

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.

1. T. Vicsek, A. Czirók, E. Ben-Jacob, I. Cohen, and O. Shochet (1995) Physical review letters, 75(6), 1226.
2. A. S. Morse, A. Jadbabaie, J. Lin (2003) IEEE Trans. Autom. Control, 48. p. 988.
3. E. Borisoglebskaya, V. Erofeeva, O. Granichin, Y. Ivanskiy, and N. Kizhaeva, (2023) Proc. 9th International Conference on Control, Decision and Information Technologies, pp. 2032-2036.
4. N. E. Friedkin, A. V. Proskurnikov, R. Tempo, and S. E. Parsegov (2016). Science, 354(6310), pp. 321-326.
5. R. Olfati-Saber (2006) IEEE Trans. Autom. Control, 51(3), pp. 401-420.
6. Y. Ivanskiy, A. Unzhakova (2022) Bull. Russ. Acad. Sci.: Phys. 86 (9), 1108-1110.
7. G. De Marzo, C. Castellano, and D. Garcia (2026) Science Advances, 12: eaea6091.

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