Temporal variation of the gravitational constant and orbit simulation of the ASTROD I mission concept

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Ever since Dirac proposed the large number hypothesis, the time rate of change of the gravitational constant in the cosmological time scale became a focus of interests in cosmology and empirical test of gravitation. The present upper limit on the variation of the gravitational constant is about 1×10^{-12}/yr from both lunar laser ranging experiment and solar-system radio ranging experiment. ASTROD I (Single Spacecraft Astrodynamical Space Test of Relativity using Optical Devices) mission concept is a deep space laser ranging mission with 3 mm ranging accuracy in the range between the drag-free ASTROD I spacecraft and the Earth station. The spacecraft will experience 2 Venus swing-bys and goes to inner solar orbit with a perihelion distance about 0.5 AU. The drag-free noise requirement is 1×10^{-13} m/s2(Hz)1/2 at frequency f 0.1 mHz. The timing accuracy is 10 ps (3 mm in terms of ranging). With these timing and drag-free requirements, we simulate the accuracy of the determination of the rate of change of the gravitational constant (G-dot) together with other relativistic and solar-system parameters; the accuracy of determining G-dot is around 1×10^{-13}/yr for an 2015 launch choice. This will be an order of magnitude improvement over the present accuracy. Further improvement would be able to detect the mass loss from solar radiation and other processes (7×10^{-14}/yr). A discussion of various solar loss rate and further future improvement will be presented.