Developments of HFB solvers and continuum effects in deformed drip-line nuclei

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With the developments of RNB facilities in the world, one of their major scientific goals is the study of unstable nuclei towards the drip-lines. This is crucial for benchmarking the existing nuclear models and thus improve the model precision for nuclear energy and nuclear astrophysics. In theoretical descriptions of drip-line nuclei, one of the key issues is the proper treatment of continuum effects, which is important not only for ground state properties and but also for nuclear excitations. The coordinate-space Hartree-Fock-Bogoliubov (HFB) approach was demonstrated to be able to treat the bound states, quasi-particle continuum and resonances on an equal footing [1]. This method, referred to as the $\mathcal{L}^2$ discretization, is rather accurate compared to exact solutions with outgoing boundary conditions [1]. However, in deformed cases the coordinate-space HFB approach results in an very large configuration space and supercomputing becomes essential [2]. To this end, we developed a 2D coordinate-space HFB solver HFB-AX using a hybrid MPI and OpenMP programming model, and a 3D solver MADNESS-HFB based on multi-wavelet techniques and sophisticated parallelism programming methodologies [2]. With these latest coordinate-space HFB solvers, we can study the drip-line nuclei within large boxes and other important problems that require big computations. We are also interested in looking for some intriguing phenomena near drip-lines, for example, deformed halo structures, islands beyond the neutron drip-line and pygmy resonances.

References

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