MASTER DE PHYSIQUE ET APPLICATIONS - 2ème année
Spécialité Sciences des Matériaux et Nano-objets
International Nanomat Master Program

Internship proposal 2009-2010

Laboratory : Institut de Minéralogie et Physique des Milieux Condensés

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Effect of calcium on the elasticity of majorite at high pressure: Implication for seismic profile of the mantle transition zone

Scientific project: The study of seismic wave propagation and normal mode oscillation are two of the most direct probes of the Earth's interior, providing a remote sensing method to obtain sound velocities and density. However, to derive an accurate compositional model, these seismic observations have to be combined with laboratory-based experiments constraining the density and elastic properties of highly compressed minerals.Majoritic garnet is a high-pressure garnet-structured solid solution between $M_4Si_4O_{12}$ majorite and $M_4Al_2Si_3O_{12}$ garnet (with M=Mg,Fe, Ca, Na) and one of the most abundant phases in the mantle transition zone (MTZ) along with high-pressure polymorphs of olivine. Accordingly, the sound velocity profile estimated for a mixture of these constituent minerals, at relevant pressure and temperature conditions, should in principle reproduce the seismic profile observed in the MTZ. However, while qualitatively the main features are accounted for, the high velocity gradients ($\partial V_P/\partial Z$ and $\partial V_S/\partial Z$, where V_P and V_S are, respectively, the aggregate compressional and shear sound velocity, and Z the depth) in the transition zone are largely underestimated.
The lack of direct measurements of the elastic properties of mantle materials at high pressure greatly hampers the possibility to constrain mineralogical models of the mantle. In particular, the potential effect of calcium inclusion of the elasticity of majorite has not so far been experimentally or theoretically investigated. Thus, here we propose to undertake an experimental study of the effect of Ca inclusion on the sound velocity and elastic properties of majorite at high pressure. The student will participate to the high-pressure high-temperature synthesis of the sample and to its chemical characterization. The prepared samples will be then loaded in diamond anvil cells and hydrostatically compressed up to ~30 GPa. The student will be in charge of the parallel Brillouin spectroscopy and x-ray diffraction measurements, in order to determine both acoustic wave propagation and density.
As initial case, we envisage measurements on polycrystalline samples, hence deriving average aggregate properties, but in a second step, depending on the time frame and student interests, measurements can be extended to single crystals, having then access to the complete elastic tensor.
The obtained results will be used as inputs for simple mineralogical modelling of the Earth's transition zone, and the outcome of the model directly compared with observed seismic profiles.

Techniques in use : Brillouin scattering, x-ray diffraction, diamond anvil cell

Applicant skills : Knowledge of fundamental solid-state physics, experimental skills are a plus, interest for interdisciplinary studies at the frontier between solid-state physics and geoscience.

Granted internship : yes (400 €/month)
C'nano IdF laboratory (France only) : yes
Possibility for a thesis : yes