Master Internship proposal : *Modeling the formation of the solid crust of a neutron star*

Neutron stars (observationally recognized as pulsars) represent the last stage of evolution of massive stars. In these stars, matter is so dense that it must be described from degrees of nucleonic freedom (protons and neutrons). In the solid crust of neutron stars, nucleons are organized into clusters similar to atomic nuclei. This is why the properties of the strong interaction at the nuclear scale, or "equation of state", still poorly known today, play an essential role in the structure of the neutron star crusts. The neutron star being born hot, the solid crust is formed in a cooling mechanism of the star plasma from an initially liquid state. A correct modeling of the crystallization and of the star composition at the temperature of the liquid-solid transition is important to understand accretion phenomena in binary systems, which are believed to be at the origin of the observed X and gamma ray bursts in those compact objects.

We have recently developed within the theoretical physics group of the LPC an approach that allows to describe in a single formalism or meta-model, all the different models for the equation of state that can be found in the literature. The exploration of the meta-model parameter space thus makes it possible to estimate the influence of the state equation parameters of the different theoretical approaches on astrophysical variables. During this internship, we will address the problem of the influence of equation of state models on the crystallization temperature of neutron stars. Depending on the trainee, two different orientations are possible: (i) a more computer simulation oriented training will consist in determining a confidence interval on the crystallization temperature by exploring with Bayesian methods the space of the parameters (ii) a more formalism oriented training will consist in developing the phase equilibrium equations beyond the commonly used approximation of a single-component plasma.

Contact: F.Gulminelli gulminelli@lpccaen.in2p3.fr . This project will be carried out within the Theory and Phenomenology group of the LPC. A PhD student (T.Carreau) will be associated with the trainee's supervision.