Interacting with granular materials on asteroid and small-body surfaces

Cecily Sunday\textsuperscript{a,b,*}, Naomi Murdoch\textsuperscript{a}, Simon Tardivel\textsuperscript{c}, et Patrick Michel\textsuperscript{b}

\textsuperscript{a} Institut Supérieur de l’Aéronautique et de l’Espace (ISAE-SUPAERO), 10 Avenue Edouard Belin, 31055, Toulouse, France
\textsuperscript{b} Université Côte d’Azur, Observatoire de la Côte d’Azur, Centre National de la Recherche Scientifique (CNRS), Laboratoire Lagrange, 96 Boulevard de l’Observatoire, 06300, Nice, France
\textsuperscript{c} Centre National d’Études Spatiales (CNES), 18 Avenue Edouard Belin, 31400, Toulouse, France

* email: cecily.sunday@isae-supaero.fr

Small-bodies, such as asteroids, comets, and moons, can be covered by a layer of loose grains, referred to as regolith \cite{1}. The shape and size distribution of the surface grains can vary drastically from one body to another, and the material properties of the grains are often unknown. The low-gravity found on small bodies coupled with the surfaces’ unknown material properties makes it difficult to predict and understand the macroscopic behavior of the regolith. Fortunately, recent missions like OSIRIS-REx (NASA) and Hayabusa2 (JAXA) have provided us with new and fascinating insights into this problem \cite{2, 3}.

The OSIRIS-REx sampling mechanism met little resistance when it touched down on the surface of the asteroid Bennu \cite{2}. In contrast, the MASCOT rover deployed by the Hayabusa2 spacecraft rebounded several times off of the surface of the asteroid Ryugu \cite{4}. Though surprising, the fluid-like response of Bennu’s surface and the rebound of the MASCOT rover are not completely unexpected. In this talk, we discuss how granular materials behave differently under terrestrial and low-gravity conditions. We use results from drop-tower experiments \cite{6} and Discrete Element Method numerical simulations \cite{7} to show how landing and sinking behavior for varied gravity levels compares with predictions from existing phenomenological collision models \cite{7, 8}. Finally, we present the implications of our findings in the context of several upcoming small-body missions.

\cite{3} Arakawa et al. Science, 368, 67 (2020).

\textbf{Figure 1}: (a) The MASCOT lander approaching the surface of Ryugu (DLR/CNES/JAXA), (b) the OSIRIS-REx sampling mechanism approaching the surface of Bennu (NASA/Goddard/University of Arizona), (c) an artist rendition of a rover on the surface of Phobos as part of the planned Martian Moons eXploration mission (CNES/DLR/JAXA).