THE PRECESSION OF ASTEROID 1620 GEOGRAPHOS

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ABSTRACT. The frequency analysis of the fine photometric effects in the photometric observation obtained during asteroid 1620 Geographos approaching to Earth in 1994 allowed to derive the precession of asteroid spin axis. The periods of $0^d.8$ and $2^d.8$ or multiple to them were revealed. The magnitude of precession angle was estimated to be near 3°. The nature of the precession discussed. The emergence of the free precession may be supported at time of the formation of the asteroid or by the collision with another body. The forced precession does not contradict to the Geographos connection with meteor streams and the assumption that Geographos may have small satellites.

Key words: asteroids: rotation, precession, satellites

Introduction

Asteroid 1620 Geographos belongs to the group of Apollo S-type. The silhouette of asteroid has the dimension of 5.11x1.85 km accordingly to the radar data. The three-dimensional ellipsoid model of asteroid has the axis-ratio $a/b = 2.8$ and $b/c = 1.1$ (Magnusson et al. 1996; Michalowski et al. 1994). The sidereal period is P=0.2176386 days and maximum amplitude of light variations about 2^m. The light curves have fine photometric effects: time displacements of extrema, irregular brightness and amplitude changes and other.

The rotation motion of an irregular body can be described in common case by a solution of Euler equations. There are two stable solutions: the rotation around the largest or smallest axis of the momentum of inertia. For the three-dimensional ellipsoid these axes coincide with the longest and shortest axes. In the common case asteroids have rotation, precession and nutation motions. Sher (1971) was the first who noted that the changes of light curve forms may be caused by the precession.

External force excites the forced precession. In such case the changes of asteroid mean brightness occurs with the precession period. Asteroid 1220 Crocus showed such effect and Binzel (1985) pointed out on existence of an satellite.

In the case of free rotation the angular momentum vector is constant and the instant axis of rotation is precessing around the main axis. As a result the amplitudes of light curves change. But the asteroid mean brightness remains constant.

The goal of this paper is the investigation of the fine effects in rotation motion of Geographos by means of care frequency analysis of photometric data.

The frequency analysis

Selected for analysis observations contained 25 light curves of V-magnitudes from August 28 to September 14 1994 (Magnusson et al. 1996). All data were corrected for phase function and reduced to unit geo- and heliocentric distances. Two partly overlapping in time sets were created for analysis from 1322 brightness measurements. Each set was whitened by the frequency of asteroid rotation. As the result the obtained data contained only precession light variations. For comprehensive analysis seven additional sets were formed also: asteroid brightness at maxima and minima of light curves, the amplitudes of light curves, mean brightness, time displacements of observed light curves extrema moments relatively calculated moments.

Three different methods of frequency analysis were used for search of unknown periods (Prokof'eva et al. 1995). They are assumed to be real if they are presented in all methods and sets.

The rotation of rigid body was confirmed. Two sets of multiple periods $2^d.8, 5^d.6, 11^d.2$ and $0^d.8, 1^d.7, 2^d.4$ with probability 98% were found. The periods with smaller significance are not involved.

The evaluation of precession angle

The results obtained for light curve maxima (period $2^d.8$ with amplitude $0^m.05$) were used for the evaluation of the precession angle. At this moments the largest asteroid axis lays in picture plane and the dimension of asteroid shape projection on this plane is the largest. The change of brightness in light curve maxima is possible only when axis b projection on picture plane varies periodically. Using relation $b/c = 1.1$ and mean value of aspect angle 98° we estimated the angle of precession as 3°.

The evaluation of precession period

According to Kopal (1970) periods of free precession P_f and rotation P_r in the case of three-dimensional rotation in space are connected with rough relation

$$(P_r/P_f)^2 = (C - B)/A$$

where A, B, C denotes the moments of inertia of the body about axes x, y, z. We used known half-axes of Geographos $a = 2.55$ km, $b = 1.02$ km, $c = 0.92$ km calculated A, B, C and evaluated free precession period as $P_f = 0.7^d$. This value is very close to the period $0^d.8$ that was found by our analysis. This fact confirms our assumption that we found the free precession of Geographos with period $0^d.8$ or multiple of it $1^d.7$ or $2^d.4$.

On Geographos precession nature

We have found two sets of multiple periods. One period from each set is real, but we don't know what. It is impossible also to make right conclusion what kind of precession was recorded.

The physical conditions of formation of free or forced asteroid precession has different nature. Both kind of precession may exist.

The free precession has relict nature. There are two reasons of initiation of it. Firstly, the small asteroid have time scale of damping to steady rotation around the shortest axis comparable to the Solar system age. Secondary it was possible that free precession had catastrophic cause that was pointed by Rozaev and Tomanov (1996).

The forced precession arises under the action of external force. Such force may be created by satellite. Facts revealed the Geographos connection with meteor streams: Virgo (Kres'ak, Stohl 1990) and possible 9 small streams (Ryabova 1986). Geographos may be surrounded by a cloud of dust and other fragments of different sizes. In such conditions our suppose about satellites of Geographos may be real.

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