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Investigation of Nutation beyond the IAU2000 Model

Véronique Dehant [1], *Olivier de Viron* [1], *Martine Feissel-Vernier* [2]

[1] *Royal Observatory of Belgium*

[2] *Observatoire de Paris/SYRTE and Institut Géographique National/LAREG*

Contact author: Véronique Dehant, e-mail: `Veronique.Dehant@oma.be`

1. Introduction

Precession and nutations are mainly generated by the luni-solar attraction on the Earth equatorial bulge. Diurnal variations in the atmospheric and oceanic angular momenta in an Earth-fixed reference system induce additional contributions to some nutation motions.

Precession and nutations are observed through the variations of the Earth Orientation Parameters obtained using Very Long Baseline Interferometry (VLBI) data, assuming that the direction of observed quasars are fixed in space. We may consider different ways of interpretting the discrepancies between the observed nutations and the model MHB2000 ([5], model adopted by the International Astronomical Union): either the model needs to be improved, or that there are imperfections in the observed nutation series. In particular, we investigate in this study the time variable atmospheric and oceanic effects. The possible contamination of VLBI-derived nutation amplitudes by apparent changes in the directions of the extragalactic radio sources is examined in [3].

The residuals between the observed nutation using VLBI and the MHB2000 model adopted by the International Astronomical Union (IAU2000) are of the order of a few tens of microarcseconds for particular frequencies. Considering the relatively small mass of the external fluid, there are only two ways that their effects on nutation can reach the observable level: (1) at frequencies corresponding to special frequencies in the fluid dynamics such as the annual prograde nutation, corresponding to exactly one solar day in the terrestrial frame, and (2) by exciting the nutation free modes namely the Free Core Nutation (FCN) and the Free Inner Core Nutation (FICN). In the adopted model MHB2000, a constant prograde annual contribution attributed to the external geophysical fluids is adjusted. Additionally, a time variable FCN amplitude is adjusted on the observations. This partly accounts for the atmospheric and oceanic contributions.

2. Atmospheric Excitation of FCN and FICN and their VLBI Detection

For this study, we have considered a nutation series obtained from a subset of radio-sources which are selected for their stability (see [2], [4]). Wavelet analysis and moving window Fourier transform of the residuals show peaks around 500 days and 900 days. The 500-day signal can be explained by a direct atmospheric effect, as we have found that signal at the same frequency and at the same level. Conversely, there is practically no power at all in the atmospheric data at 900 days. If we believe that the 900-day peak is of geophysical origin, the power can only be explained if either the geophysical fluids excite the FICN (the theoretical period of the FICN is 1025 days [930,1140] in Mathews et al. [5]), or the atmopsheric models fail to adequatly represent the dynamics of the atmosphere at that frequency.

Assuming a random signal in the atmosphere and ocean excitation function, we investigate the level of the FICN signal that would result from that excitation, using a simple Earth model. From the angular momentum data, it is not possible to obtain a reliable evaluation of the noise level at the FICN frequency. Consequently, we have assumed that the noise level at the FICN is close to the noise level at the FCN frequency. Accounting for a ratio of the resonance strengths at the FICN and FCN frequency of 1.8×10^{-4}, we obtain a 0.05 μas signal at the FICN. This is far too small compared to the observed residual which is at 20 μas level.

On the other hand, a candidate FICN with an amplitude of 37 ± 10 μas, that is detected in the VLBI observations in the 1990-1995 time frame, is believed to be partly an artefact of residual source instabilities [3].

3. Conclusion

We study the residuals between the observed nutation and the adopted nutation model (MHB2000). By improving the source selection strategy, we obtain residuals more physically meaningful. But the contamination of source instability is still a question (see [3]). We observe that some part of the residuals can be explained by the atmosphere even outside the annual prograde nutation. We have also observed a large peak around 900 days, which is close to the FICN frequency as expected from the forced nutation (1025 days [930,1140]). Note that this peak is only present for a few years around 1995. The estimation of the FICN signal resulting from a random noise excitation by the ocean and the atmosphere is too small, below the μas level.

In our evaluation, we assumed that the geophysical excitation of the FICN was at the same level as the one of the FCN; it is possible, but not likely, that this excitation would be much larger. In this case, we need to have power at the FICN that is two orders of magnitude larger than at the FCN, which does not seem reasonable. So far in our investigation, an artefact from the data analysis seems the most probable explanation. We would like to invite the VLBI community to clarify the effect of the stability of the network, which might also be mapped in the VLBI residuals.

References

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