Postdoc position

Context and goals of the position

Reconnaissance, Origin, & Characterization of Small bodies of our Solar System - Uncovering the nature of celestial bodies with methods of material sciences

A key challenge for solar system science is to establish a comprehensive understanding of the variety of processes that create, evolve, and shape the surfaces of small bodies. Recent development of numerical methods dedicated to High Performance Computing (HPC) in materials science will be used to this purpose. The challenge will be to treat the heat transfer in a multi-scale granular medium laid out on the complex, rough surfaces of asteroids (see Figure 1). **This study will be for the NASA's space mission OSIRIS-REx, which is on its way to meet the asteroid 101955 Bennu and return a sample of its regolith back to Earth**.

This project will lead to a new approach to the study of the surfaces of nearby celestial objects. Asteroids are like time capsules, allowing us to study the most pristine materials, including life-precursor organic molecules and water, from which the planets formed 4.5 Ga. Additionally, NEAs represent an important resource for mining rare minerals and for future human space exploration (e.g. NASA's ARM - Asteroid Retrieval Mission). NEAs can also impact Earth, as recently demonstrated by the fall of the Chelyabinsk asteroid that injured more than 1,500 people. This study will also help the interpretation of observations of asteroids in the thermal infrared in general, for instance those obtained by NASA's WISE satellite.

These topics call for an understanding of a largely unexplored set of physical quantities (thermal inertia, roughness, regolith size, rock abundance) related to the nature of the surfaces of asteroids, which are still poorly understood. This is extremely important for the OSIRIS-REx mission. Its science team will take decision about the sampling site with the aid of thermal measurements interpreted in terms of regolith properties, such as abundance, grain size, and presence of rocks hazardous for spacecraft touch down. The main parameter that is determined from thermal measurements is the thermal inertia of the soil. Thermal inertia measures the resistance of a material to temperature changes. Thermal inertia is derived from the analysis of asteroids thermal infrared observations applying the so-called thermophysical models (TPMs) in which thermal inertia is a parameter directly fitted to the data.

The main purpose of this project will be, thanks to a digital material framework, to define a new approach of asteroid thermal modeling, instead of the classical TPMs used up to now. Recent improvements of numerical modeling of complex and massively multi-domain media in materials science is a great opportunity to develop a better understanding of the regolith properties from measurements of its thermal inertia.

The proposed techniques are based on different high density packing algorithms (dropping and rolling, advancing front methods etc.), full field description of the objects and powerful FE (finite element) simulations. Full field description of the topology is very promising in the current context in order to describe in a realistic way the top surface of the asteroids, which could be made of a mixture of rocks and regoliths, laid over a complex topography made of crates, rough terrains subject to rapidly changing illumination conditions. Figures 2 and 3 illustrates an example of a representative digital regolith immersed in a FE mesh and a thermal calculation on it.

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Partners

Candidate profile and skills

Degree: PhD in Earth sciences, Physics, Astronomy, Applied Mathematics, Digital Materials or related discipline, with excellent academic record. Skills: Thermophysics, Numerical modeling, proficiency in English, ability to work within a multi-disciplinary team.

Offer

This 1-year postdoc position, starting approximatively Nov 1st, 2017, will take place in LAGRANGE OCA and CEMEF MINES ParisTech, two internationally-recognised research laboratory located in Sophia-Antipolis and Nice, on the French Riviera. This project, under the supervision of M. Delbo and M. Bernacki, offers a dynamic research environment with a synergy between multidisciplinary teams. It is a part of the C4PO structuring project in the framework of the UCA-JEDI excellence initiative. Collaborations with scientists of the OSIRIS-REx team will be also important (in particular with the Regolith team). An application as a single file in PDF format should include a CV, a brief statement of research interests, and two names of reference. All applications received by Sept 15, 2017 will be given full consideration.

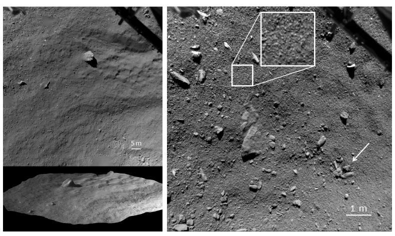

Figure 1. Philae landing gear - Agilkia site during its descent onto comet 67P/Churyumov-Gerasimenko [Mottola et al., cometary science, 2015].

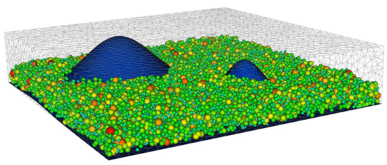

Figure 2. A representative regolith immersed in a FE mesh.

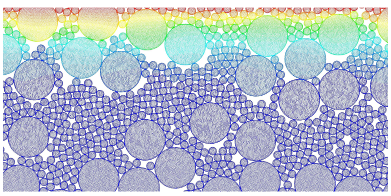

Figure 3. Thermal response of a digital regolith.