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SENSITIVITY ANALYSIS OF ASTEROID EJECTA MODELS FOR FUTURE IN-ORBIT SAMPLE COLLECTION MISSION

Abstract

Asteroids carry fundamental information on the evolution of our Solar System. They are rich in valuable resources, which could be exploited through future asteroid mining missions, and enable long-duration mission self-sustaining. Our knowledge of the physical composition of asteroids can be significantly improved collecting and studying their samples, thus better targeting asteroids for material exploitation or increase the efficiency of asteroid deflection missions. One of the most challenging aspects of scientific missions at asteroids is to collect and sample asteroids material by means of an on-ground collection, involving landing (or touchdown) and mining. In a context of future asteroid exploration missions, within the Collecting Asteroid-Orbiting Samples - CRADLE project, funded by the Horizon 2020 MSC Actions, we envision the possibility to perform in-orbit collection as an alternative to landing or touchdown operations.

This work presents the development of a statistical ejecta model by means of probability density functions. These distribution functions are used to model the ejecta in terms of particle size, launch location, ejection velocity, and ejection direction, to model the outcome of an impact of a small kinetic impactor onto asteroid surfaces. The model is general and encompasses oblique impacts. The parameters defining the models are determined by the characteristics of the target and the impactor and are computed based on experimental correlations and conservation laws.

As the aim of the CRADLE project is to verify the collectability of particles generated by small kinetic impactors, it is important to understand the sensitivity of the ejecta models from both the impact conditions and the modelling assumptions. In this work, we will study the sensitivity of the fate of the ejecta in terms of residence time and particle density around the asteroid, as well as the percentage and distribution of impacting particles. We will consider modelling parameters such as the types of distributions used (e.g., Gaussian and uniform distributions for the ejection angle), and impact conditions, such as the type of target, the impact location, and the impact angle. A discussion of the results based on their relevance for in-orbit particle collection is given.