Experimental Observation and Computational Modeling of Hypervelocity Impacts with Emphasis on Plasma Formation and its Consequences

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In experiments performed at the NASA Ames Vertical Gun Range (AVGR), optical and radiofrequency electromagnetic emissions, plasma formation and electrostatic charge separation during hypervelocity impact have been characterized for a variety of impactor and target geometries. While being investigated as potentially diagnostic of an event, such effects could also interfere with communications or remote sensing equipment if an impact occurred on a satellite. The highly conducting plasma could act as a current path across normally shielded circuits, potentially leading to satellite loss.

In the AVRG experiments, early time solid debris ejected from the impact site are negatively charged and impact-generated plasma, late-time ejecta and materials left in the transient cavity are positively charged. Charge separation can lead to large electrostatic fields with implications for dust motion, especially in low gravity environments. The motion of charged ejecta can create transient magnetic fields. The experiments demonstrate that total charge separation is a function of impactor kinetic energy with a near linear mass dependence and velocity dependence proportional to $v^{2.6}$.

CTH is a Sandia developed, well validated, Eulerian, multi-material, computational hydrocode designed to treat a wide range of shock propagation and material motion phenomena in one, two, or three dimensions. Adaptive mesh refinement is available for maximizing resolution in regions of interest. CTH has models suitable for most conditions encountered in hypervelocity impact including material strength, fracture and multi-state materials, including plasma. It has been used extensively in hypervelocity impact studies at laboratory and large scale. Computational studies using CTH have shown that a simple two dimensional model based on electrostatic probe theory can match experimentally observed plasma and electrostatic charge separation. We are extending the CTH model to three dimensions to improve our ability to predict plasma formation and charge separation under more general circumstances.

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