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SYMPOSIUM ON STEPPING STONES TO THE FUTURE: STRATEGIES, ARCHITECTURES, CONCEPTS AND TECHNOLOGIES (D3)
Novel Concepts and Technologies for the Exploration and Utilization of Space (2)

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MASS ATTRACTION EFFECTS FOR DRAG-FREE SATELLITE

Abstract

A scientific satellite that is guided in a drag-free orbit by a shielded free-falling proof mass could be used to make precise measurements in geodesy and might be good enough to performance the experiments to test general relativity. Protected inside the satellite, the proof mass is shielded from atmosphere drag and solar radiation pressure; and, in the ideal case when the effects of other disturbing forces are negligible, the proof mass will follow a purely gravitational orbit. The only disturbing forces that can act on the proof mass will arise from the satellite itself or from any interactions that can penetrate the shield. Forces due to the satellite can arise from mass attraction, stray electric and magnetic fields, and the interactions of the position sensor. However, the effects of mass attraction are the most serious disturbances which cause the proof mass drifts away from the purely gravitational orbit and difficult to be reduced. In the ideal situation that the outer satellite has a homogeneous density and is distributed completely symmetric about the proof mass, the mass attraction should vanish. However, this can not be achieved in practice. Meanwhile, there will be temperature dependence distortion of the outer satellite and relative translation between the outer satellite and the proof mass in space, which will cause additional mass attraction disturbances. There are several challenges in modelling and controlling these disturbances. This paper addresses the problem of analysis and control of the mass attraction for drag-free satellites. Firstly, the geometry factor is defined to evaluate the mass attraction; and, a numerical method and programmes to compute the effects are given. It indicates that moving the disturbing masses far away is an available solution and a large cavity is needed. Then a compensation scheme to reduce the mass attraction effects to values within requirements follows. When taking an experiment package as example, the approximate shapes of compensation block which minimizes the residual gravitational imbalance while adding a minimum of mass can be obtained. To achieve the ideal design in the manufacture and assembly procedure, the criterion of technical precision is calculated. Finally, the method of measuring and reducing the temperature dependence distortion of the structure is presented.