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# Surface Motion Relative to the Irregular Celestial Bodies

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**Abstract**. We study the motion and equilibria of the grains on the surface of the irregular celestial body (hereafter called irregular bodies). Motions for the grains on the smooth and unsmooth surfaces are discussed, respectively. The linearized equations of motion relative to a surface equilibrium point and its characteristic equations are presented. Considering the stick-slip effect, the damping forces and the spring forces for the grain are calculated, then the linearized equations of motion and the characteristic equations relative to the surface equilibrium points are derived. The number of non-degenerate surface equilibria is an even number. We compute the motion of a grain released above three different regions relative to the irregular asteroid 6489 Golevka, including the flat surface, the concave region, and the convex region. Following the grain release and initial bounce, three kinds of motions exist: the orbital motion, the impact motion and the surface motion. We find that the maximum height of the next hop may be bigger than the maximum height of the current hopping. We also used Monte Carlo simulations to calculate 100 grains' hopping motions, the results shows that the stable surface equilibria are on the concave region and flat surface of the asteroid.

**Key words**: Asteroid; Comet; Grain; Surface motion; Impact motion; Equilibria



## 1. Introduction

Previous work have studied the physics and chemistry character of the surface grain and dust, such as the dust grain's electrostatic and rotational ejection from the cometary nucleus (Oberc 1997) and the mineralogy and mineral chemistry of the asteroid's dust particles (Nakamura et al. 2011). The motion of grain and dust can be caused by the YORP effect (Fahnestock and Scheeres, 2009), the windmill effect