Possible observation of free core nutation of the moon

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The Earth has a fluid core and it can rotate around the axis different from that of the mantle because it is fluid.
If the axis of rotation of the fluid core and that of the mantle incline a little to each other for some cause, they begin rotation around the other axis anticlockwise because forces acting on the core mantle boundary (CMB) are asymmetrical to the figure axis of the mantle. This phenomenon is called the Free Core Nutation (FCN).
In case of the Earth tides, the period of FCN is about 460 sidereal days, and when seeing on the rotating coordinate fixed to the Earth, the angular velocity becomes 1-1/460 (turns/ sidereal day), which is close to the period of 1 sidereal day.
There are a lot of components of diurnal Earth tides near the period of 1 sidereal day, and the amplitudes of these components are magnified according to the resonance of the period of FCN, which is called fluid core resonance.

Whether the Moon has a fluid core or not is still unclear although it is an important issue which is related to existence or non-existence of paleo magnetic field and thermal history of the Moon. There were researches which suggested energy dissipation inside of the Moon from the analysis of Lunar Laser Ranging data (Williams et al, 2001) and which suggested partial melting inside of the Moon from the theoretical estimation of tidal heating (Harada et al., 2014). However there has been no observation which directly show the existence of the fluid core.

The period of FCN is estimated to be from several to 20 decades according to lunar model and the amplitude is less than 16 arc seconds (Gusev et al., 2016). Astronomical observations of FCN might be very difficult because its period is too long. However observations of deformation or gravity variation affected by resonance of FCN appear on the lunar surface are more practical like the Earth. Supposing the mean angular velocity of the Moon be Ω_L, angular velocity of FCN relative to inertia space be n_L, then FCN is observed on the Moon as the angular velocity of Ω_L-n_L. It becomes 0.0366-1 / (200×365) = 0.03660099-0.00001370=0.03658729 (27.331 days) for the period of 20 decades..

Because there are a lot of components of lunar diurnal tides around the 27.3 days, there is possibility that the amplitudes are magnified by the resonance of FCN. Not only the tidal variations but the forced physical librations which are caused by the same forces must be affected by the resonance. Actually there are some evidences of resonance in the result of analyses of Lunar ephemeris DE421 expanded to over 1000 years (Rambaux&Williams, 2010). However, there are free modes such as the precession (about 24 year period), the Chandler like polar-motion (about 75 years), the free librations (about 100 years for latitudinal mode and 2.9 years for longitudinal mode) as well as FCN (Gusev et al., 2016), and the resonance effects must be complicated.

We try to estimate the effect of resonance existence of FCN, and we propose to observe tidal deformation and gravity tides on the moon surface.

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