Polar Motion: Historical and Scientific Problems
ASP Conference Series, Vol. 208, 2000
S. Dick, D. McCarthy, and B. Luzum, eds.

The Markowitz Wobble

A. Poma

Stazione Astronomica, 09012 Capoterra (Cagliari), Italy

Abstract. Several decades ago Markowitz was the first to report the existence of fluctuations in the motion of the Earth's axis with a period of about twenty-four years. This empirical term was often considered not real but only an artifact due to local effects. In this paper long-term variations and the relationship between the 30-yr Markowitz wobble and changes in the Earth's rotational speed are briefly discussed.

1. Introduction

With the advent of new space geodesy techniques, the determination of fluctuations in the Earth's rate of rotation and in the motion of the axis of rotation on the Earth and in space has improved substantially in the last two decades. For the study of long-term phenomena, however, recent data are obviously and seriously limited.

Both polar motion and the Earth's rotation, in fact, exhibit secular, irregular and low frequency components. The analysis, interpretation and the real causes of most of these can even today be considered as open questions. The rate of rotation is affected by a secular retardation due to tidal forces on which variations of varying magnitude, with an apparent time scale of about 30 years, are superimposed. Also the mean rotation pole exhibits a linear drift and an apparent oscillation of about 30 years.

Despite several papers on this subject, no particular attention has been given to the fact that changes in spin rate as well as those observed in polar motion may arise from a common cause.

2. The Markowitz Wobble

The evidence of a long-term libration of the mean rotation pole was first claimed by Markowitz (1960) as an empirical term having a period of about 24 years superimposed on a linear drift of the mean pole. After Rochester (1970) which so christened it in a classical review work, this wobble is now known in the literature as the Markowitz wobble.

As reported in Table 1, successive estimates (Wilson and Vicente 1980, Dickman 1981, Poma *et al.* 1987), indicated an apparently highly elliptical motion nearly linear along the direction 35°–40°E with a period of about 30–31 years and with an amplitude of about 20–30 mas. Also in this case there are no plausible explanations, and few in reality have attempted to supply one.

https://doi.org/10.1017/S0252921100061480 Published online by Cambridge University Press

Busse (1970) suggested that a motion of this kind might be caused by dynamic couplings between the Earth's inner core and mantle, but this possibility was dismissed by Kakuta *et al.* (1975). Another hypothesis was advanced by Dickman (1983), who suggested the existence of a natural wobble in the coupled mantle-ocean system.

One of the most critical points in the discussion of the problem of long-term variations in polar motion, which may perhaps explain the slight attention given to their interpretation, is surely the data source. Precise information on polar motion has been available starting from around 1900 and, at least as regards the first 60 years of this century, it has been derived exclusively from astronomical observations of latitude variations at the five stations of the International Latitude Service (ILS). Since these stations are few in number and some are close to plate boundaries (Ukiah is located near the San Andrea Fault, Mizusawa, Kitab and Carloforte lie on the Eurasian plate near the margins of the Pacific and African plates respectively) the reality of secular drift and the Markowitz wobble has sometimes been regarded with scepticism, and often dismissed as being the results of local effects (Yatskiv 1981, Okamoto & Kikuchi 1983). The existence of secular motion and long-term fluctuations now appears to be confirmed by the analysis of the other independent series of polar coordinates based on a large number of observing stations. It is important to point out that Vondrák (1999) from analysis of old astrometric series re-reduced in the Hipparcos system combined with the last 10 years of space geodesy data, also confirmed the reality of the secular drift and the Markowitz wobble.

Markowitz himself (1986) in a letter sent to me wrote "it will take another decade or two by modern methods, such as IRIS, to decide if the motion is real."

Table 1. Parameters of the Markowitz wobble.

Author	Period (yr)	Ellipticity	amplitude (mas)	direction (°E)
Wilson & Vicente (1980)	29	Linear	30	52
Dickman (1981)	31	0.92	27	32
Markowitz (1982)	29	0.89	47	41
Okamoto & Kikuchi (1982)	30	0.87	34	38
Vondrák (1985)	28	0.93	26	38
Poma *et al.* (1987)	31	0.87	32	39
Vondrák (1999)	31	0.91	20	33

3. The Markowitz wobble and decade accelerations

From a general, and above all geodynamic, point of view, polar motion and rotational variations should be considered together, since important processes, such as mass displacements or electromagnetic torques, may influence both phenomena. One hypothesis in this sense was advanced by Runcorn (1968), who argued that irregular changes in the Earth's rotation may arise from the same physical cause as polar displacements. On the other hand, Rochester (1968), discussing a linear coupling mechanism, denied that electromagnetic torques could cause significant interchange of angular momentum between the spin axis and an axis in the plane of the equator. In most cases polar motion and variation in speed have been dealt with separately, and insufficient attention has been focused on a possible correlation between these phenomena.

A decade ago Poma *et al.* (1987, 1990) found a relationship between the Earth's angular acceleration and the Markowitz wobble. Both phenomena presented fluctuations in good phase agreement, even if less in amplitude. Recently this subject has been revisited and a new study is now engaged. Very preliminary results, not reported here, seem similar to those we obtained in the previously cited works analyzing ILS data. A critical point in the analysis of new geodetic series is the separation of the secular polar motion from the Markowitz wobble in a short span of data. In recent years, in fact, the secular polar motion, as derived by space geodesy, apparently is increasing its rate (Korsun & Yatskiv 1999, Korsun & Kurbasova, 1999) suggesting the linear trend may be a manifestation of a very long period on a small time scale. It is also interesting to note that Vondrák (1999) found also a periodic term of about 72 years in the polar motion.

4. Conclusions

Secular motion of the pole and the Markowitz wobble have required about a century to be determined by astrometric methods. The high accuracy of new geodetic techniques promises to enable reliable results in a more short span. When the correlation between the Earth's rotation and polar motion receives further confirmation and is better established in the near future, by means of other, more recent and precise series of data, it may constitute an important step for arriving at a better understanding of the geophysical mechanisms that influence the Earth's motion.

References

Busse, F.H. 1970, in *Earthquake Displacement Fields and the Rotation of the Earth*, L. Manshinha, D.E. Smylie & A.E. Beck, Dordrecht: Reidel, 88.

Dickman, S.R. 1981, *J. Geophys. Res.*, **86**, 4904.

Dickman, S.R. 1983, *J. Geophys. Res.*, **88**, 6373.

Kakuta, C., Okamoto, I., & Sasao, T. 1975, *Publ. Astron. Soc. Japan*, **27**, 357.

Korsun, A.A., & Kurbasova G. 1999, in *Journées 1998 Système de Référence Spatio-temporels*, N. Capitaine, Observatoire de Paris, 210.

Korsun, A. A., & Yatskiv Ya. S. 1999, in *Journées 1998 Système de Référence Spatio-temporels*, N. Capitaine, Observatoire de Paris, 223.

Markowitz, W. M. 1960, in *Methods and Techniques in Geophysics*, Vol. I, S.K. Runcorn, Interscience, New York, 325.

Markowitz, W. M. 1982, report to IAU Comm. 19 & 31, Patras, Greece.

Markowitz, W. M. 1986, private communication.

Okamoto, I., & Kikuchi, N. 1982, *Publ. Inter. Latit. Obs. Mizusawa*, **XVI**, 2.

Poma A., Proverbio E., & Uras, S. 1987, *Journ. Of Geodynamics*, **8**, 245.

Poma A., & Proverbio E. 1990, in *New Approaches in Geomagnetism and the Earth's Rotation*, S. Flodmark, Word Scientific, 78.

Rochester, M.G. 1968, *J. Geomagn. Geoeletr.* **20**, 387.

Rochester, M.G. 1970, in *Earthquake Displacement Fields and the Rotation of the Earth*, eds. L. Manshinha, D.E. Smylie & A.E. Beck, Dordrecht: Reidel, 3.

Runcorn, S. K. 1968, in *Continental Drift, Secular Motion of the Pole and Rotation of the Earth*, W.M. Markowitz & B. Guinot, Dordrecht: Reidel, 80.

Vondrák, J. 1985, *Ann. Geophys.*, **3**, 351

Vondrák, J. 1999, in *Journées 1998 Système de Référence Spatio-temporels*, N. Capitaine, Observatoire de Paris, 195.

Wilson, C.R. & Vicente, R.O. 1980, *Geophys. J. R. Astr. Soc.*, **62**, 605.

Yastkiv, Ya. S. 1981, in *Reference Coordinate System for Earth Dynamics*, eds. M. Gaposckin & B. Kołaczek, Dordrecht: Reidel, 155.