Lecturer : Olivier Lopez, LPC Caen, France
Duration : 2h

Title : **From transport properties to the nuclear equation of state : an experimental survey in the Fermi energy range**

Heavy-ion induced reactions in the Fermi energy range are a quite unique probe to investigate transport properties : nuclear stopping, thermalization process, isospin transport, also thermodynamical properties via the study of the signals for phase transition (liquid-gas - first order versus second order - critical phenomena) , and the establishment of the nuclear equation of state at finite temperature [1-3]. This latter is indeed crucial in the astrophysical context of core collapse supernovae and neutrons star mergers [4]. Generally, all these studies need to cover a broad range of nuclear systems in terms of incident energy and size and require as much as possible experimental systematic studies [5]. In this lecture, I will present a general overview of the experimental results obtained so far during the last decades in the Fermi energy domain. I will also discuss the hot topics under investigation and have a special focus on the experimental perspectives.

The lectures will be organized as follows :

1. Introduction : some basic concepts on heavy-ion induced collisions in the Fermi energy domain, methods for extracting results and qualifying uncertainties in an experimental context,

2. Dynamical features in heavy-ion induced collisions : from transport properties to thermal and chemical equilibration, characterizing the path from pre-equilibrium toward equilibrium, constraints brought for many-body dynamical models,

3. Thermodynamical properties : signals of phase transition in HIC at Fermi energy, phase diagram of nuclear matter, spinodal instabilities in the low density region, isovector extension of the phase diagram for asymmetric nuclear systems,

4. Nuclear equation of state : probing the iso-scalar and iso-vector sectors, uncertainties and experimental constraints obtained from HIC, and perspectives from an experimental point of view.

References

[1] D. Durand, B. Tamain and E. Suraud, *Nuclear Dynamics in the Nucleonic Regime*, Institute of Physics, New York, 2001

[2] B. Borderie and J.D. Frankland, *Liquid-Gas Phase Transition in Nuclei*, Prog. Part. Nucl. Phys. **105** (2019) 82

[3] Topical volume, *Dynamics and Thermodynamics with Nuclear Degrees of Freedom*, Eur. Phys. J. A **30** (2006)

[4] J.M. Lattimer and M. Prakash, *The Equation of State, Dense Matter and Neutron Stars*, Phys. Rep. **621** (2016) 127

[5] G. Lehaut *et al.*, *Study of Nuclear Stopping in Central Collisions at Intermediate Energies*, Phys. Rev. Lett. **104**, 232701 (2010),
M. Henri *et al.*, *In-medium Effects in Central Heavy-ion Collisions at Intermediate Energies*, Phys. Rev. C **101**, 064622 (2020)