CAN THE CORE-MANTLE BOUNDARY TOPOGRAPHY INFLUENCE THE EARTH'S NUTATION?

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Abstract. The nutation of the Earth with slightly nonelliptical liquid core is investigated by the perturbation theory method. It is shown that first-order terms affect the core ellipticity and its triaxiality. The most sensitive nutation terms in the second approximation were found to be retrograde 18.6-year term and retrograde annual term. The observed nutation amplitude values can be satisfied by special core-mantle boundary form.

The estimates of the forced nutation amplitudes display deviation between calculated and observed values. This deviation was supposed to be explained, for example, by assuming the higher value of the core ellipticity than that of the hydrostatic theory [1], the effects of the core viscosity, or the internal structure of the core [2]. The influence of the core-mantle boundary topography on the nutation is investigated in the present paper.

Model and method. The Earth is considered to consist of the rigid shell and liquid core of the shape S (the liquid is homogeneous and incompressible). The problem is solved by the perturbation theory with small parmater equal to the ratio of the inclination angle of the core-mantle boundary surface element to that of the ellipsoid. The Poincare solution is used as an initial approximation. If the velocity vector is represented as a sum $\vec{v} = \vec{v}_0 + \vec{v}_1 + \vec{v}_2 + \dots$, and normal vector is $\vec{n} = \vec{n}_0 + \vec{n}_1$, where $\vec{n}_0$ is normal vector to ellipsoid S_0 : $r = r_0\,(1 + e \sin^2\theta)$, $\vec{n}_1$ is one to the real boundary S :

$$r = r_0\,(1 + e \sin^2\Theta) + \sum_k \sum_l a_{kl}\, Y_{kl}\,(\Theta,\varphi) \qquad (1)$$

r_0 , e are the mean radius and the ellipticity of the core, Y_{kl} are spherical harmonics, normalised as in [3], then considering the terms of the same order of smallness,

$$(\vec{v}_0,\vec{n}_0)_{s_0} = 0 \qquad (2a)$$

$$(\vec{v}_1,\vec{n}_0)_{s_0} + (\vec{v}_0,\vec{n}_1) + (\delta\vec{v}_0,\vec{n}_0) = 0 \qquad (2b)$$

$$(\vec{v}_2,\vec{n}_0)_{s_0} + (\vec{v}_1,\vec{n}_1) + (\delta\vec{v}_1,\vec{n}_0) = 0 \qquad (2c)$$

etc., $\delta\vec{v}_1 = \vec{v}_i|_s - \vec{v}_i|_{s_0}$

$\vec{v}_1|_s$ is defined by equation (2b) with known $\vec{v}_0$, $\vec{n}_1$, $\vec{v}_0$, $\vec{v}_2|_s$ is defined by (2c) ,etc. So every $\vec{v}_i$ can be found as an expansion in inertial modes V_{nm} in rotating liquid ellipsoid [4]. $V_{nm}|_s \sim Y_{nm}(\theta,\varphi)$ and are the full orthogonal function system. Each inertial mode V_{nm} is induced by the spherical harmonic Y_{nm} with the corresponding number.

Results. The calculations were carried out for the eight main nutation terms. In the first approximation the nutation is influenced by the

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modes V_{20}, V_{40}, affecting the seaming increasing of e and V_{22} resulting in the ellipticity of the angular velocity vector moment in rotating coordinate system: $(A_x-A_y)/2A_0 \sim 10^{-2}$, where A_x, A_y and A_0 are the nutation amplitudes for the Earth with liquid core in x and y directions and for the absolutely rigid Earth, respectively.

Second-order terms consideration shows that in this case the significant role is played by boundary harmonics, inducing the inertial modes with eigen frequencies closest to the frequencies of forced nutation. The calculations reveal that these are the harmonics with l=0 and k=164,78,250,... for different nutation terms. Then to satisfy the observed nutation amplitude values it must be accepted that the boundary S_0 is superimposed by the wave Y_{k0} with amplitudes dr given in the table.

nutation terms	corrections to nutation amplitudes(mas) I	II	k	dr (km)
+6800	-0.03	-0.02 ± 0.0004		
-6800	0.23	0.27 ± 0.05		
-365.3	0.17	0.61 ± 0.15	164	1.5
+182.6	-0.04	-0.02 ± 0.01	250	13.8
-182.6	0.01	0.02 ± 0.01	78	2.9

I-1 approximation, the results obtained for mode Y_{40}, $a_{40}=4.4 \pm 2.4$ km according to [3]. II- 2 approximation, the core-mantle boundary coefficients are assumed to be distributed randomly with mean value equal to zero and dispersion $=(h/n)^2$, where h=10 km is boundary relief [3], n is the quantity of coefficients, n=200.

Discussion. Therefore the results obtained demostrate, that the observed nutation amplitude deviations can't be explained by the core-mantle boundary topography influence in the first approximation. The choice of the special core-mantle boundary form can yield the observed results in the second approximation without contradiction to modern seismic data [3]. However it is very doubtful. If the core-mantle boundary expansion coefficients are assumed to be distributed randomly the probabilistic estimates can be made. The probabilities of the dr from the table are 0.00001. So such a situation seems to be physically unrealizible.

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