Contribution ID: **28** Type: **Contributed talk**

Assessing the impact of metallic adhesion on the injection function of a proof mass into a geodesic trajectory

Wednesday, 2 October 2024 12:00 (20 minutes)

The design of Gravitational Reference Systems (GRS) heavily hinges on the technologies developed, such as the mechanisms in charge of securing a reference test mass (TM) during the mission launch and then releasing it into free fall.
Such mechanisms need to be tested to ensure they minimize friction, adhesion, and fretting at the contacting surfaces, since space environment provides critical conditions for cold-welding phenomena, especially with the requirements of gravitational wave science.

The case of study here dealt with analyzes the quick separation of two gold surfaces in the frame of the LISA Pathfinder (LPF) flight-tested GRS.
The mission initialization depends on the performance of a mechanism in the release of a TM into a geodesic trajectory, minimizing the residual velocity with respect to the spacecraft.
The presence of adhesion between the metallic surfaces of the release mechanism end-effector and the TM constitutes a limiting factor for the injection function, proving to be a key factor influencing the TM net residual velocity.

The experimental characterization of the momentum produced by the rupture of adhesive bonds at the separation of two metallic surfaces is a complex research activity involving system dynamics, experimental design, measurement techniques, and the modeling and measurement of mechanical vibrations. Moreover, the accurate prediction of the adhesion momentum poses a significant technological challenge since existing models in the literature fall short of providing a dependable prediction.

Therefore, at the University of Trento, a dedicated experimental facility has been developed to assess the impact of adhesion on the injection function.
The testing facility is based on a sensing body suspended in a nearly free-fall condition as a pendulum inside a vacuum chamber.
Usually, the pendulum swing mode response constitutes the main observable for the estimation of the impulse, i.e. the time integral of the adhesion force time history up to the rupture of the bonds. In this research, the observable quantities correlated to the adhesion impulse characteristics are extended to the vibration modes of the suspended body of the pendulum, where the impulse is applied.
The proposed approach aims at developing a novel techniques based on analytical and experimental methods to measure the adhesion momentum transferred to the TM at the release.
The technique combines a numeric finite element model of the suspended pendulum, a dedicated symbolic dynamic model of its motion and a fitting procedure, improving the overall estimation performance. The multiplicity of the outputs (amplitudes of vibration) produced by the same input (adhesion impulse) is exploited to characterize additional properties of the impulse, i.e. not only the adhesion force time integral but also the impulse time duration.
This enhanced characterization approach provides valuable insights into the influence of adhesion on the injection function of a proof mass into geodesy, facilitating a deeper understanding of the adhesive bonds dynamical properties.

Primary author: DALLA RICCA, Edoardo (Università di Trento)

Co-authors: Dr ZANONI, Carlo (Istituto Nazionale di Fisica Nucleare); BORTOLUZZI, Daniele (Università di Trento)

Presenter: DALLA RICCA, Edoardo (Università di Trento)

Session Classification: Other challenges for future GW detectors

Track Classification: Other challenges for future GW detectors