IAF ASTRODYNAMICS SYMPOSIUM (C1)
Orbital Dynamics (1) (6)

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EJECTA DYNAMICS AROUND ASTEROIDS IN VIEW OF IN-ORBIT PARTICLE COLLECTION MISSIONS

Abstract

Space exploration missions to asteroids have always drawn the attention of the scientific and engineering community given the challenges they pose and the possibility they present to further our knowledge of the Solar System. Asteroids carry fundamental information on the evolution of our Solar System. They are rich in valuable resources such as metals, silicates, and water, which could be exploited through future asteroid mining missions, and enable long-duration mission self-sustaining. The physical composition of asteroids is varied and, in most cases, poorly understood; it can be significantly improved collecting and studying their samples. Improving our knowledge, we can better target asteroids to be exploited and increase the efficiency of asteroid deflection missions. Several missions have visited asteroids and other small bodies; however, only few have orbited, landed, or impacted on them. Examples are JAXA missions Hayabusa and Hayabusa2, ESA Rosetta, and NASA OSIRIS-REx. One of the most challenging aspects of such missions 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, we envision the possibility to perform in-orbit collection as an alternative to landing or touchdown operations. Such a collection mechanism relies on the knowledge of the dynamical behaviour of small particles orbiting the asteroid, which is influenced by the third body effect, solar radiation pressure and the gravitational potential of the asteroid. This paper explores the evolution of the small particles around asteroids in the context of the circular restricted three body problem. The ejection of the particles from the surface of the asteroid is obtained via a small kinetic impactor, which is modelled as a modified version of the NASA Standard Break-up Model adapted to asteroid impacts to obtain the distribution of the particles' ejection velocity and area-to-mass ratio. Given that the dynamical evolution of such particles is influenced by their size and ejection velocity, the aim of this work is to study how this is influenced by different types of impactor and impact sites. Particularly, if the particles can be temporary captured around the asteroid and is there are regions favourable for the in-orbit collection given the combination of particle size and energy. The artificial impact performed during the Hayabusa2 mission about asteroid Ryugu will serve as the baseline test case for the present work.