Solution of HFB equation in HFB canonical basis

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Canonical-basis expression of the Hartree-Fock-Bogoliubov (HFB) ground state is one of the most promising approach to describe pairing correlation of neutron-rich unstable nuclei, in which the pairing correlation of neutrons significantly involves the continuum single-particle states. Consideration of the coupling to the continuum in coordinate space is a demanding task. Namely, the small separation energy of unstable nuclei makes the wavefunction spatially extended and thus demands a coordinate-space representation of the wavefunction rather than the foolproof way of the oscillator-basis expansion (it is foolproof because the essential parts of the numerical calculations are matrix manipulations and are taken care of in terms of some library programs). The widely employed approximation of the HF+BCS approach does not work because it makes the neutron density distribution unlocalized. Therefore one has to solve the HFB equation without approximations.

The solution in the coordinate space was first formulated in [1] using the quasi-particle states and performed for spherically symmetric states. The application of the quasi-particle method to deformed states is very difficult because there are a huge number of quasiparticle orbitals even for a moderate size of a box (cavity) to contain wavefunctions. Transformation to an equivalent expression called the HFB canonical-basis representation can overcome the difficulty. In this new representation, the HFB solution have the BCS variational form but, unlike in HF+BCS approximation, the positive energy orbitals have localized wavefunctions. There is a strong reason to believe that the necessary number of canonical orbitals is much smaller than the number of basis. This expression was used to solve HFB for spherical states originally in [2]. I improved the method and applied it to deformed states in a three dimensional cubic mesh representation with density dependent delta interactions[3,4]. In this paper I discuss the features of my canonical-basis approach, which are suited to 3D mesh treatments[5] and can treat deformation, halo-like spatially extended situations, and continuum pairing simultaneously. I also discuss about the cut-off. I found that the restrictions of the number of canonical orbitals is not sufficient to prevent divergence in paring correlation. Dependence on pair density is introduced in the pairing interaction to obtain physically plausible solutions successfully.

References

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