PhD position @ ISAE-SUPAERO

Seismic propagation in planetary regoliths

Thesis advisors: Naomi Murdoch (ISAE-SUPAERO, Toulouse), Ludovic Margerin (IRAP, Toulouse)

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

Expected start date: September to November 2025

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

Application process: Candidates should contact the PhD supervisors with a letter of motivation and CV. Please include the contact details of at least two referees.

Summary: On Earth seismic sounding is commonly used as a non-destructive method for geophysical surveys. Since the beginning of planetary exploration, surface-based seismic sounding has also been considered a key technique for understanding other planetary bodies (Fig. 1). However, the extra-terrestrial environment provides a significant challenge for understanding the behaviour of seismic propagation in 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 (Fig. 2). 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.

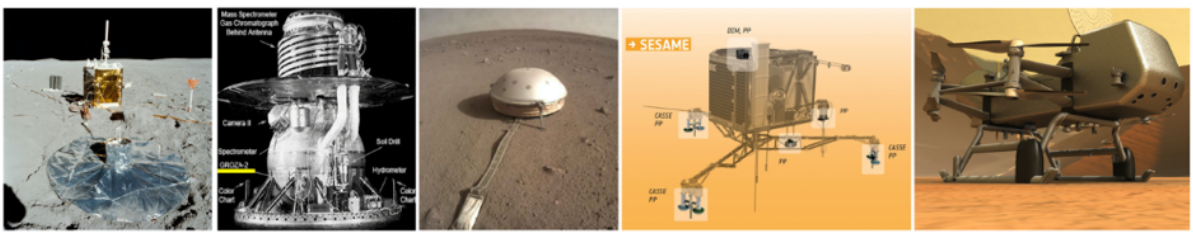

Figure 1: Interplanetary seismometers. From left to right: Apollo 16 Passive Seismic Experiment, Venera 13 with the Grozo 2 seismometer, InSight seismometer SEIS, schematic of Philae showing the locations of the CASSE sensor, and an artist's impression of Dragonfly with its ventral seismometer deployed.

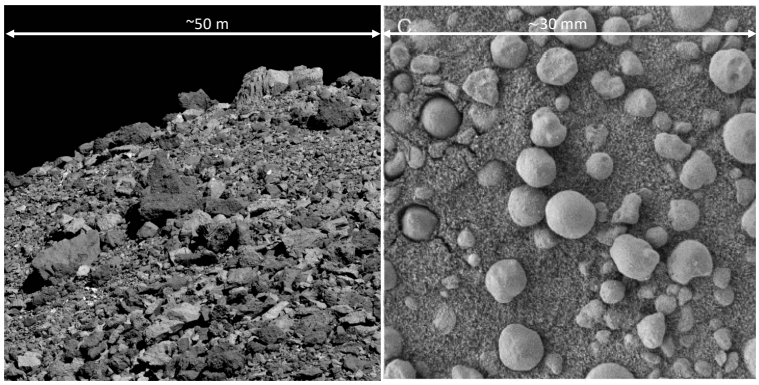

Figure 2. Left - Particles on surface of asteroid Bennu, Image Credits: OSIRIS-Rex/NASA/Goddard Space Flight Center/University of Arizona. Right – Particles on the surface of Mars, Sullivan et al., (2011).

The goal of this thesis is to study seismic propagation in diverse granular materials under varying gravitational conditions. The thesis will involve terrestrial experiments and also low-gravity experiments using a new facility that is currently under construction at ISAE-SUPAERO. The results are directly relevant to the ESA Hera and RAMSES space missions.

The specific tasks of the thesis will be to contribute significantly to the design and implementation of an experiment to be used with the new experimental facility, to generate a unique database of experimental data, and to analyse the experimental data to understand the complex roles of material parameters and gravity in seismic propagation.

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.

Desired Profile: Candidates should have a Masters-level degree (or be in the final year of a Masters degree) ideally in geotechnical engineering, geophysics, 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 signal processing would be an advantage.