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Consensus based approach to modeling of interacting nuclear particle system

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For a system comprised of a large number of particles, it is extremely difficult to specify their interactions analytically. The multi-agent approach provides a possibility to construct a numerical model of a system composed of many particles. Such many-particle system stabilizes over time, and its final state is, to a certain degree, independent of the initial conditions. The multi-agent approach is actively used in modern computer science and control theory for control of distributed, decentralized networks.

This work employs an approach based on the Vicsek model [1], which was proved analytically by Morse [2] and subsequently found numerous applications including load balancing [3], opinion dynamics [4], swarm control [5]. Its application to nuclear system modelling was proposed in [6]. In these applications, the key feature is the agents' ability to coordinate without external influence. The capacity of such coordination has been recently demonstrated for AI agents [7].

The implemented algorithm makes it possible to simulate the aggregation and evolution of proton-neutron system as well as the clustering of nuclear many-particle subsystems, while accounting for long-range but relatively weak Coulomb-type interactions. At the heart of the algorithm lies a consensus mechanism that balances the influence of the mutual attraction and repulsion of particles and models the system's transition to a stabilized state. The multi-agent nature of the proposed model allows evading the problem of specifying a dynamical system that describes many-body interactions. It scales efficiently and allows simulating a many-particle system with a large number of particles.

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