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TITLE

Estimation of the Electrostatic Effects in the LISA-Pathfinder Critical Test Mass Dynamics via the Method of Moments

AUTHORS

Carlo Zanoni

National Institute of Nuclear Physics (INFN), TIFPA Center, Trento, Italy and Department of Industrial Engineering, University of Trento, Italy.

Daniele Bortoluzzi

Department of Industrial Engineering, University of Trento, Italy and National Institute of Nuclear Physics (INFN), TIFPA Center, Trento, Italy.

Davide Vignotto

Department of Industrial Engineering, University of Trento, Italy and National Institute of Nuclear Physics (INFN), TIFPA Center, Trento, Italy.

ABSTRACT

LISA-Pathfinder is an ESA space mission flown between 2015 and 2017 to demonstrate a technological maturity sufficient for building a gravitational waves telescope in space, such as the Laser Interferometer Space Antenna (LISA). A pair of cubic test masses is hosted inside the LISA-Pathfinder spacecraft and shielded from any force other than the interplanetary gravitational field. The purity of the shielding gives the performance of the mission.

There are a number of aspects that had to be confirmed in-flight. One of them is the transition phase from the launch configuration, when the test masses are locked, to the science free-falling configuration. Each test mass is initially released from the mechanical constraints via a dedicated mechanism and then captured by an electrostatic control system. In fact, each test mass is surrounded by a set of electrodes for actuation and sensing purposes. The performance criterion of the release is the final velocity of the test mass relative to the spacecraft, with an upper threshold set to 5 μm/s. The LISA-Pathfinder first in-flight release velocities highlighted an unexpected dynamics with large linear and angular velocities. The electrostatic control was successful, but only relying on a manual procedure that cannot be considered as baseline for LISA.

This paper helps investigating the in-flight non-compliance by dealing with the modeling of the electrostatic environment around each test mass and its contribution to the release and capture dynamics. The electrostatic model is based on the method of moments, a boundary element numerical technique suitable for estimating forces and capacitances between conductors. We also provide a short overview of the method, which can be used for the analysis of other phenomena within LISA and for the design of future gravitational waves telescopes and space projects.

CITATION

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