Gamow Shell Model: nuclear structure

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Nuclei situated at drip-lines exhibit different properties as those lying close the valley of stability. The ground states of drip-line nuclei can be very extended in space, so that they form a halo of nucleons in the classically forbidden zone, or can even be unbound by particle emission. As a fact, drip-line nuclei are open quantum systems, for which the close vicinity of the continuum of unbound scattering states must be taken into account theoretically.

For this, the Gamow Shell Model (GSM) has been introduced several years ago. Its fundamental idea is to generate a basis of many-body states from the one-body Berggren basis, comprising bound, resonant and scattering states. The continuum degrees of freedom are thus included at basis level, and the configuration mixing between many-body basis states takes care of inter-nucleon correlations.

Consequently, loosely bound and resonant nuclear many-body states can be calculated with GSM. In order to avoid center of mass excitations, GSM is defined in the Cluster Orbital Shell Model (COSM) frame, using a core and valence nucleons. The lack of exact antisymmetry in laboratory frame of COSM wave functions will be discussed and shown to be very small. Another issue is the identification of the many-body GSM resonant states from the diagonalization of the GSM matrix, situated in the middle of many-body scattering states. For this, the overlap method is used to identify GSM resonant many-body states from their pole approximation, along with the Davidson method, targeting interior GSM eigenvalues. However, for very large matrices, the Davidson method can no longer be used, so that the Density Matrix Renormalization Group (DMRG) has been introduced. Its fundamental idea is to build a basis of increasingly correlated many-body states, so that matrices bear tractable dimensions.

Applications will consist of the study of ^{6}He and ^{8}He charge radii, of experimental interest. GSM-COSM has also been tested against the Gaussian Expansion method for the case of ^{6}He and ^{6}Be. GSM-DMRG has been successfully applied to realistic interactions in the context of no core GSM, with the examples of ^{4}H, ^{4}Li, ^{5}He and ^{6}Li. Center of mass issues in this case will be discussed. The introduction in GSM and DMRG of natural orbitals, a basis tailored to the many-body state calculated, hence beyond the Hartree-Fock approximation, will also be presented.