On nature of bound and resonance states in ^{12}C.

V. S. Vasilevsky, F. Arickx, W. Vanroose, J. Broeckhove
Bogolyubov Institute for Theoretical Physics, Kiev, Ukraine
University of Antwerp, Group Computational Modeling
and Programming, Antwerp, Belgium

We present the results of a study of both bound and resonance states in ^{12}C embedded in a three-α-cluster continuum, using a three-cluster microscopic model. The model, originally formulated in Ref.[1], relies on the Hyperspherical Harmonics basis to enumerate the channels describing the three-cluster continuum. This model forms an alternative to the Complex Scaling Method and the Analytic Continuation in the Coupling Constant Method. The latter two methods have been mostly used to determine the position of resonances in many-cluster and many-channel systems.

Our method starts from a calculated form of the S-matrix in a wide energy range, and determines the resonance states as the pole(s) of the S-matrix. The advantage of this method is that it provides the scattering quantities (such as phase-shifts, cross-sections, etc.) within a desired energy range, the resonance properties (energies and widths), as well as the wave functions of both scattering and resonance states. The latter then allow to obtain additional information about the nature of the resonances, by computing observable quantities.

We consider the Minnesota potential for the nucleon-nucleon force. The parameter u of the potential is adjusted to reproduce the phase shifts of the $\alpha - \alpha$ scattering and the properties of the 0^+, 2^+ and 4^+ resonances in ^8Be. We use a large number of hyperradial and hyperspherical excitations leading to convergent results for the energy of the bound states as well as the energy and width of the resonance states.

It is shown [2] that the resonance states of ^{12}C are formed by only a few number of channels. These channels are weakly coupled to one another leading to a very narrow resonance. Partial widths are determined, from which the most probable channels for resonance decay are obtained. Correlation functions and density distributions reveal the dominant shape of the three-cluster triangles for bound and resonance states of ^{12}C. There are no indications of a linear three-cluster structure of resonance states.

References

[1] V. Vasilevsky, A. V. Nesterov, F. Arickx, and J. Broeckhove, "Algebraic model for scattering in three-s-cluster systems. I. Theoretical background", *Phys. Rev. C*, **63**, 034606, 2001.

[2] V. Vasilevsky, F. Arickx, W. Vanroose, and J. Broeckhove, "Microscopic cluster description of ^{12}C", *Phys. Rev. C*, **85**, 034318, 2012.