SCIENCES SORBONNE UNIVERSITÉ

2021-2022

Master thesis proposal

Institut de Minéralogie, de Physique des Matériaux et de Cosmochimie

Campus Pierre et Marie Curie
Tower 23 - 4th floor -23-22
Director: A. Marco Saitta

Title: Melting curve determination under extreme conditions by laser acoustics

Keywords: melting, phase diagram, high pressure, high temperature, laser heating, diamond anvil cell, picosecond acoustics

Scientific description: Phase diagrams are central for both fundamental and applied physics and chemistry, as is understanding how materials' properties changes with pressure- and temperature-induced structural modifications. In particular, the determination of melting curves under extreme conditions has been attracting a lot of interest with direct implications for both materials science and planetary science. Indeed, just as few examples, melting curves bring information on exotic phenomena such as liquid-liquid phase transitions and place constraints in the thermo-chemical evolution and crystallization mechanisms of planets.
The experimental determination of melting curves at pressure in the Mbar range is however technically challenging. Few protocols have been recently established, but they all call for the use of synchrotron techniques, which strongly limits the number of studies that can be performed. Here we propose to overcome these limitations by use of a laboratory-based technique combining diamond anvil cell for pressure generation, laser heating for temperature generation, and picosecond acoustics for melting determination. As both optical reflectivity and the sound velocity highly depend on the liquid vs. solid nature of the sample, and even a small fraction of melt can largely influence such physical properties, ultra fast laser acoustics stems as very powerful melting diagnostic of samples under extreme conditions.
An experimental setup, unique in the world, has been recently fully implemented at IMPMC. This master internship aims at developing the protocol for melting determination performing measurements on reference metals (e.g. Mo, Ti, Ni, Co) and then applying it for the studies of iron and iron-alloys of direct interest for the core of Mercury and Mars.
This internship is carried out within the frame of the InSight NASA Discovery program mission currently operating on Mars, and the ERC-funded project PICKLE (Planetary Interiors Constrained by Key Laboratory Experiments).

Techniques/methods in use: diamond anvil cell, laser heating, luminescence, spectroradiometry, picosecond acoustics
Applicant skills: Interest for experimental activity; Motivation to work on a project at the frontiers between materials science and planetary science.
Industrial partnership: N

Internship supervisor(s): Daniele Antonangeli (daniele.antonangeli@upmc.fr; 01 44 27 52 22); Silvia Boccato (silvia.boccato@upmc.fr)
Internship location: SU, campus Pierre et Marie Curie, IMPMC

Possibility for a Doctoral thesis: Y