Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

PPS03-P01 Room:Convention Hall Time:May 20 18:15-19:30

Optical Response Simulation of Corner Cube Reflectors for SELENE2 Mission

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The object of these simulations is clearing up the criterion for the Corner Cube Prism (CCP) and the Corner Cube Mirror (CCM) in order to measuring the distance from the Earth to the Moon in cm order. In case of the CCP, the refractive index inhomogeneity restricts its size to small (~10cm), so we did not calculate the effect of any deformation. In case of the CCM, we calculated both effects of the Moon gravity deformation and the thermal deformation.

The Optical responses were calculated with CodeV (Synopsis, Inc.), and we did not consider DAO (Dihedral Angle Offset), because the common optical simulation software cannot calculate its effect.

The Optical response criterion is that the encircled energy within 3.5mrad (half angle) $>$ 50%, where 3.5mrad is equal to the minimum deflection by the velocity aberration without DAO. The velocity aberration deflect 3.5-7mrad from the Laser emitted direction according to the relative speed between the Earth and the Moon.

Keywords: corner cube reflector, laser ranging, PSF

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Developement of the telescope for ILOM (In-site Lunar Orientation Measurement) using the DOE (Diffractive Optical Elemen

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ILOM demands the very high performance to the optical system in order to realize the determination of star positions with 1 milli arc second accuracy on the Moon whose environmental condition is very fierce. There are several causes that degrade the optical performance and the most effective cause is the change of the environmental temperature. The temperature change causes the change of lens shape and the change of the refractive index of each lens material and the later is much dominant. The optical system of ILOM is the refractive system so we have to reduce the chromatic aberration using so-called the low dispersion glass, but this type glass has a much bigger dn/dt (the index change for the temperature change) than the normal glasses. In result of this, the optical system using the low dispersion glass lens becomes very sensitive to the change of the environmental temperature.

So we developed the optical system (objective lens) using the DOE (Diffractive Optical Element). Using the DOE, we can reduce the chromatic aberration without the low dispersion glass lens. So we can develop the objective lens that is very tolerant to the environmental temperature change because we can design the objective lens using small dn/dt glass lens only.

Keywords: ILOM, DOE

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Planetary Tectonic System (#2): Classification for the Search of Life Beyond Earth

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For life to initiate, diversify, and flourish, it requires a continuous nutrient supply, metabolism with continuous reactions to gain energy, and self-duplication [1; also see Shigenori Maruyama, this conference]. Based on our understanding of the evolution of Earth, which includes the Cambrian explosion [1; also see Shigenori Maruyama, this conference], these conditions can be optimally met through a planetary tectonic system (PTS) that is composed of a nutrient-enriched continental landmass, an ocean, tectonic structures such as rift systems that act as conduits for the migration of volatiles and heat energy, as well as the delivery of toxic elements (e.g., radiogenic nuclides) for the diversification of life (evolution requires perturbations from normal conditions), and a sunlit planetary surface [1].

Since a PTS provides the road map for the search for life beyond Earth [also see, Maruyama and Dohm, this conference], we propose a classification of planetary bodies with certain PTSs unfolded through geological investigation using existing planetary data sets.

Such a classification is not only based on the distance of the planetary body from the Sun and its composition, but also by its characteristic PTS. This is important, because the birth place of life and evolution is controlled by an optimal PTS as exemplified during the Cambrian explosion [1; also see Maruyama and Dohm this conference]. Without understanding PTS, it is impossible to target possible candidates of life-sustaining habitable environments both in and outside our solar system.

The types of PTS are: (1) Earth-Cambrian-explosion [1; also see Maruyama, this conference], (2) Ice-house Mars [2,3], (3) Hot-house Venus [3,4], (4) Rigid Mercury, (5) Gaseous-giants, and (6) Frigid, dynamic, and/or hydrologically exotic satellites. Others types (e.g., Kuiper belt planets and dwarf-planets) could be added in the future.

Detailed characteristics of the various PTSs will be detailed at the conference.

References

[1] Maruyma, S et al., (2013?in press), Geoscience Frontiers 171.

[2] Dohm, J.M., et al. (2011) GSA Special Paper 483, 317?347, doi:10.1130/2011.2483(21).

[3] Baker, V.R. et al. (2007) In Superplumes: beyond plate tectonics. D.A Yuen, S. Maruyama, S-I Karato, and B.F. Windley (eds.). Springer, pgs. 507-523.

[4] Schulze-Makuch, D., et al. (2005) Astrobiology 5, 778-795.

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Luni-Solar Tides in the Earth Atmosphere

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The gravitational tides in the atmosphere are recorded as the waves with the periods close to one day and its subharmonics. Some of them are usually interpreted as the proper atmospheric modes. They commonly have either the amplitude or the frequency modulations. A new explanation of the quasy-diurnal and quasy-semidiurnal tides lines in the spectrum of the atmospheric angular momentum (AAM) and other atmospheric characteristics is proposed. The role of gravity tides in the dynamics of the atmosphere and the ocean is underestimated. The reasons of a wrong estimation of a role of the tidal phenomena in geophysics are explained.

We have calculated the power spectrum of the complex series h1+ih2. The resulting spectrum has been analysed. . The most striking detail of the spectrum of h1 + ih2 is a blurred maximum of the spectral density at ?0.85 cpd. Its height is indicative of a high power of h1 and h2, and the width shows considerable ?uctuations of the period. What lies behind this phenomenon and why does the atmospheric circulation produce strong noise in this frequency range? Due to our discovery, it becomes clear why the role of gravity tides in the dynamics of the atmosphere and the ocean is underestimated. The fact is that all hydrometeorological and hydrophysical characteristics are measured at moments of mean solar time, which is the hour angle of the Sun determined by the Earth diurnal rotation and annual revolution. That is, by default, a frame of reference tied to the Sun (referred to hereafter as the solar frame) is used in this case. In this frame, the apparent velocity of a tidal wave is the sum of its proper velocity and the translational velocity. The latter arises due to the Earth diurnal rotation and the Earth annual revolution around the Sun. Its magnitude is very high compared with the proper velocities of tidal waves Therefore, in the solar frame we deal only with quasi-diurnal tidal waves and their subharmonics. In the spectral (or Fourier) analysis of observations, the low-frequency waves of gravity tides are di?cult to distinguish from the harmonics of diurnal or annual thermal tides and are nearly imperceptible for study. Hydrometeorologists construct synoptic maps or time-coordinate sections with a ?xed geographical grid of parallels and meridians. That is, by default they use a frame of reference tied not to the Sun, but rather to the stationary Earth surface. In this frame, the Earth diurnal rotation and orbital revolution are eliminated, while the proper motion of tidal waves is only present. Hydrometeorologists give attention only to fast quasi-diurnal tidal waves predicted by the theory. The proper motion of tidal waves remains unnoticed. All slow waves moving over the Earth surface, including tidal waves, are interpreted as usual atmospheric or oceanic waves. To detect low-frequency tidal waves in spectral analysis, we have to eliminate the e?ects of the Earth rotation and revolution demodulate measured time series. For this purpose, it is su?cient to ?x the time of measurements (one measurementa day to eliminate the Earth diurnal rotation or one measurement a year to eliminate the Earth annual revolution). As a result, weekly and semimonthly lunar tidal waves were detected in the spectrum of the atmospheric angular momentum. This method opens up new opportunities for studying the e?ects of lunisolar tides and functions of the Sun barycentric motion.

Keywords: Luni-solar gravitational, The gravitational tides

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Kaula's rule and the scaling law of the Kaula constant in the lunar-planetary gravity fields

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Gravity fields of the moon and planets are modeled as the sum of spherical harmonics of various degrees/orders, and their coefficients are called as the Stokes' coefficients. These coefficients with degrees and orders complete to a few hundreds have been estimated using the tracking data of artificial satellites such as GRACE (the earth), SELENE and GRAIL (the moon). High degree coefficients show fine structure of the shallow mass distribution, and low degree coefficients reflect global scale mass distribution of the body. Kaula's rule-of-thumb predicts that the Stokes' coefficients are inversely proportional to the square of the degree n of the spherical harmonics. In this study, I confirmed that this is the case for the moon, the earth, Mars and Venus. Smaller coefficients for higher degrees mean that the long wavelength components have larger amplitudes.

Here I refer to the factor to link 1/n2 to the Stokes' coefficients as the Kaula constant. The smaller celestial body is considered to have a larger Kaula constant, and they are considered to obey a scaling law that the coefficient is inversely proportional to the square of the surface gravity of the body (in the original paper by. Kaula [Kauka,1963], the constant is suggested to scale with R4/M2, where R and M denote the radius and the mass of the body, respectively). This scaling law is confirmed to hold true for the moon, Mars, Venus, and the earth. Departure from this scaling law would imply some difference of the physical properties (such as viscosity) of the material that makes up the interior of the body. Recent data on the gravity field of Mercury taken by MESSENGER seem to indicate such a departure, which may reflect the unusually large relative radius of the metallic core of Mercury.

The lunar farside and nearside are known to be very different, i.e. the nearside has thin crust and flat terrain, whereas the farside has thick crust and rugged terrain. There are several hypotheses for the origin of such lunar dichotomy, and many of those suggest some difference in thermal history between the two sides. Such a difference can be studied with the gravitational field. Here I compared the Kaula constant of these lunar two hemispheres by creating two hypothetical moons, those composed of only farside and only nearside. The Kaula constant of the farside showed slightly larger value than the nearside, suggesting colder internal temperature of the lunar farside.

Keywords: scaling law of the kaula constant

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A time scale of true polar wander on a quasi-fluid planet: Effect of a low-viscosity layer inside a mantle

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In this study, model calculation on long-term polar motion accompanied by viscoelastic deformation are performed in order to investigate the effect of a low-viscosity layer inside a mantle of a solid planetary body on a time scale of true polar wander. Here a planetary body is supposed to be similar to the Earth or Mars, but with the low-viscosity zone. The most important key is dependence of the viscoelastic response on this low-viscosity layer. On the other hand, note that deformation process in here is regarded to be incompressible for solving normal modes of viscoelastic Love numbers. For the sake of the calculation based on this assumption, the interior structure is still simplified to some extent except for the presence of the low-viscosity zone. However, this simplification does not affect the validity of the subsequent discussion.

In this calculation, the quasi-fluid approximation is applied so that the polar motion equation can be integrated just as a nonlinear one. The reason is that the linear approximation is not generally applicable to large polar motion of a magnitude of several tens of degrees as discussed here. Following the application limit of the quasi-fluid equation, load formation is assumed to be much slower than characteristic time scales of viscoelastic deformation. This approximation scheme has already been constructed by the author as well as some other researchers. The present study also deals with this integration in the same manner.

As a result, the above calculation indicates the fact that the time variation of a spin pole with the effect of the low-viscosity layer is faster compared to that without it. In addition, the result also reveals that, the shallower the low-viscosity zone is, the faster the polar wander speed is. The reason why the low-viscosity layer makes polar wander speed faster is because the behavior of this layer is like that of liquid even with respect to relatively short-term variation of external forcing. This corresponds to, in turn, faster hydrostatic readjustment to centrifugal potential perturbation, which shortens a time scale of variation in the moment of inertia tensor associated with that in the spin axis. Furthermore, variation of an oblate shape with viscous relaxation of this layer negatively depends on the thickness of the upper shell which elastically reduces the above-mentioned fluid-like displacement of the layer. This point assures that the effect of the low-viscosity layer on polar wandering is stronger if the upper shell is thinner, that is, this soft layer is shallower.

The calculation result shown above provides the conclusion that the presence of the low-viscosity layer in a planetary interior largely affects true polar wander even if the layer is relatively thin. The previous studies simplified mantle viscosity structure and ignored the low-viscosity layer inside. Unlike them, the present study demonstrates time evolution of true polar wander with the explicit effect of this specific layer. Although it has been pointed out in the past that such an easily deformable domain plays an important role in viscoelastic deformation induced by tide or load on the Earth, this point is the same in the case of secular rotational motion.

It should be noted, however, that the present calculation is also based on the assumption of incompressibility like the former one. Possible effect of compressibility might be required for more realistic calculation in the future.

Keywords: true polar wander, quasi-fluid approximation, low-viscosity layer, mantle