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SPACE DEBRIS SYMPOSIUM (A6)
Hypervelocity Impacts and Protection (3)

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DEVELOPMENT OF AN IMPLOSION-DRIVEN HYPERVELOCITY LAUNCHER FOR ORBITAL DEBRIS AND MICROMETEOROID SIMULATION

Abstract

The ability to launch intact and well-characterized projectiles with masses of up to 10 g to velocities exceeding 10 km/s is required to fully reproduce, in a laboratory setting, the grave threat posed by orbital debris and micrometeoroids to all spacefaring operations. Uncertainties in material properties and dynamic phenomenon at these speeds prevent the computational simulation of impacts in the absence of verification data, motivating the need for a laboratory-scale launcher. The 10 km/s velocity requirement exceeds the capabilities of conventional light gas guns. In order to launch projectiles to these velocities, a novel hypervelocity launcher has been developed that uses explosively driven implosion of the launcher to drive very high pressures in the helium propellant gas. The projectile is cushioned by the helium from direct contact with the explosives and experiences sustained accelerations comparable to the peak accelerations in conventional gas guns. The explosively-driven imploded tube, filled with helium, replaces the pump tube of a conventional light gas gun. Advanced implementations of the concept continue the explosive "pinch" along the launch tube behind the projectile, in order to maintain the driving pressures to very high velocities. Use of explosive lensing techniques permit the phase velocity of this pinch to be set arbitrarily high (velocities of 14 to 20 km/s have been demonstrated). The gasdynamic operation of the launcher is simulated in this study using the unsteady method of characteristics with variable entropy and area change. The method takes into account several non-ideal effects unique to the implosion-driven launcher, including significant radial expansion of the launch tube walls due to the extreme pressures generated. This model has successfully reproduced the performance of experimental implementations of the implosion launcher using projectiles in the 0.4 g to 10 g mass range and can be utilized to identify the important design parameters that must be optimized in the design.