Thesis subject

Name of the laboratory: Laboratoire d'Astrophysique de Marseille (LAM)

Thesis advisor: Pierre Vernazza

Email and address: pierre.vernazza@lam.fr ; 38 rue Frederic Joliot Curie, 13013 Marseille
Tel: 04 91 05 59 11

Co-advisor: Laurent Jorda (LAM)

Subject's title: Surface composition of planetary surfaces: from Mercury to TNOs

Subject description: Constraints on the formation of a planetary system can be derived from observations of interstellar clouds, star-forming regions, and exoplanets, enabling the characterization of the diversity of ingredients, processes, and products of stellar formation. The study of nascent extra-solar stellar systems and their planets is, however, limited by our inability to follow the formation processes of a single system over its entire formation interval, which takes millions of years. The study of our own solar system provides the complementary information and in particular a complete chronology of the major events (e.g., planetary migrations) that shaped it and that resulted in the formation of an inhabited planetary system. Confronting the astrophysical view of planet formation as observed across the galaxy to that derived for the solar system is of prime importance to assess whether the processes governing the formation of our planetary system were the exception or the rule (Vernazza et al. 2021).

The exploration of the surface of planetary objects, from planets and their satellites to small bodies, has always been a major scientific objective to provide key constraints to the formation history and subsequent thermal, collisional and dynamical evolution of the solar system. Indeed, the surface of a body contains fundamental evidence to understand its origin and evolution, including the surface composition and its variegation, the global and local topography and the variety of surface morphologies.

Here, we propose a PhD subject around two main axes:

(1) **Decipher the silicate composition of Centaurs and small TNOs with JWST.** Ongoing cycle 2 mid-infrared spectroscopic observations with JWST/MIRI of 2 Centaurs and 2 small TNOs (PI: P. Vernazza; GO 2820) will first allow to place constraints on the silicate composition of these bodies. Second, these observations will provide critical information regarding the extent of radial mixing among primordial small bodies which took place during their early reorganization. Specifically, our measurements will allow us to confirm/refute the genetic link between outer (Centaurs, small TNOs) and inner (P/D type asteroids, Jupiter Trojans) solar system small bodies, as advocated by the Nice model.

(2) **Constrain the surface composition and variegation of Mercury with BepiColombo.** Although our understanding of Mercury's geological history has significantly evolved thanks to the NASA MESSENGER mission, most fundamental questions regarding its origin, formation and evolution remain so far unanswered. In December 2025, the BepiColombo mission will enter in orbit around Mercury after a seven-year long journey. The PhD candidate will use spectroscopic data from two instruments (SIMBIO-SYS VIHI: 0.4-2.0 micron; MERTIS : 7-14 micron) to perform a robust and complementary analysis of Mercury's surface composition (P. Vernazza is co-I on MERTIS and scientific associate on SIMBIO-SYS; L. Jorda is co-I on SIMBIO-SYS).

This PhD topic will allow the candidate to become an expert in the analysis of spectroscopic observations of planetary surfaces over an extended wavelength range, from the visible range to the mid-infrared. This competence will serve well the student in the future, such instruments equipping the majority of the interplanetary missions (e.g., JUICE, ExoMars, …) and groundbased telescopes (e.g., ELT/Harmoni, …).