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Nature of Pauli resonances states in light nuclei

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The resonating group method (RGM) [1] is a rigorous and self-consistent realization of cluster model. It has been numerously proved the RGM is a powerful tool to study the structure of light atomic nuclei and nuclear reactions of different types. Thus it equally well describes bound and continuous spectrum states. The main advantages of the RGM is that it takes into account the internal structure of interacting nuclei (clusters) and correctly treats the Pauli principle. In the standard (initial) version of the RGM, the internal structure of clusters was described by wave functions of the many-particle shell model. Then, many attempts have been made (undertaken) to use more realistic wave functions of clusters. They aimed at a more correct description of interacting clusters and compound system as well. These attempts brought new interesting results. However, they also gave a birth of a new problem, which is called the Pauli resonances and which are considered as a redundant solutions of the RGM equations. It was recognized, the Pauli principle is the origin of the problem.
In our work, we perform a systematic investigation of the Pauli resonance states in the continuum spectrum of light atomic nuclei: ^{6}Li, ^{7}Li, ^{8}Be, ^{9}Be and ^{10}B. These nuclei are considered as two-cluster systems. One of the clusters of two-cluster system, which is weakly bound, is also considered as a two-cluster system. We especially interested in the Pauli resonance states appearing in interaction of neutrons, protons, deuteron, tritons and alpha particles with ^{6}Li. For this purpose, we employ of a microscopic three-cluster model, formulated in [2]. This model uses square-integrable Gaussian and oscillator bases to expand wave function of relative motion of clusters. As a result, the many-particle Schrödinger equation is transformed into a set linear algebraic equations. It is numerously demonstrated that discrete algebraic form of two-cluster Hamiltonian is the best way to analyze effects of the Pauli principle.
It is shown that the Pauli resonance states in selected nuclei lie in the energy range between 11 and 45 MeV, and their widths are varied from 8 keV to 8 MeV. It is demonstrated that in main cases, only one Pauli resonance emerges in continuous spectrum of two-cluster systems. We have also found several cases when two Pauli resonances are formed by interaction of two clusters.
Analysis of wave functions of the Pauli resonance states and the many-particle Schrödinger equation in the discrete space allowed us to formulate an algorithm for elimination of Pauli resonance states. This algorithm suggests new definition of so-called totally-forbidden and almost-forbidden Pauli states which are responsible for creation of the Pauli resonances. It is demonstrated that the suggested algorithm completely eliminates all Pauli resonance states.

1. J.A. Wheeler, Phys. Rev. 52, 1107 (1937).
2. V.S. Vasilevsky, F. Arickx, et al. Nucl. Phys. A. 824, 37 (2009).

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