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RESEARCH HIGHLIGHT

Molecular dynamics for collisions of heavy ions

Ying-Xun Zhang, Ning Wang, and their collaborators systematically reviewed the molecular dynamics and its application to heavy ion collisions at low and intermediate energies [6].

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Collisions of heavy ions are means of heating and compressing nuclear matter beyond normal density. Properties of such matter are of interest in the context of supernova explosions, neutron star structure and neutron star mergers [1]. These properties can also challenge many-body theory. Dynamics studied in the collisions expands upon the macroscopic features of nuclei in their ground states and excitations around ground states. With this, heavy-ion collisions have become an important focus area for a number of constructed nuclear accelerators, including High-Intensity Heavy Ion Accelerator Facility in Lanzhou [2], Facility for Rare Isotope Beams at my home institution [3] and other across the world.

Excitation of nuclear matter and macroscopic system evolution take place at transient stages of the collisions and physics conclusions must be read off from comparing predictions of reaction simulations to collision measurements. Macroscopic concepts of baryon and energy density, temperature, collective velocity, etc., are not sufficient to tell the story for the collisions. As the systems in the collisions have a finite number of constituents, fluctuations and granularity play important roles in the dynamics too. The same initial conditions can lead to different outcomes and clusters of varying mass may be abundant in the final states of the collisions.

Molecular dynamics is means of modelling of heavy-ion collisions, that combines classical and quantal features of the systems. The models allow for variations in the assumptions on the bulk properties of nuclear matter and they describe fluctuations and production of clusters. Foundations for the molecular dynamics were laid out in the community of German physicists [4, 5], but benefits of the approach were quickly recognized elsewhere. Prof. Zhuxia Li pioneered the approach in China and she and the next generation of physicists she educated, including Ying-Xun Zhang, the main author of the review [6], made molecular dynamics models an everyday tool for describing heavy-ion collisions at low and intermediate energies, well beyond the original premise. This particularly pertains to the Improved Quantum Molecular Dynamics Model [7] and also Ultra-Relativistic Quantum Molecular Dynamics Model [5]. The expanded scope included connection to nuclear ground states, description of reactions around Coulomb barrier, in the works of Ning Wang and others [7], incorporation of results from microscopic theory, in particular pertaining to pion production, recognition of produced fragments, and impacts of isospin on the dynamics, of great importance for the extrapolations to astrophysical circumstances.

In Ref. [6], Ying-Xun Zhang, Ning Wang, and their collaborators systematically reviewed the molecular dynamics and its application to heavy ion collisions at low and intermediate energies.

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