lumme and Bowell (1981) for $V(0^\circ)$, where

TABLE 1

OBSERVING CONDITIONS OF 40 HARMONIA[a]

Year	Month	D	H	q	r(AU)	Δ(AU)	Phase α	Eclip. Coord. λ (1950.0)	β
1986	5	8.2	7	10	2.336	1.333	3.7°	233.5°	5.1°
1986	5	11.1	2	7	2.335	1.328	2.6°	232.8°	5.1°
1986	5	13.3	3	7	2.334	1.326	2.2°	232.2°	5.0°

a. D – mean instant of the observing period, in days and fraction of days from Oh UT; H – hours of observation; q – number of observations per hour.

$$\psi(\alpha) = 1 - \frac{\text{sen}\,\alpha}{0.124 + 1.407\,\text{sen}\,\alpha - 0.758\,\text{sen}^2\alpha} \; .$$

We assumed that the value of the multiple scattering parameter is Q = 0.15, which is the mean value of an asteroid of type 5 (Bowell and Lumme 1979). The asteroid 40 Harmonia is of this taxonomic type.

Even though the uncertainty in the Q parameter introduces very small variations in the result, the observations were preferably referred to a mean phase angle (α = 2.9°), since in this way the correction introduced by F(α) becomes smaller.

The instant of observation was corrected by light-time.

III. RESULTS

We obtained 3 fragments of lightcurve corresponding to 3 different nights. By Fourier analysis we looked for periods producing good fits to the observations. To obtained an overall period, we superposed the data of the second and third nights on the first one. The best coupling of the different fragments was found to occur for a period of 8h 54.6m ±0.6m. The results are shown in Figure 1. We tried to couple the different fragments with periods close to 9h 08m, but the results were negative. We found a maximum amplitude of 0.14 mag.

The period determined by us is very close to the period of 8h 52.8m found by Lagerkvist (1978). We must bear in mind that the observations used by Lager-

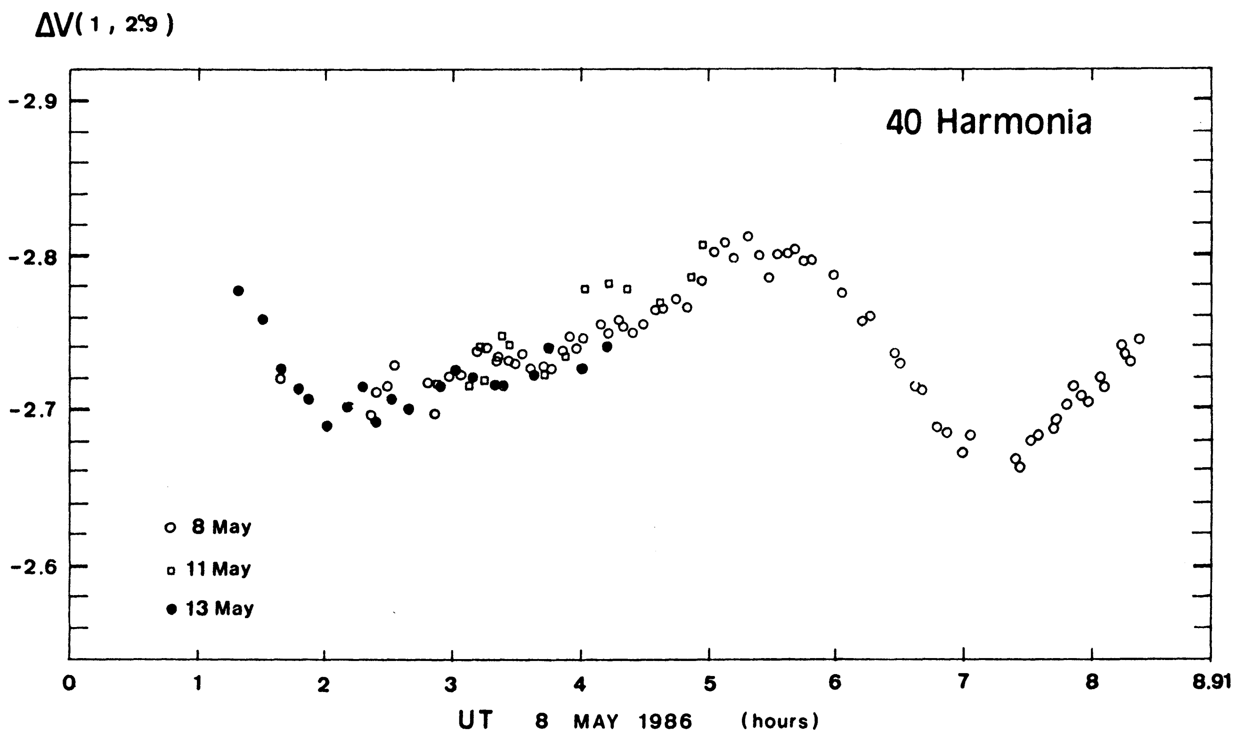

Fig. 1. Lightcurve of 40 Harmonia.

kvist extended for only 6 hours; also these measurements were made by photographic photometry, which has a greater dispersion than photoelectric photometry.

Gehrels and Owings (1962) chose the number of 39 cycles between the two observations, because it was the closest to the approximate period found from the January 29, 1958 observations. However, we should point out that for this determination they considered a lightcurve including observations of rather poor quality at one of its ends. If 40 cycles were adopted, instead of 39 cycles, we would arrive at a period of 8h 54m, in close agreement with our determination.

By adopting a period of 9h 8.15m, Mc. Cheyne *et al.* (1985) find a discontinuity between their observations of 7–8 October, 1983 and the ones of 8–9 October. They explain it as due to a fault with the data of 8–9 October. Yet, we note that such a discontinuity vanishes if a period of 8h 54.6m is considered, in which case a good match between the two fragments of lightcurve is accomplished.

IV. CONCLUSIONS

We found a synodic period of 8h 54.6m ±0.6m and a maximum amplitude of 0.14 mag for 40 Harmonia. Our computed period turns out to be in agreement with that determined by Lagerkvist (1978) and the observations of Gehrels and Owings (1962) by supposing that forty cycles have elapsed between their two observing nights. The observations of Mc. Cheyne *et al.* (1985) fit very well to our derived period.

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