FLUCTUATIONS OF THE EARTH´S ROTATION BY STELLAR OCCULTATIONS

C. JORDI, G. ROSSELLO
Dept. Física de l´Atmosfera, Astronomia i Astrofísica
Universitat de Barcelona
Avda. Diagonal, 647, E-08028 Barcelona, Spain.

ABSTRACT. Observations of lunar occultations made between 1800 and 1955 are analyzed in order to determine the fluctuations of the Earth´s rotation before the International Atomic Time was established. The reduction is made on the basis of the DE200/LE200 ephemeris and the FK5 system. The analysis of the fluctuations shows a main period of 11.7 lunations caused by the error in the stars places.

1. INTRODUCTION

Fluctuations of the Earth´s rotation before the International Atomic Time scale was established, were studied by several authors (Brouwer, 1952; Martin, 1969; Morrison, 1979; Morrison & Stephenson, 1981). Main limitations on these works were the accuracies of both the Moon´s positions given by the ephemeris and the reference system.

The introduction in 1984 of the FK5 reference system and the new ephemeris DE200/LE200 build at JPL by numeric integration, allowed us to study these fluctuations with more detail. About 50000 observations of occultations of stars by the Moon made between 1800 and 1955.5 have been analyzed with this purpose. The stars positions and proper motions were taken from SAOC.

2. REDUCTION AND ANALYSIS

Reduction method is described in detail in Jordi and Rosselló (1987). If the systematic errors in the FK5 reference system and in Watts´ datum (Jordi & Rosselló, 1987; Rosselló et al, 1989), are subtracted from the residuals ($\Delta\sigma$), the new residuals ($\Delta\sigma'$) can be interpreted as due only to the error in the time-scale, i.e. due to the fluctuations of the Earth´s rotation, $\Delta\sigma'=(\partial\sigma/\partial T)\Delta T$.

Our first purpose was to analyze the new residuals each lunation. However, the number of observations decreases backwards in time, so, some compromise has to be taken between the length and the number of observations within the period to be analyzed. Regarding the distribution of the observations along the time, we took annual

J. H. Lieske and V. K. Abalakin (eds.), Inertial Coordinate System on the Sky, 203–204.

solutions between 1800 and 1830, four lunations solutions between 1830 and 1890 and two lunations solutions between 1890 and 1955.5. We computed the average of ΔT each period rejecting those observations showing a difference with the average ΔT greater than 2.5 the standard deviation. The coefficient $\partial\sigma/\partial T$ is clearly correlated with the angle of the occultation measured from the North Pole of the Moon, and it decreases at the Poles. On the other hand, the Watts´ charts have poor limb at these positions. So, this coefficient was used as a weight when the means were computed.

A polynomial of second degree was fitted to seven points, and the curve $\Delta T(t)$ and its first derivative, that represents the change of the length of the day (l.o.d.), were obtained. The amplitude of our values for the change of l.o.d. is about 3 ms/day while the BIH values for the years after 1955.5, have an amplitude of 1.5 ms/day. This means that some systematic errors are still present in the residuals. When applying a Fourier analysis, a main period of 11.7 lunations appears.

Within a lunation the majority of the observations are made around the first quarter. The Moon moves along its orbit and that means a progressive change in right ascension and declination from a lunation to the next one. As the stars catalogues have systematic errors in $\Delta\alpha \cos\delta$ depending on declination, and an error as such is fully related with ΔT, the application of Fourier analysis to the mean declination of each period, reproduces the period of 11.7 lunations. When performing the reduction taking the positions of the stars from other catalogues (AGK3, CAMC, FK5), the behavior of $\Delta T(t)$ and its first derivative changes from one catalogue to another. This is a clear confirmation of the effects of the errors in the stars places when computing the fluctuations of the Earth´s rotation.

We know the differences between the time-scales after 1955.5. Then the observations afterwards are only affected by the systematic errors in the stars places. We are working now on these observations in order to determine them and in this way, to improve the values of ΔT before 1955.5.

Acknowledgements

We wish to thank L.V. Morrison for his valuable comments on this work. This work has been supported by the Comisión Interministerial de Ciencia y Tecnología under contract ESP88-0731.

References

Brouwer, D., 1952: Astron. J., **57**, 125.
Jordi, C. Rosselló, G., 1987: M.N.R.A.S, **225**, 723.
Martin, Ch. ,1969: PhD dissertation. Yale University.
Morrison, L.V., 1979: Geophys. J.R. astr. Soc., **58**, 349.
Morrison, L.V., Stephenson, F.R., 1981: Reference Coordinate Systems for Earth Dynamics. Ed. E.M. Gaposchkin & B. Kolaczec, 181.
Rosselló, G., Jordi, C., Salazar, A., 1989: Proceedings of IAU Colloquium (Belgrade, 1987). Celestial Mechanics (in press).