ASTRODYNAMICS SYMPOSIUM (C1)
Attitude Dynamics and Control (9)

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NEW METHODS FOR ACCURATE THERMAL DISTURBANCE FORCE CALCULATION WITH APPLICATION TO PIONEER AND FLYBY ANOMALY

Abstract

The exact modeling of external and internal perturbations becomes increasingly important for current and future space missions which have high requirements on disturbance knowledge. The simulation of perturbations which are caused by thermal effects are particularly challenging because the optical properties of spacecraft surfaces can change during the mission due to exposure to the space environment. At ZARM (Center of Applied Space Technology and Microgravity) algorithms for the simulation and analysis of thermal perturbations have been developed. These codes include the simulation of the thermal recoil force (waste heat dissipation), Earth Albedo influence as well as Solar radiation pressure. The simulations are based on a detailed model of the spacecraft geometry which is exported from a thermal Finite Element analysis. If the analysis is conducted for an already flown mission, housekeeping and sensor data can be included thus acquiring a thermal temperature/heat flow map based on real measurement data. The environment is also included as Finite Element boundaries based on the mission profile. The results of the analysis and the geometry can be exported into the disturbance algorithms where raytracing methods are applied to compute the resulting disturbance forces. As an example the computation of the thermal dissipation recoil force will be shown for the Pioneer 11 spacecraft in detail and the results will be evaluated with respect to the Pioneer anomaly. The main challenges of the thermal modeling process (such as the simulation of the louver system and the radio isotopic generators) and lessons learned will be provided. In addition, a short outlook on the influence of geometry-based disturbance modeling on the Flyby-anomaly will be given. The conducted analyses show that in particular for fundamental physics missions with high requirements on attitude and orbit knowledge (such as LISA, LISA pathfinder, MICROSCOPE) the exact modeling of thermal perturbations is a key issue for the calculation of accurate disturbance budgets.