Master Internship project – Erasmus Mundus

Place : Grand Accélérateur National d'Ions Lourds (GANIL)

Title : NEUTRON-STAR CRUST FORMATION

Project type : nuclear astrophysics : theoretical

Scientific context and project details:

Neutron stars are among the densest objects in the Universe. Being born from core-collapse supernova explosions, they are initially very hot. Therefore, their outer layers (crust) are expected to be made of a dense liquid composed of various nuclear species immersed in a background of electron (and eventually neutron) gas. As the neutron star cools down, it is generally assumed that this plasma crystallizes and remains in full thermodynamic equilibrium until eventually reaches a cold solid crystalline phase.

In the latter hypothesis, the final structure of the crust would be that made of layers, each of which consists of only one nuclear species. However, it is likely that the star does not maintain full equilibrium after crystallization. Therefore, the picture of the crust made of one-species layers is challenged, and a co-existence of various nuclear species could still persist after crystallization. This, in turn, can have important consequences on the neutron-star properties and dynamics, such as its cooling.

During the Master internship, a theoretical study of the crystallization of the neutron-star crust will be performed. In particular, the internship will be focused on the study of the properties of the (hot) crust during its formation. The presence of the different nuclear species in nuclear statistical equilibrium at finite temperature and the liquid-solid transition during the crust formation will be analysed. Different nuclear models will be used, thus assessing the impact of theoretical uncertainties in this astrophysical scenario.

Prerequisites:

- Physics courses at bachelor level;
- Understanding of program languages (e.g. Fortran) and linux-based system at bachelor level.

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