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Probing the nuclear Equation-of-State and the Symmetry Energy with heavy-ion collisions

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Heavy-ion collisions provide unique terrestrial means to explore the nuclear equation of state (EoS) under laboratory controlled conditions. The outcome of such studies plays a key role in constraining important properties of stable and exotic nuclear systems as well as those of astrophysical systems and phenomena (such as supernovae explosions and neutron star properties). The study of isospin symmetric nuclear matter has already made significant progress achieving significant constraints. In contrast, the EoS of asymmetric nuclear matter remains still poorly unconstrained both at sub-saturation and supra-saturation densities. Therefore, the last decade has seen an increasing interest towards the isospin degree of freedom in nuclear matter. Several heavy-ion accelerators around the world have delivered beams spanning a wide range of neutron/proton number (N/Z) asymmetries, with the aim of better isolating the effects induced by the symmetry energy on reaction dynamics and studying its density dependence. This research field presently represents a subject of great debate and gathers scientific communities working in different fields (astrophysics, nuclear structure, nuclear dynamics).

In this talk the status on the study of the EoS and the symmetry energy with heavy-ion collision dynamics will be presented. The main experimental observables probing both sub-saturation and supra-saturation density will be discussed. In the sub-saturation domain heavy-ion collisions at intermediate energies (E/A<100 MeV) are studied with measurements of fragmentation observables, isotopic ratios, isoscaling phenomena, isospin diffusion and drift and neutron/proton pre-equilibrium emissions. At supra-saturation densities measurements require studying collisions at energies E/A>400 MeV: sensitive observables include neutron/proton pre-equilibrium emission and elliptic flow, and pion and kaon production and yield ratios.

The results obtained by different groups working in the field, with the present status of our understating on the EoS for asymmetric nuclear matter and views on possible perspectives for future directions will be discussed.