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Estimation of Lunar Ephemeris from Lunar Laser Ranging

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Lunar Laser Ranging (LLR) has been measuring the distance between the Earth and the Moon since 1969, where the measurements are provided by the observatories as Normal Points (NPs). The Institute of Geodesy (IfE) LLR model has (as of April 2021) 28093 NPs. Using the LLR observation equation, the LLR residuals (difference of observed and calculated values of the light travel time) are obtained for each NP. The LLR analysis procedure is an iteration of the calculation of ephemeris of the solar system followed by the calculation of residuals and the estimation of parameters using a Least-Squares Adjustment (LSA). The initial orbit of the Moon (Euler angles and angular velocity of the lunar mantle, Euler angles of the lunar core, and the position and the velocity of the selenocenter), amongst many other parameters, is estimated from the LSA. In our previous standard calculation, the initial orbit of the Moon was estimated for June 28, 1969 and ephemeris was calculated from this time until June 2022. In this study, we estimate the initial orbit of the Moon for Jan 1, 2000 to be able to benefit from the higher accuracy of the NPs over the timespan of LLR. The ephemeris is then calculated in forward and backward directions (until June 2022 and June 1969). When comparing the uncertainty obtained from a LSA of this study with the previous standard calculation, preliminary results show an improvement of over 50% in the initial position and the initial velocity of the Moon, a deterioration of about 20% in the Euler angles of the mantle and the core, and an improvement of over 15% in the angular velocity of the mantle. The changed analysis procedure will allow to compute a more accurate ephemeris for the upcoming years benefitting future lunar science. Recent results will be presented and major changes would be discussed.

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