Gamow Shell Model: reaction observables

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The Gamow Shell Model (GSM), a configuration interaction model where many-body states are constructed from the one-body Berggren basis, bearing bound, resonant and scattering states, has been shown to be a powerful tool to describe the structure of drip-line nuclei as loosely bound and resonant many-body states can be efficiently calculated therein. The Cluster Orbital Shell Model (COSM), where nucleon coordinates are defined with respect to the center of mass of the core, allows to suppress center of mass excitations by directly working in a translationally invariant frame.

However, GSM cannot be used directly for the determination of reaction cross sections and observables. Indeed, as particle-emission channels cannot be identified in general in GSM, it is impossible to build scattering many-body states with well defined entrance and exit channels. To solve this problem, GSM has been extended to a reaction framework using the Resonating Group Method (RGM). In the RGM method, a basis of channels is constructed from target states and projectile states, which generate compound many-body basis states. Target states and projectile states are calculated in GSM, as they consist of bound or resonant eigenstates of the GSM Hamiltonian matrix. The Hamiltonian is then represented by a set of coupled integro-differential equations. Scattering many-body states are solutions of the Hamiltonian coupled-channel equations, from which reaction observables such as scattering and radiative capture cross sections can be calculated.

Due to the strong non-locality of coupling potentials, the coupled-channel equations of GSM-RGM are difficult to solve numerically. Consequently, a new method to solve coupled-channel equations has been introduced, where the coupled-channel Green function is represented by the Berggren basis. In particular, the complex-energy character of the Berggren basis states automatically provide proper outgoing asymptote to exit channels. The use of COSM coordinates also demands to carefully define the different projectile energies in different frames. While initially introduced with nucleon projectiles, GSM-RGM can be used as well with cluster projectiles. The main problem therein is to calculate projectiles with proper intrinsic and center of mass wave functions.

The GSM-RGM has been used to calculate the ^{18}Ne(p,p) and ^{14}O(p,p) reactions, where the proton-rich ^{19}Na and ^{15}F nuclei are unbound and thus are nuclei of choice for GSM and GSM-RGM. The ^{6}Li(p,p) scattering reaction, and ^{6}Li(p,γ)^{7}Be, ^{6}Li(n,γ)^{7}Li, ^{7}Be(p,γ)^{8}B and ^{7}Li(n,γ)^{8}Li radiative capture reactions, of astrophysical interest, will also be presented using GSM-RGM.