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EFFECTS OF PRIMARY SHADOWING ON ASTEROID EJECTA CAPTURED INTO PERIODIC ORBITS

Abstract

The exploration of small bodies in our solar system is of great interest for the planetary science community due to their high scientific value. Close-proximity operations around small bodies can be extremely challenging due to their highly uncertain dynamical environments. Furthermore, recent missions indicate that surface activity and ejecta can exist for both asteroids and comets, thus increasing the uncertainty and risks. In recent years there has been a significant amount of work investigating ejecta from natural sources and man-made impacts on small bodies. However, few studies have looked at the low-velocity portion of the ejecta population and the combined effects of gravity, solar radiation pressure (SRP), and thermal radiation pressure (TRP) (McMahon et al., JGR 2020).

Previous work indicates that the fate of ejecta is strongly controlled by the effects of SRP. Further, for low-altitude particles, shadowing from the primary body and TRP forces can also have a strong effect. In particular, these perturbations can lead to changes in orbital energy as the particles traverse different regions of the primary body. In previous work (Villegas-Pinto et al., AIAA SciTech 2020), it was demonstrated that the stability and geometry of orbit families change when including the effects of eclipses in the case of the asteroid Ryugu.

In this work, the equilibrium points and associated periodic orbits in which asteroid ejecta can be captured will be studied making use of the polyhedral gravity model. For many small bodies, the equilibrium points tend to exist near the equator; a region where shadowing from the primary body may occur. Additionally, in the case of fast rotators, the equilibrium points can be located at very low altitudes. Therefore, eclipses are likely to happen and can cause a significant perturbation to the particles whose trajectories cross these regions. The asteroid Bennu possesses these characteristics and will be used as our test case.

This work aims to further examine and understand the existence and stability of equilibrium points and periodic orbits in the presence of SRP with shadowing and TRP. The ejecta particles will be modeled as spheres of constant density and have material characteristics equal to those of the asteroid. Further, different fidelity eclipse models will be used to assess the importance of shadowing effects on SRP force modeling. Specifically, the shadowing algorithm will be based on using a high-fidelity shape model compared to approximate limbs of the body to solve the ray-tracing problem.