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Visualization of nuclear cluster correlations in microscopic wave functions

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In general, the quantum many-body wave function obtained by theoretical calculation contains an enormous amount of information about many-body correlations. However, theoretical analyses in nuclear physics are mainly performed for quantities such as one- and two-body densities, which are obtained after integrating out most of the information in a many-body wave function.
On the other hand, in the field of quantum chemistry, methods have been developed to visualize the information on the correlations among all the electrons and applied to the structure studies of molecular systems [1]. We are attempting to apply such a method to nuclear systems. As the first step, we start with finding the most probable arrangement of nucleon coordinates, i.e, the set of position and spin coordinates that maximizes the square of the many-body wave function.
In this talk, we apply this method to Hartree-Fock and Hartree-Fock+BCS wave functions of p-shell and sd-shell nuclei [2]. We find some alpha-cluster-like correlations out of the wave functions obtained without any assumption of cluster structure. Effects of pairing correlation on the cluster structure are discussed by comparing the results between HF and HF+BCS. We also investigate the relationship between deformation and the cluster structure with constrained HF+BCS wave functions. We believe that this study gives a new viewpoint to the microscopic nuclear wave function.
[1] Yu Liu, Terry J. Frankcombe, and Timothy W. Schmidt, Phys. Chem. Chem. Phys. 18, 13385 (2016).
[2] Moemi Matsumoto and Yusuke Tanimura, Phys. Rev. C 106, 014307 (2022).

Experimental study on nuclear physics

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