Japan Geoscience Union Meeting 2014
(28 April - 02 May 2014 at Pacifico YOKOHAMA, Kanagawa, Japan)

PPS03-P01 Room:Poster Time:April 29 18:15-19:30

The free and forced librations of the Moon with liquid shell and solid core

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In report we present our results of the study of lunar physical libration of the Moon on the base of its two and three layers models. On the base of analytical solution for two layers model (the Moon with liquid core) and empirical theory of the Moon ′ s rotation (Rambaux, Williams, 2011), we have identified period, amplitude, and the initial phase of the forth mode of free libration of the Moon, caused by liquid ellipsoidal core. Preliminary results of studies of three-layers model of physical librations of the Moon have been obtained on the base of some simplified approach for the problem of rotation of the Moon with liquid and rigid cores. The plans for future studies of the Moon rotation are discussed.

The modern view of internal structure of the Moon planet takes into account a complex two- or three-layer model. In our work the analytical theory of lunar physical libration based on its two-layer model consisting of a non- spherical solid mantle and of the ellipsoidal liquid core has been developed. The Moon moves on high-accurate perturbed orbit in the gravitational field of the Earth and other celestial bodies. On the base of two layers model of the Moon we have fulfilled systematic studies of the Moon physical librations. And in first we have presented a solution of the problem in components of vector of angular velocity of the Moon. An analytical presentation of LOD of the Moon with high accuracy in form of trigonometric series has here the progressive value. In first we have determined the fourth mode of free libration of the Moon caused by the influence of the liquid core oscillations of pole axis of rotation of the Moon (its mantle), with a long period in 205.7 yr, with an amplitude of 0 ″ 0395 and the initial phase of -134 ^{0} (for the initial epoch 2000.0). This oscillation reflects the so-called phenomenon of free oscillation of the liquid core. The estimates for the dynamic (meridional) oblatenesses of the ellipsoidal liquid core of the Moon: 0.000442 and 0.000283 have been obtained. These fundamental parameters of geodynamics of the Moon could be determined only on the base of data of observations. Earlier the attempts to determine the period of free core nutation undertaken. Our results were obtained by comparing of the developed analytical theory of lunar physical libration with empirical theory libration of the Moon, constructed on the basis of laser observations in last about 40 years (Rambaux, Williams, 2011).

Preliminary results of studies of three-layers model of physical librations of the Moon have been obtained on the base of some simplified approach for the problem of rotation of the Moon with liquid and rigid cores. We have analyzed the Cassini ′ s motion of the decoupled solid core and its librations in longitude to compare with the Moon motions. On the base of Getino, Ferrandiz et al. approach we give estimations of the periods of free librations of this system. We have constructed differential equations of rotational motion of three layers Moon from positions of the Hamiltonian formalism with application of Andoyer ′ s and Poincare ′ s variables. Now we construct analytical theory of rotation of the Moon system consisting from the non-spherical mantle, ellipsoidal liquid core and solid core.

Keywords: Moon rotation, free libration, liquid core, solid core

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PPS03-P02 Room:Poster Time:April 29 18:15-19:30

Viscosity structure dependence of large-scale polar wander rate of the Earth: A potential impact of a low-viscosity zone

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In this study, we make an attempt to quantitatively evaluate an effect of presence of a low-viscosity layer inside the mantle of the Earth on the timescale of its polar wander. In particular, we perform model calculation of the viscoelastic Love number which characterizes the mechanical response of the interior of the Earth, and then investigate how the timescales and strengths of some relaxation modes in the Love number depend on the viscosity structure. I compare the structure dependence of these relaxation modes with that of the polar wander speed. For the sake of convenience of this numerical calculation, we simplify the multilayered structure of the Earth and assume its incompressibility to compute the relaxation modes.

In this calculation, we apply the quasi-fluid approximation which makes it possible to integrate the polar motion equation as a non-linear one. Its reason is because the linear approximation is not allowed for the large-scale polar wander as dealt with in here. Following the applicable condition of the quasi-fluid approximation, we consider load history which timescale is slower than the characteristic one of the viscoelastic deformation of the asthenosphere.

As a result of the calculation mentioned above, we find that the timescale of the polar wander depends almost only on the longest relaxation mode. It is a remarkable point here that, in fact, the ratio of the strength of this relaxation mode governing the polar wander to the total viscoelastic Love number is not so large. In other words, this fact means that the other modes which amplitudes of tidal deformation are more dominant have almost no effect with respect to the timescale of the polar wander. Apparently, this might seem to be a peculiar result.

The reason for this dependence is because the timescale only of the above-mentioned longest mode is much longer by a few orders of magnitude compared to those of the other modes. A mode with a longer time constant of viscous relaxation has an effect which stabilizes rotation axis in a longer term even if its strength is smaller. Oppositely, a mode with a shorter time constant contributes less to the long-term rotational stability because of its faster relaxation even if its strength is larger.

In the light of this result, we can tell that the structure dependence of the true polar wander rate also basically reflects just that of the relaxation time of this longest mode. Actually, even assuming the internal structure without the low-viscosity layer inside the mantle, we still find the influence of this mode to be prominent. Once we take the existence of the low-viscosity layer into account, lower its viscosity is, shorter the timescale of the longest mode is. It can be less than forty percent at shortest. However, if this viscosity becomes lower than a certain value, the timescale of this mode is asymptotic to a constant value. Such a trend results from that this layer behaves as a fluid rather than a viscoelastic body in a sufficiently long timescale due to its too low viscosity.

Here we conclude from the calculation result shown above that the presence of the low-viscosity layer inside the Earth generally shortens the timescale of the large-scale polar wander, and also that this impact mainly stems from the variation in the timescale of the longest relaxation mode. Indeed, the preexisting works have already discussed the dependence of the timescale of the large-scale polar wander on the internal structure of the Earth as well. However, they have not examined the impact of the low-viscosity layer therein, considering a more simplified viscosity structure. Also, they have not clearly stated that the major controlling factor on the true polar wander speed. On the contrary, this work estimates the timescale of the polar wander with explicitly including the impact of this layer, and shows the non-negligible effect of the heterogeneous viscosity structure on the large-scale polar wander.

Keywords: true polar wander, the Earth, mantle, low-viscosity layer, relaxation mode, time constant

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PPS03-P03 Room:Poster Time:April 29 18:15-19:30

Effects of global geodynamics in a series of astrometry observations of latitude at Poltava

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Diverse geodynamic phenomena observed in the modern era, received a convincing explanation in the framework of the northern drift of Earth's core. Model proposed and developed by Yuri Barkin relative to the set of ancient geodynamic processes: the secular drift of the Earth's pole, non-tidal acceleration of the Earth's rotation, secular change of gravity, the evolution of the earth's figure, plate tectonics, the formation of specific geological structures, etc.

The North drift of the core generates mass redistribution of the Earth and leads to changes in the gravitational field. Since astrometry instruments have as a reference axis direction of the local plumb line, then this process should be displayed in the slow position changes no polar zenith Observatory. It is shown that for locations in the northern hemisphere, the north drift of the core causes the displacement of local plumb in a southerly direction. Is the picture of long-term changes in the direction of gravity (NST) in the meridian of Poltava for the period 1962 - 2013 based on long-term observations of latitude prismatic astrolabe taking into account: 1) high-precision catalogs (HIPPARCOS, ARIHIP, Tycho-2), 2) improved model of the pole C01 IERS; 3) the theory of the precession-nutation IAU2000; 4) plate tectonics (NUVEL1A-NNR). The resulting long-period changes in NST can be represented as the sum of three components: a linear trend with velocity ~-0.0003 ″ /yr, the nonlinear part of the trend, consisting of two branches (descending - in 1962 to 1996. And rising - in 1998 and 2010.), which can be regarded as a fragment of a wave with period T~50 years and amplitude A~0.02 ″ ; quasi cyclic part with 11 - year period, close to the main period of index of solar activity period and amplitude <0.01 ″ .

The linear part of the translational displacement means the plumb line to the south of Poltava, which is consistent with the above Barkin ′ s model. The observed velocity of motion of zenith corresponds to moving the center of mass of the Earth in a northerly direction at the velocity in 1.4 cm/yr. Found that the nonlinear part of the trend and the 11-year cyclicity in the shifts of plummet quite clearly reproduce the form of low-frequency polar latitude variations at Poltava derived from model C01 (EOP IERS). Actually observed amplitude of long-period oscillations of latitude caused by pole motion, in 2 times higher than the calculated amplitude. The non-linear part of the trend is the projection on the Poltava meridian of the Markowitz wave.

It is shown that both low-frequency cycles are negatively correlated with the corresponding components of the index of solar activity. The most probable mechanism of solar activity influence on the motion of the pole is the North Atlantic Oscillation. An increase in the amplitude of low-frequency polar displacements of Poltava zenith in astrometric observations requires a special study. One from possible explanations - the influence of the features of the geological structure in the vicinity of Poltava, which is located in the center of the so-called rift Poltava site.

Keywords: plate tectonics, secular change of gravity, Markowitz wave

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PPS03-P04 Room:Poster Time:April 29 18:15-19:30

Minerals detection on Mars from Mars Reconnaissance Orbiter (MRO) CRISM data

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Martian mineral detection and mapping can provide important information and constraints on Martian aqueous history, which can be used to assess the potential habitability of Mars. Degrees of addressing the key question for Martian aqueous alteration are dictated by the depth and extent of grasping the Martian hydrous mineral. Therefore, it is important to know detailed minerals and chemical induction of the existence of water on the Martian surface at past or present. In-situ observations of the Martian rovers, such as Spirit, Opportunity and Curiosity have provided the mineralogical analysis of Martian surface, but restricting in a limited areas. Compact Reconnaissance Imaging Spectrometer for Mars (CRISM) aboard the Mars Reconnaissance Orbiter (MRO) with enhanced spectral resolution can provide more information at spatial and time scale. In this paper, CRISM near-infrared spectral data are used to identify mineral classes and distribution at Martian Gale region, including kaolinite, chlorites, smectite, jarosite, northupite and salts. The detection of northupite that is indicative of evaporation in Gale region suggests that the Gale region has experienced the climate change from moist condition with mineral dissolution to dryer climate with water evaporation.

Keywords: Martian minerals, Mars Reconnaissance Orbiter, CRISM