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PhD position @ ISAE-SUPAERO

Interacting with diverse planetary surfaces

Thesis advisor: Naomi Murdoch (ISAE-SUPAERO, Toulouse)

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Scientific domains: Planetary science, Geotechnical Engineering, Physics of granular materials

Expected start date: September to November 2024

Deadline for applications: Applications will be accepted until the position is filled.

Application process: Candidates should contact the PhD supervisor with a letter of motivation and CV. Please include the contact details of two referees. There is also a possibility for the student to complete a 6-month Masters-level internship on this project before starting the PhD.

Summary: Given the growing number of space missions involving interactions with regolith covered planetary bodies, knowledge about how the extra-terrestrial surface materials behave is increasingly important for robotic and human planetary exploration. Planetary scientists also need this information to correctly interpret the observed behaviour of planetary surfaces. The extra-terrestrial environment provides a significant challenge for understanding the behaviour of granular materials (soils or regolith). The gravitational acceleration varies over several orders of magnitude from Earth to asteroids, the smallest targets of planetary exploration. This changes the weight (normal stress) applied by an object on the planetary surface and influences the behaviour of the grains themselves. Frictional properties (shape and roughness) of surface materials are expected to vary drastically due to the different regolith formation and evolution mechanisms at play: comminution and thermal fracture produce very angular grains whereas aeolian processing and saltation lead to much rounder particles. Differences in grain-grain surface friction, the grains' shapes, geometrical interlocking, and size distribution will all influence the resistance of a grain to movement and affect the behaviour of the material.

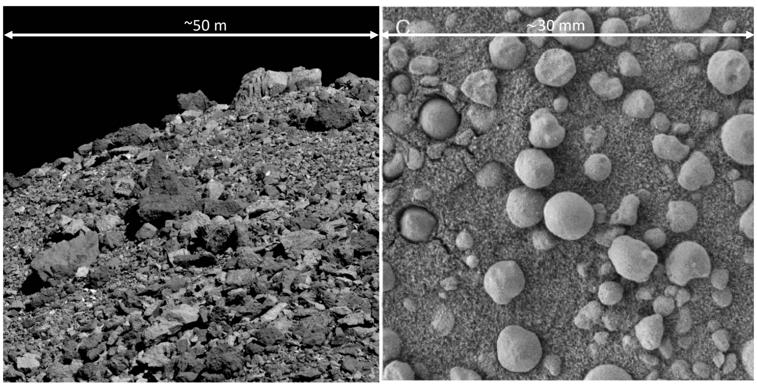

Figure 1. Left - Particles on surface of asteroid Bennu, Image Credits: OSIRIS-Rex/NASA/Goddard Space Flight Center/University of Arizona. Right – Particles on the surface of Mars, Sullivan et al., (2011).

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The goal of this thesis is to further our understanding of the response of diverse planetary surfaces to penetration testing. The thesis will involve terrestrial and low-gravity experiments using a new facility that is currently under construction at ISAE-SUPAERO, and will also make use of Discrete Element Method (DEM) simulations (e.g., Sunday et al., 2020, 2021). The results are directly relevant to the upcoming ESA Hera and JAXA MMX space missions.

The specific tasks of the thesis will be to contribute to the design of an experiment to be used with the new experimental facility, to generate a unique database of experimental data, to analyse the experimental data to understand the complex roles of material parameters and gravity, and to perform DEM simulations to complement the experimental analysis.

The student will be part of the Space Systems for Planetary Applications (SSPA) team at ISAE-SUPAERO. The team is primarily focussed on the development of space missions and the associated technologies for the geophysical exploration of the Solar System. This PhD thesis will be funded through the ERC GRAVITE project.

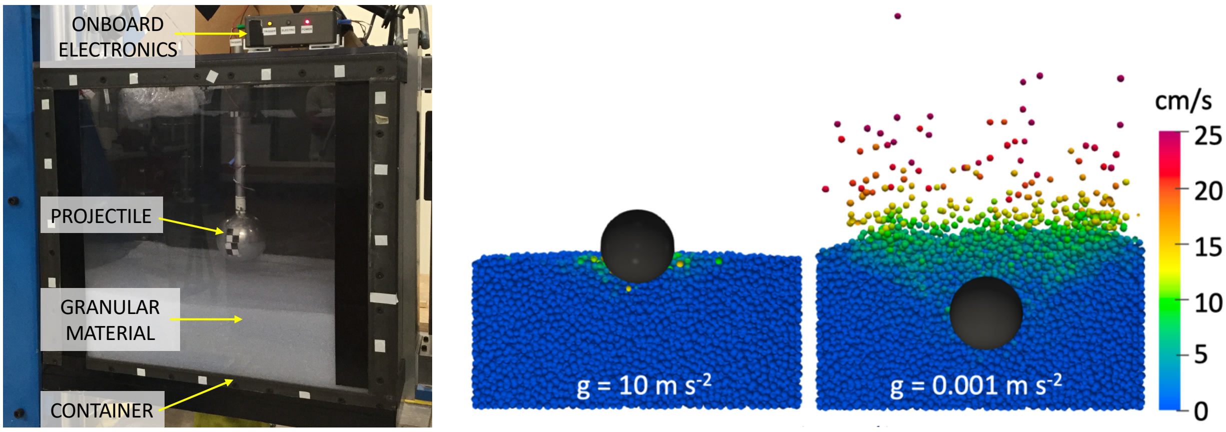

Figure 2 : Left - An experiment container used in the previous experiments at ISAE-SUPAERO (Murdoch et al., 2017, 2021). Right - Numerical simulations of penetration experiments in different gravity levels. The penetration velocity is the same in both cases (1 m/s), but the resulting behaviour is very different (Sunday et al., 2022).

Desired Profile: Candidates should have a Masters-level degree (or be in the final year of a Masters degree) ideally in geotechnical engineering, planetary science or physics but other backgrounds will also be considered. The candidates should be rigorous, autonomous and also enjoy working as part of a small team. Previous experience in experimental work and/or DEM numerical simulations would be an advantage.

References: *Murdoch et al., (2017) MNRAS 468, 2, 1259–1272; Murdoch et al., (2021) MNRAS 503, 3460–3471; Sullivan, R. et al., (2011) Journal of Geophysical Research: Planets, 116(E2); Sunday et al., (2020) MNRAS 498, 1062–1079; Sunday et al., (2021), Astronomy & Astrophysics ; Sunday et al., (2022), Astronomy & Astrophysics.*