Recent Applications of the Shell Model Embedded in the Continuum

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Astrophysical models of stars rely strongly on certain characteristics (e.g. astrophysical factors) of nuclei involved in the chains and cycles of thermonuclear reactions [1]. Many of these reactions involve weakly stable or unstable nuclei. The influence of scattering continuum on the structure of bound and quasi-bound states in these nuclei becomes very important, making standard nuclear structure theories hard to justify. On the other hand, these nuclei are good candidates to be described as open quantum systems, where all the couplings between (quasi-)bound and scattering states are accurately taken into account.

Our aim is to apply the quantum open system formalism to describe phenomena in nuclei close to the drip lines using the Shell Model Embedded in the Continuum (SMEC). This formalism relies on the explicit division of the Hilbert space of the Schrödinger equation into two disjointed subspaces, namely the subspace of (quasi-)bound states and the subspace of scattering states [2]. At the initial stage, the first one is described by means of the usual nuclear shell model and the other one in terms of coupled channels equations. Then all the couplings between these subspaces are taken into account in terms of the residual nucleon-nucleon interaction. This modifies the scattering solutions as well as the spectroscopic quantities on the structure side. The crucial modification is that the effective Hamiltonian is no longer hermitian and resonance states acquire a width which is directly related to the imaginary parts of these Hamiltonian eigenvalues. As a result, both the structure of nuclei and cross sections are modified [3].

I report on our recent results concerning the astrophysical factor for the reaction ^{7}Be$(p,\gamma)^8$B and the elastic cross section for ^{16}O$(p,p)^{16}$O. I present also the extension of this model for the description of emission of one or two protons from a dicrete state with the example of the second 1^- state of ^{18}Ne [4].

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