Dynamics Modeling and First Design of Drag-Free Controller for ASTROD I

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The Astrodynamical Space Test of Relativity using Optical Devices I (ASTROD I) mainly aims at testing relativistic gravity and measuring the solar-system parameters with high precision, by carrying out laser ranging between a spacecraft in a solar orbit and ground stations. It is the first step of ASTROD with 3 spacecraft. In order to design the Drag-Free and Attitude Control system (DFACS) for the spacecraft a numerical simulator of spacecraft and test mass dynamics as well as models of main forces and torques are established using Matlab/Simulink.

The aims of the DFACS are to reduce the acceleration disturbance on the test mass to a level of $10^{-13} m \cdot s^{-2} \cdot Hz^{-1/2}$ at a frequency of 0.1 mHz in one axis and keep the telescope pointing to the ground stations on the earth. The dynamics of spacecraft and test mass is a coupled multiple degree of freedom non-linear system. So the first step of the DFACS design is to reduce the order of the system with assumptions without loss of generality. Then the system is linearized at nominal state. With the linear state space model of the system a Linear Quadratic Gaussian Regulator (LQG) is derived. LQR and the feed-forward of a constant disturbance constitute the controller.

This paper will present the numerical simulator and the first drag-free controller design for ASTROD I. It will show the development of the simulator, the derivation of the controller as well as first simulation results.