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Report of IAU Working Group on 'Non-Rigid Earth Nutation Theory'

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With respect to the publication in the Proceedings of the IAU Colloquium 180 (Dehant 2000), I have a few additional remarks that I would like to make. There were three competing models:

1. MHB2000 of Mathews et al. (2000), (see also Mathews 2000), constructed from a rigid Earth nutation series with about 1400 terms and a transfer function obeying the sum rules, based on the fit of a semianalytical nutation theory to VLBI observations, with resonances determined by geophysical parameters including those estimated from the fit, incorporating the atmospheric annual effect fitted to observations, including ocean tide effects based on admittances with frequency dependence due to the FCN (Free Core Nutation) resonance and to ocean dynamics (fitted to ocean tide data), including electromagnetic couplings of the fluid core, and with mutual consistency maintained in the treatments of nutations, solid Earth tides and ocean tides which influence one another;

2. GF2000 of Getino and Ferrándiz (2000), using a global Hamiltonian approach for 106 waves fitted to VLBI data, incorporating a resonance with global parameters fitted to observations such as the FCN free mode frequency, compliances, and dissipation coefficients, incorporating ocean corrections from Huang et al. (2000) with a frequency dependent resonance and fitted atmospheric corrections, and necessitating empirical corrections;

3. SF2000 of Shirai and Fukushima (2000a and 2000b) or Herring (2000, not published), empirical models, based on a simple resonance formula fitted to the VLBI observation.

Because of the frequency dependence imparted to some Earth parameters by the effect of ocean tides (and to a small extent by mantle inelasticity and by electromagnetic couplings at the core boundaries), the resonance formula cannot be considered as exact. A resonance frequency is not coincident with the eigenfrequency in general, when the system has parameters that are frequency dependent. In the present case, contributions from both mantle inelasticity and ocean tides to compliance parameters at the observed Chandler frequency are substantially different from those at retrograde diurnal frequencies. The resonance strengths and the mode frequencies are frequency dependent. This is the reason why MHB2000 provides a 'mean' resonance formula and additional theoretical corrections. This is not accounted for in GF2000, neither in SF2000.

The physical modeling of the electromagnetic torque at the core-mantle boundary involves the presence of an induced electric current in a conductive layer at the bottom of the mantle. The high conductance (product of the conductivity and the thickness of the layer) of this layer is not only necessary to explain the nutations, but also to explain the length-of-day variations. But laboratory experiments on porosity of perovskite in the mantle and on iron infiltration from the core do not allow for such a large conductance (Poirier et al. 1998, see also Poirier and Le Mouël 1992). The thickness of the layer was thus previously rather controversal. However, the existence of such a large conductive layer has been explained at the last SEDI symposium (Study of the Earth's Deep Interior, Exeter, UK, July 2000) by a chemical reaction between the perovskite of the mantle and the iron of the liquid core, followed by a sedimentation process at the core-mantle boundary (Buffett et al. 2000). Therefore, these new findings reconcile the different thicknesses found in the literature, and in particular, justify the nutation dissipation found from the VLBI data.

The advantage of the GF2000 model is the global approach. This is believed to be the future for nutation computation. It has the advantage of unifying the rigid and non-rigid nutations.

The advantage of the empirical models is their simplicity. But the parameters obtained in the fit cannot be interpreted in terms of physics of the Earth's interior.

Consequently, it is believed that the most complete geophysically based nutation series is MHB2000. Additionally, MHB2000 does not only give the nutations of long periods, but also diurnal and subdiurnal nutations.

On the other hand, analyses of residuals of the competitive models with respect to the observations (as done by McCarthy 2000, and Dehant et al. 2000) have shown that they are not distinguishable at the level of the observation precision.

References

Buffett B., Jeanloz R., & Garnero E. 2000, "Sediments at the top of the Earth's core", in Proc. of the SEDI Symposium, Exeter, UK, Special issue of Phys. Earth planet. Inter., submitted

Dehant V. 2000, in Proc. of IAU Coll. 180, eds. K. Johnston, D. McCarthy, B. Luzum & G. Kaplan, Washington, USA, 201

Dehant V., Feissel M., de Viron O, Yseboodt M., & Bizouard Ch. 2000, this volume

Getino J. & Ferrándiz J.M. 2000, in Proc. of IAU Coll. 180, eds. K. Johnston, D. McCarthy, B. Luzum & G. Kaplan, Washington, USA, 236

Huang C.L., Jin W.J. & Liao X.H. 2000, Geophys. J. Int., 146, 126

Mathews P.M. 2000, in Proc. of IAU Coll. 180, eds. K. Johnston, D. McCarthy, B. Luzum & G. Kaplan, Washington, USA, 212

Mathews, P.M., Herring, T., & Buffett, B. 2000, "Modeling of nutation-precession: new nutation series for nonrigid Earth, and insights into the Earth's interior", J. Geophys. Res., submitted.

McCarthy D. 2000, this volume

Poirier J.-P. & Le Mouël J.-L. 1992, Phys. Earth planet. Inter., 73, 29

Poirier J.-P., Malavergne V., & Le Mouël J.-L. 1998, in The Core-Mantle Boundary Region, eds. E.K.M. Gurnis, M.E. Wysession, & B.A. Buffett, AGU/IUGG Publication, 131

Shirai T. & Fukushima T. 2000a, "Improvement of non-rigid Earth nutation theory by adding a model free core nutation term", Astron. J., submitted, also in Proc. of IAU Coll. 180, eds. K. Johnston, D. McCarthy, B. Luzum & G. Kaplan, Washington, USA, 223

Shirai T. and Fukushima T. 2000b, "Numerical convolution in the time domain and its apllication to the non-rigid Earth nutation theory", Astron. J., in press