Gravitational quadrupolar coupling and center of gravity: application for Drag-Free Satellites

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The motivation of this work is the refinement of modelling of a Drag-Free Satellite (DFS) for improvement of the disturbance reduction system, a so called Drag-Free Control (DFC), and for the improvement of the data analysis. Drag-Free Satellites are missions on fundamental physics as well as geodesy. They measure accelerations on a very small scale. Especially for the satellites planned for fundamental physics, the level of acceleration to be measured is in the range of 10e-15 to 10e-18 m/sˆ2. Because of that, any disturbance and misalignment should be modelled. Due to the gravity gradient for most extended bodies the center of gravity deviates from the center of mass. This results in a gravity gradient torque on satellites as well as on the test masses which depends on the attitude with respect to the gravity gradient. In addition, the gravity force is also attitude dependent. This paper describes this gravity gradient force acting on arbitrary bodies for higher orders of the inertia moments. It shows also the influence of the quadrupolar gravitational coupling to the Earth gravity field. An equation is developed that determines the center of gravity in the body frame. It provides a visualization of the deviation of the center of gravity from the center of mass. In order to evaluate the significance of this effects, values are computed for several fundamental physicals missions (e.g. GRAVITY PROBE B and STEP).