

Interpretation of unexplained secular changes of the lunar orbit

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Unexplained secular effects in the orbital motion of the Moon are consequences of the observed phenomenon of remove of the center of mass of the Moon relatively to its mantle and crust toward the back-side. An explanation of anomalous part of secular variation in the longitude of the Moon and in the eccentricity of the lunar orbit has been obtained.

Unexplained secular variation of the eccentricity of the lunar orbit. In the works of James Williams and his colleagues showed that the observed rate of secular change of the eccentricity of the orbit of the Moon in 2.3×10^{-11} 1/year can not be explained within the framework of the classical model of the tides. Earth tides give only a fraction of the value specified in 1.3×10^{-11} 1/year and lunar tides result even effect with the opposite sign and give part of the acceleration in -0.6×10^{-11} 1/year. Remains unexplained an anomalous part of the secular change in the eccentricity $(1.6 \pm 0.4) \times 10^{-11}$ 1/year. This value corresponds to abnormal changes in the distances to the perigee and apogee at 6 mm / year. "Abnormal speed distances to the perigee and apogee of the lunar orbit is up to 6 mm / year and its cause is unknown" (Williams J.,2006).

Tidal acceleration and evolution of the Moon's orbit. Laser ranging method proved to be very sensitive to the tidal acceleration of the Moon. Tides on the Earth dominate in the transfer of angular momentum, and energy in the orbital motion, in particular in the removal of the Moon from the Earth. Tidal effects on the Moon are separable from the effects of Earth tides in laser range measurements to the Moon (Chapront et al., 2002; Williams et al., 2009). Full tidal acceleration in the mean orbital longitude (due to the tides of the Earth and the Moon) is estimated at $-25.85''$ 1/cy², corresponding to the removal of the Moon from the Earth at a speed of 3.81 cm / year (Williams et al., 2009). The rate of secular variation of the eccentricity of the lunar orbit $e = (9 \pm 3) \times 10^{-12}$ 1/year also detected on the basis of long laser observations over a period of 38.7 years (March 16, 1970 - November 22, 2008) (Williams, Boggs, 2009). The basis of dynamical studies makes a precision lunar ephemeris DE421, taking into account all of Newtonian and Einsteinian effects. The authors believe that the study of the evolution of the lunar orbit is an important and surprisingly difficult task. Lunar laser ranging provides the numerical values for the two sources of dissipation on the Earth and the Moon.

Possible secular drift of the center of mass of the Moon relative to its crust and mantle toward the back side and an explanation of the anomalies of the orbital motion. In this report we give some first estimations of the possible rate of the secular drift of the Moon center of mass with respect to its crust and mantle in the 10 - 15 mm / year toward the back-side of the satellite. This secular drift of the center of mass of the Moon should be considered by the studying of the orbital motion of the Moon on laser-based observations. Namely, to add to the value obtained by laser observations. The result will be an estimate of the secular increasing of semi-major axis is the center of mass of the Moon. It should be expected that this will obtain the interpretation and explanation of the unexplained part of the secular acceleration of the Moon orbit and the anomalous part of the secular variation of the eccentricity of the lunar orbit, identified according to the perennial laser observations of the Moon. An anomalous part of the orbital acceleration (unexplained) of the Moon is $0.7''$ / cy², and the anomalous part of the secular variation of the eccentricity is characterized by rate in 1.23×10^{-11} 1/year (Williams et al., 2011). Found offset - drift of the center of mass of the Moon (12 - 15 mm / year) is explained by the mechanism of excitation and the relative displacements of the shells of the Moon (solid core, liquid core, mantle) (Barkin, 2002).

Keywords: anomalous secular variation of the eccentricity of the lunar, tidal and non-tidal acceleration of the Moon, the center of mass of the Moon drift