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SHAPE EFFECT MODEL FOR HYPERVELOCITY IMPACTS

Abstract

The response of spacecraft components and protections is normally evaluated with hypervelocity impact tests and numerical simulations, that usually employ spherical projectiles to represent the debris environment. Such impactors are adequate for most of the small meteoroids and for part of the artificial debris population but could be inadequate for many fragmentation debris of irregular shape. The space community is showing interest on this topic, as current damage models could lead to inaccurate predictions if impactors significantly deviate from the spherical shape.

In this context, this paper describes an engineering model for shape effects in hypervelocity impacts. The model is based on sensible geometric assumptions which describe the shape of craters excavated on semi-infinite targets after impact with projectiles having spherical, oblate or prolate shapes. The crater model parameters are tuned using dedicated hydrocode simulations and then extended to oblique impacts. The model is compared with literature data, showing good agreement in predicting craters shape and size. In the second part of this paper, the model is extended to thin plates, and the influence of target thickness on the crater morphology is discussed; predictions on both target perforation and debris cloud features are validated with dedicated simulations.

Finally, the shape effect model is implemented in the "Collision Simulation Tool" (CST) semi-empirical tool for spacecraft collision. Thanks to the use of the model described in this paper, a campaign of numerical simulations with CST is described to investigate the response of a Whipple Shield to the impact of projectiles having different shapes; results calculated by the software are compared with experiments derived from literature.