LABORATOIRE DE PHYSIQUE CORPUSCULAIRE DE CAEN

CNRS – IN2P3 – ENSICAEN – UNICAEN

UMR6534

2025 PhD subject, Groupe Dynamique et thermodynamique LPC Caen

Constraining in medium effects in nuclear matter at low density.

Nuclear physic allows to describe object of various size and nature. From one side the microscopic world of atomic nuclei which compose the matter and from the other side astrophysical objects present in the far universe. In both cases we need to describe the nuclear interaction in those objects ideally often far from normal conditions. Using accelerated ion beams, nuclear collisions bring nuclei in various conditions of temperature, density and even exotic chemical composition. Those conditions are also present in dense astrophysical objects like neutron stars, supernovae or binary compact stellar systems, where conditions of temperature, pressure and composition are such that matter is not anymore in a state of isolated nuclei, but a kind of a soup, more or less uniform, with nucleons in interaction. Around saturation density (the one encountered in atomic nuclei) the matter is homogenous and behaves like a fluid. At low density, the nuclear matter is no more homogenous, light nuclei (or clusters) coexist with free nucleons. These clusters, present inside the nuclear matter, are affected by the surrounding medium; we speak about *"in-medium effects"*. Those effects modify clusters abundancy and so the properties of the matter. This low-density state is present either in nuclear collisions but also for example in the crust of cooling proto-neutron stars and may modify the neutrino transport and the shock wave propagation during core collapse supernovae.

The main objective of this PhD thesis will be to constrain the in medium effects in low density nuclear matter and finite temperature. Extensive comparisons with nuclear reactions data obtained with the INDRA-FAZIA detectors (at GANIL) and models (like Relativistic Mean Field) will provide constraints on the parameters describing the nuclear interaction. The main goals being:

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- Isolate, from all acquired data from the INDRA-FAZIA E818 experiment performed at GANIL, events corresponding to a low-density gas thermodynamical situation.
- Extract the proper observables (for instance the mass fractions) in order to confront them to model calculations which include in-medium effects.

The candidate will participate to data analyses of various experiments in the framework of the INDRA-FAZIA international collaborations (France, Italy, Spain, Korea…). His/her work will be presented regularly during collaboration meetings and participation to the life of the collaboration (preparation of experiment, developments, conferences) is warmly expected. The proposed work is also a collaboration with University of Coimbra (Portugal) initiated already during previous PhD thesis on the subject and exchanges are foreseen.

Required skills are basic knowledge in nuclear instrumentation, electronics and detection identification techniques of charged particles, multi parameter data base analyses, Monte-Carlo simulations, statistical approaches (Bayesians analyses…), C++ programming language, ROOT.

Where: Laboratoire de Physique Corpusculaire de Caen, France IN2P3/Université de Caen

When: October 2025

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