

Optical Flash Expansion Geometry in Hypervelocity Impact Events

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Abstract

Space environment conditions such as background plasma and presence of neutral species from space weather events can setup spacecraft conditions which can amplify the threat from hypervelocity impacts. Hypervelocity impactors, Meteoroids and orbital debris, travel between 7 to 72 km/s in the solar system. When they impact onto the spacecraft, their high kinetic energy will be converted into energy of ionization and vaporization within a very brief timescale, and result in a small and dense expanding plasma with a very strong optical flash. The radio frequency (RF) emission produced by this plasma can lead to electrical anomalies within the spacecraft and cause catastrophic system failure within the spacecraft. During the impact, a very strong impact flash will be generated. By studying the geometry of the optical flash, we hope to study the impact generated gas cloud/plasma properties, and advance our understanding of the hypervelocity impact events.

The impact flash emitted from a ground-based hypervelocity impact test is long expected by many scientists to contain the characteristics of the impact generated plasma, such as plasma temperature and density. In this paper, we present a study that correlates the impact flash expansion geometry with the external electric field and the impact generated plasma. The time-resolved optical emission is measured by three photomultiplier tubes in both an electrostatic dust accelerator and a light gas gun facility. The impact target is a thin tungsten film, and it will be charged to various potential to simulate the spacecraft charging conditions in orbit. High speed imaging stereo cameras are also used in the light gas gun facility to capture the evolution of the impact flash. The optical emission expansion geometry (the optical cone) is found to be dependent on the external electric field direction around the impact target and the expanding plasma condition. For biased target, the optical expansion cone exhibit a stronger directionality corresponding to the external electric field and shows a narrower optical cone. For grounded target, the optical expansion cone is wider and less dependent of the external electric field direction.