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月レーザ測距データ精密解析のためのソフトウェアの開発とその初期成果
Software development for precise LLR data analysis and initial results of parameter estimation for lunar motion

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In order to estimate lunar interior structure from lunar libration and tidal displacement, we are developing new analysis software for precise determination of lunar orbital/rotational motion using lunar laser ranging (LLR) observation data.

As the first step of the software development, we construct an LLR observation model. The model consists of the newest physical models compatible with IERS Conventions (2010) such as Earth orientation, solid tides of the Earth and the Moon, atmospheric delay correction, and some relativistic factors affecting laser propagation delay. For the purpose of calculating these components precisely, we use modules of the geodetic data analysis software ”c5++” [Otsubo et al., JpGU, 2011]. Comparison between observed and calculated ranges is done by combining our own-developed observation model and the lunar orbit/libration obtained from the numerical ephemeris DE430 (provided by NASA JPL). In this calculation, there are 3577 LLR normal points distributed from June 1996 to July 2013, observed at Apache Point, Grasse, Matera and McDonald. The mean value of the residuals of one-way ranges is about 5.7 cm, and the standard deviation is about 4.8 cm.

The following steps are numerical integration of lunar orbit and libration, and the least-squares fitting of integrated ephemeris to observed values. As the date of the submission, only the orbital motion can be determined, and some relating parameters such as positions of retroreflector arrays, lunar mass and the lunar displacement Love numbers are to be estimated. For the models of lunar orbital motion, we implement post-Newtonian EIH equation of motion and perturbations from spherical harmonics of geopotential and J2 term of solar gravity field.

The presentation contains the current status of software development. We will report the results of above-mentioned observation modeling, numerical integration of lunar motion, and estimation of lunar physical parameters.

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