THE ASTEROIDS' ROTATION PARAMETERS DETERMINATION USING PHOTOMETRICAL DATA

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ABSTRACT. Presented a new method of determination of the asteroid rotation parameters.
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There are a few methods of determining the period and orientation of the asteroids' rotational axis by using their light curves obtained in several oppositions. These methods have a number of drawbacks: the use of a "geometrical" reflection law and that of a vector-bisectrix phase for approximating the variation of maximum phase in light curves.

We have used the asteroid model in the ellipsoid form (or some other more intricate body) with the most adequate law of its surface light reflection to calculate theoretical light curves and compare these with the observed moments of the asteroids' light extrema.

In changing the position of a test pole of rotation, for one time interval between extrema moments ΔT_K we get different values of f_K which are used for the sidereal period determination.

The period determination procedure is based upon the testing of a series of test periods. To optimize a search algorythm both the determination of test periods and their refinement is devided into three stages.

In the first stage are set limits of the period search P_{max} and P_{min}. A series of intervals $\Delta T_K = T_i - T_j$ is formed and their values are limited to one opposition. As the main interval ΔT_o the minimum one is chosed from of the series.

Let us calculate values $N_{max} = [\,\Delta T_o / P_{min}\,]$ and $N_{min} = [\,\Delta T_o / P_{max}\,]$. This is an uppon and a lower limits for the quantity of cycles N. The brackets designate the nearest integer. When choosing N_l from the interval $N_{min} \le N_l \le N_{max}$, we get $(N_{max} - N_{min} + 1)$ of the test periods:

$$P_l = \Delta T_o / (N_l \pm f_o).$$

In this case the sign "+" is used for a prograde rotation whereas that of "−" for the retrograde one.

Further on all the test periods are tested for all the series ΔT_K. Determine

$$N_k = [\,\Delta T_k / P_l \pm f_k\,].$$

N_k obtained are used to calculate average test period $\overline{P}_l$ and $\sigma_{\overline{P}_l}$.

$$\overline{P}_l = \frac{1}{m}\sum_{k=0}^{m-1} \frac{\Delta T_k}{N_k \pm f_k}$$

For each period found in this way we determine extrema phases from the observations

$$\varphi_k^l = \frac{\Delta T_k}{P_l} - N_k$$

and set up differences $(O-C)_k^l = \varphi_k^l \pm f_k$ and calculate mean square deviation for a prograde and retrograde rotation

$$\overline{(O-C)}_l = \frac{1}{m}\sum_{k=0}^{m-1} (\varphi_l^k \pm f_k)^2 .$$

The test period $\overline{P}_l$ respective minimum of $\overline{(O-C)}_l$ is chosen to be refined in the second stage. New values for the limits are determined by the formulas

$$P_{max} = \overline{P}_l + 3\sigma_{\overline{P}_l}; \quad P_{min} = \overline{P}_l - 3\sigma_{\overline{P}_l}.$$

In the second stage, moments T_i for the formation of intervals ΔT_K are chosen from different oppositions. As the main interval ΔT_o the maximum one is chosen from the series available and the prosedure is repeated.

We calculate ephemeris moments T_{calc} with the period value obtained in the second stage

$$T_{calc} = T_o + P(N \pm f).$$

Differences $T_{obs} - T_{calc}$ for respective values N and f enable us to write a system of conventional equations

$$(O\text{-}C) = \Delta T_o + \Delta P(N \pm f).$$

This system of equations is solved by the least squared method, then convections ΔT_o and ΔP are calculate. Allowing for these correcttions, as a finite result we get new ephemeris moments and new deviations values (O-C) and determine mean square deviations

$$\overline{(O-C)} = \frac{1}{m}\sum_{k=0}^{m-1}(T_k - T_O - P(N_k \pm f_k))^2,$$

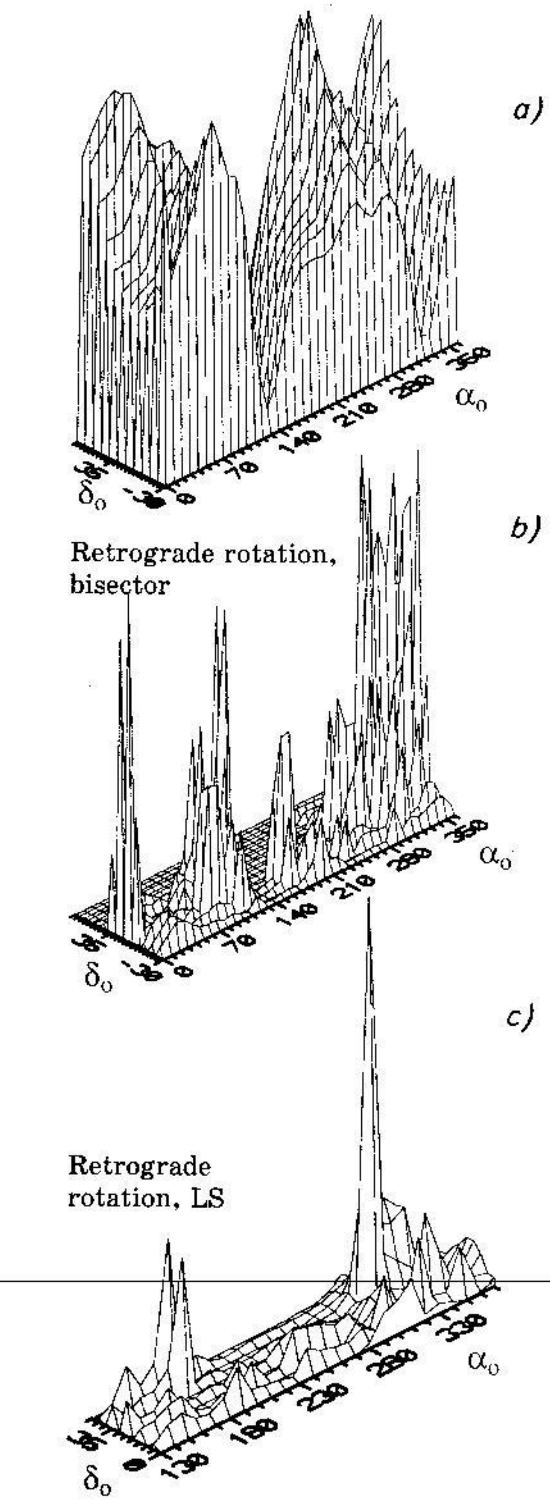

Figure 1: The deviations of amplitude and $\overline{(O-C)}$ value for asteroid 79 Eurinome.

where T_0, P and N determined separately for a prograde and retrograde ratation.

Now varying the position of a test rotational pole we calculate respective values of $\overline{(O-C)}_{pro}$ and $\overline{(O-C)}_{retr}$. The minimum value $\overline{(O-C)}$ determines a solution for the pole position, direction and rotational period.

Application. The asteroid 79 Eurinome was observed during three oppositions. We have used 11 moments of maximum light by Michalowski and Velichko (1990). In Fig. 1a is shown a deviation course of the observed amplitude from the calculated one for the "geometric" law of reflection. In Fig. 1b are presented mean deviation $\overline{(O-C)}$ for the retrograde rotation obtained by using the bisectrix. And in Fig. 1c are illustrated mean deviations $\overline{(O-C)}$ for the retrograde rotation obtained for Lommel-Seeliger model. The best solution in this case agrees with $\alpha_0 = 310^\circ$ and $\delta_0 = 30^\circ$ and $P_{sid} = 0^d.24918182$.

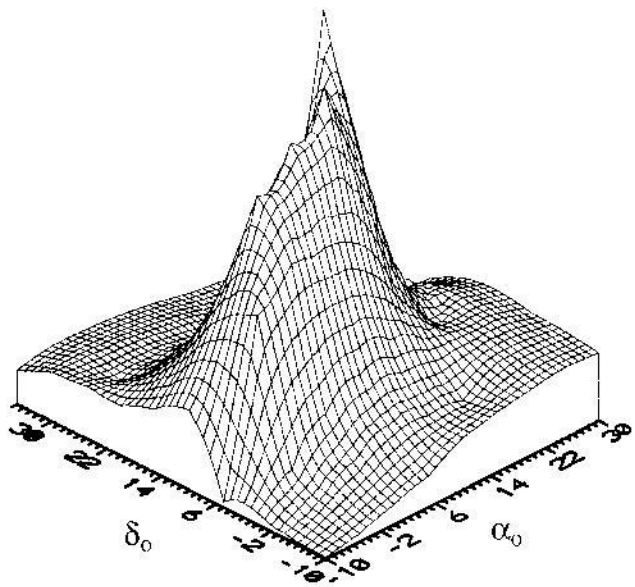

Figure 2: The deviations of $\overline{(O-C)}$ value for asteroid 433 Eros.

In Fig. 2 are shown mean deviations $\overline{(O-C)}$ for the asteroid 433 Eros. This asteroid has been observed in five oppositions since 1901. For the given solution, 35 moments of minimum light are used. The best solution corresponds to $\alpha_0 = 15^\circ$ and $\delta_0 = 15^\circ$ and $P_{sid} = 0^d.21959392$.

References

Michalowski T., Velichko F.P.: 1990, *Acta Astron.*, **40**, 321.