Tuesday Nov. 28th At 3:30pm

Violent Fluctuations in Fluids of Neutrons and Protons Explain How Atomic Nuclei Disintegrate

Abstract:

Perturbing fluids of neutrons and protons (nuclear matter) may lead, as the most catastrophic effect, to the rearrangement of the fluid into clusters of nucleons. A similar process may occur in a single atomic nucleus undergoing a violent perturbation, like in heavy-ion collisions tracked in particle accelerators at around 30 to 50 MeV per nucleon: in this conditions, after the initial collision shock, the nucleus expands and then clusterizes into several smaller nuclear fragments.

Microscopically, when violent perturbation are applied to nuclear matter, a process of clusterization arises from the combination of several fluctuation modes of large-amplitude where neutrons and protons may oscillate in phase or out of phase. The imposed perturbation leads to conditions of instability, the wavelengths which are the most amplified have sizes comparable to small atomic nuclei. We found that these conditions, explored in heavy-ion collisions, correspond to the splitting of a nucleus into fragments ranging from Oxygen to Neon in a time interval shorter than one zeptosecond (10^-21s). From the out-of-phase oscillations of neutrons and protons another property arises, the smaller fragments belonging to a more volatile phase get more neutron enriched: in the heavy-ion collision case this process, called distillation, reflects in the isotopic distributions of the fragments.

The resulting dynamical description of heavy-ion collisions is an improvement with respect to more usual statistical approaches, based on the equilibrium assumption. It allows in fact to characterize also the very fast early stages of the collision process which are out of equilibrium. Such dynamical description is the core of the Boltzmann-Langevin One Body (BLOB) model, which in its latest development unifies in a common approach the description of fluctuations in nuclear matter, and a predictive description of the disintegration of nuclei into nuclear fragments. After a theoretical introduction, a few practical examples will be illustrated.

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Refreshments will be served at 3:15pm