Core Sampling on Phobos: A Numerical Study

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To provide better understanding the Martian formation and origin of the moons, spacecraft missions to Martian moons have been considered by the scientific and engineering community. JAXA is currently planning a sample return mission that will reach the surface of Phobos for the first time in history, aiming for launch early 2020's. The mission is known as the "Martian Moon eXplorer" (MMX). In this mission, it is planned to obtain a core sample of Phobos regolith using the Core Sampler (C-Sampler). It will penetrate the surface of Phobos and attempt to sample regolith up to 10 cm below the surface. Though core samplers are widely used in deep sea surveys and other applications on the Earth, their performance in a low-gravity environment such as Phobos is unknown. We try to estimate their performance in the environment different from the Earth's gravity by performing simulations, using PKDGRAV. We study how much the core sampler can penetrate the Phobos surface.

In order to better constrain the possible behavior of MMX's C-Sampler in the Phobos environment, we have conducted numerical simulations of the interaction of the C-Sampler with the regolith surface of Phobos. We use pkdgrav, a parallel N-body code, which simulates the regolith surface of Phobos using spherical particles, and contact dynamics with a soft-sphere discrete element method (SSDEM). This allows us to model multi-contact and frictional forces using dissipative and frictional parameters that allow us to mimic the behavior of angular and rough particles of the Martian moon. The C-sampler is modeled as a rigid body made up of a combination of simple geometric shapes in the pkdgrav environment that can interact with spherical particles through SSDEM.

Our strategy is to first calibrate our simulations with laboratory experiments of the C-Sampler penetrating a bed of Phobos simulant in Earth gravity. This will allow us to verify that the simulation parameters accurately represent Phobos simulant. Once we have an accurate set of dissipative and friction parameters, we reduce the gravity in our simulation to Phobos levels and study the change in the sampling dynamics. In particular, we study how the change in the gravity might alter the jamming transition of the regolith particles. Furthermore, we study the effect of inter-particle cohesion in the low-gravity environment, as the relative strength of cohesive bonds is expected to become dominant in low-gravity.
While the actual mechanical properties of Phobos regolith is still poorly constrained, our simulations show the range in possible behaviors of the regolith and the outcome of sampling attempts for a range of likely Phobos regolith properties and sampling conditions.

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