Determining parameters of Moon's orbital and rotational motion from LLR observations using GRAIL and IERS-recommended models. Dmitry A. Pavlov[1], James G. Williams[2], Vladimir V. Suvorkin[1], [1] Institute of Applied Astronomy RAS, St. Petersburg, Russia (dpavlov@iaaras.ru), [2] Jet Propulsion Laboratory, California Institute of Technology, Pasadena, USA

Abstract: The aim of this work is to combine the model of orbital and rotational motion of the Moon developed for DE430 with up-to-date astronomical, geodynamical, and geo- and selenophysical models. The parameters of the orbit and physical libration are determined in this work from lunar laser ranging (LLR) observations made at different observatories in 1970–2013. Parameters of other models are taken from solutions that were obtained independently from LLR. A new implementation of the DE430 lunar model, including the liquid core equations, was done within the EPM ephemeris. The postfit residuals of LLR observations make evident that the terrestrial models and solutions recommended by the IERS Conventions are compatible with the lunar theory. That includes: EGM2008 gravitational potential with conventional corrections and variations from solid and ocean tides; displacement of stations due to solid and ocean loading tides; and precession-nutation model. Usage of these models in the solution for LLR observations has allowed us to reduce the number of parameters to be fit. The fixed model of tidal variations of the geopotential has resulted in a lesser value of Moon's extra eccentricity rate, as compared to the original DE430 model with two fit parameters. A mixed model of lunar gravitational potential was used, with some coefficients determined from LLR observations, and other taken from the GL660b solution obtained from the GRAIL spacecraft mission. Solutions obtain accurate positions for the ranging stations and the five retroreflectors. Station motion is derived for sites with long data spans. Dissipation is detected at the lunar fluid core-solid mantle boundary demonstrating that a fluid core is present. Tidal dissipation is strong at both Earth and Moon. Consequently, the lunar semimajor axis is expanding by 38.20 mm/yr, the tidal acceleration in mean longitude is $-25.90''/\text{cy}^2$, and the eccentricity is increasing by 1.48×10^{-11} each year.

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