



ERASMUS MUNDUS JOINT MASTER IN NUCLEAR PHYSICS

Academic Year 2026/2027

MASTER THESIS PROPOSAL

TITLE: CLUSTERS IN THE MEDIUM

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ABSTRACT

(just few lines 5-10 explaining briefly the idea of the proposed work and the place where it will be developed).

The ultra-dense matter in the central regions of core-collapse supernovae can be represented as a strongly interacting plasma composed of neutrons and protons and their bound states (deuterons and heavier nuclei), neutralized by a homogeneous electron background and assumed to be in local thermodynamic equilibrium. To evaluate the relative abundance of monomers and composite particles, the standard astrophysical treatment (Clayton, 1968) consists in considering the nucleon fluid as a statistical ensemble consisting of an ideal gas of nucleons and clusters treated as independent quasi-particles. However, this description does not account for the dissolution of clusters in a dense medium, a phenomenon known as the Mott effect (Schmidt et al., 1990). To understand this feature, a microscopic evaluation of the quasiparticle energy of composites can be obtained within the thermal Green-function formalism. After a quasiparticle reduction of the Bethe-Salpeter equation in ladder approximation (Fetter & Walecka, 1971), it is possible to obtain an in-medium eigenvalue equation for the quasi-particle composites, that is solved in perturbation (Schmidt et al., 1990; Ropke, 2009). In this project, we will develop an improved non-perturbative method based on channel decomposition to study the asymptotic regime associated to the continuum threshold. An implementation in a quasi-particle statistical model will allow us to evaluate cluster abundancies and compare with the results of the perturbative method, as well as with other simplified approaches introduced in the literature.

The project is a collaboration between LPC France and University of Catania. The student will spend part of the time in both sites.