Measurement of light charged particle Equilibrium constants using heavy-ion reactions

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Over the last two decades, the study of heavy-ion collisions with the INDRA charged particle multi-detector has produced major advances in the understanding of nuclear matter dynamics and thermodynamics.

In a recent article, Qin et al. (Phys. Rev. Lett. 108 (2012) 172701) have investigated clustering in low density nuclear matter. Equilibrium constants for ^{2}H, ^{3}H ^{3}He ^{4}He have been measured following Guldberg and Waage law by selecting experimentally a sub-set of events corresponding to a gas of neutrons and protons in equilibrium with clusters. Equilibrium constants measure the composition of nuclear matter at a given density and a given temperature.

Besides the fact that these results are important for the knowledge of the density dependence of the nuclear equation of state (Baldo M et al. Prog. Part. Phys. 91 (2016) 203), the measurements are related to density and temperature values that are of major importance for astrophysics since nuclear equation of state plays a fundamental role in the understanding of core-collapse supernovae, mergers of compact stars and cooling proto-neutron stars for example. In particular the chemical composition of proto-neutron stars influences the neutrino opacities and then the cooling of the star (Hempel et al. Phys. Rev. C91 (2015) 045805, Pais H et al. Phys. Rev. C97 (2018) 045805).

The INDRA collaboration also measured equilibrium constants for Xe+Sn system (Bougault R et al. J. Phys. G (2019) submitted). The proposed work is to extend the analysis to Ni+Ni system which has been studied at several bombarding energies.

Skills required: background in nuclear physics; knowledge of thermodynamics and statistical physics could be useful; computer skills, familiarity with C++ would be an advantage.