次世代の全地球衛星重力場：数理理論とその環境への応用

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Abstract:
Space gravity missions have been widely used to improve global gravity models and to monitor the environment of the Earth such as global warming, survey of water resources and detection of gravity change due to earthquakes. Although space geodetic observing systems have been advanced recently to such a revolutionary level that low Earth Orbiting (LEO) satellites can now be tracked almost continuously and at the unprecedented high accuracy, none of the three basic methods for mapping the Earth’s gravity field, namely, Kaula linear perturbation, the numerical integration method and the orbit energy-based method, could meet the demand of these challenging data. Except for some recent effort, no theoretical progress has ever been reported for four decades that can match measurements of CHAMP and GRACE types. Although the numerical integration method has been routinely used to produce models of the Earth’s gravity field, for example, from recent satellite gravity missions CHAMP and GRACE, the modelling error of the method increases with the increase of the length of an arc. In order to best exploit the almost continuity and unprecedented high accuracy provided by modern space observing technology for the determination of the Earth’s gravity field, we propose using measured orbits as approximate values and derive the corresponding coordinate and velocity perturbations. The perturbations derived are quasi-linear, linear and of second-order approximation. Unlike conventional perturbation techniques which are only valid in the vicinity of reference mean values, our coordinate and velocity perturbations are mathematically valid uniformly through a whole orbital arc of any length. In particular, the derived coordinate and velocity perturbations are free of singularity due to the critical inclination and resonance inherent in the solution of artificial satellite motion by using various types of orbital elements. We then transform the coordinate and velocity perturbations into those of the six Keplerian orbital elements. For completeness, we also briefly outline how to use the derived coordinate and velocity perturbations to establish observation equations of space geodetic measurements for the determination of geopotential. For more details, one may consult Xu (2008, Celest Mech Dynam Astr, 100, 231-249).