Structure Analyses for light nuclei based on AMD+GCM

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Antisymmetrized Molecular Dynamics (AMD) was originally invented as a simulation code for nuclear reactions [1, 2]. However recently it is recognized as a tool for the analyses for light nuclei, and Kanada-En'yo *et al.*have shown the validity [3, 4, 5]. The essential feature is that this method is free from any assumption of cluster configurations, then we can investigate the development or dissolution of cluster automatically over wide mass number range.

In this report I will show the extension of this approach which means the combination of AMD and Generator Coordinate Method (GCM). GCM is a way to describe quantum state as a superposition of different intrinsic states, then we can discuss the co-existence of cluster-like structure and shell-like structure. As a example we study the structure of ^{12}C which has been successfully analyzed by α-cluster model. The problem is that traditional effective interactions including density dependent one cannot reproduce ^{12}C and ^{16}O with the same exchange parameter [7]; the calculated binding energy of ^{12}C shows shortcoming comparing with the experimental data if we reproduce the binding energy of ^{16}O. Now we investigate the contribution of ls force which cannot be taken into account in α-cluster model space to see whether the coupling with α-breaking states improves the binding energy of ^{12}C or not.

We apply constraint cooling method of AMD which is a method to obtain the energy minimum state under some constraints. We prepare different intrinsic state as GCM basis states by changing the value of constraint (in this case principal quantum number n). In addition we must also generate GCM basis states where α-cluster is evidently broken and ls force contribution is large. For this purpose we introduce another constraint spin $\langle s^2 \rangle = 1$. Fig.1 shows n dependence of the ^{12}C energy. Dotted line and solid line correspond to states which are cooled under the constraint of only n, and n and $\langle s^2 \rangle = 1$ respectively. We superpose these states and solve the coupling with α-cluster model. FIg.2 shows the coupling effect (middle) between α-cluster basis states (left) and α-breaking states (right) obtained by AMD. The energy gainy about 2 MeV can be seen for 0^+ ground state. However it is not so large for 2^+ and 4^+ state, and the levels distance between these states become larger and it is closer to the observed value than the result obtained by only the α-cluster model.

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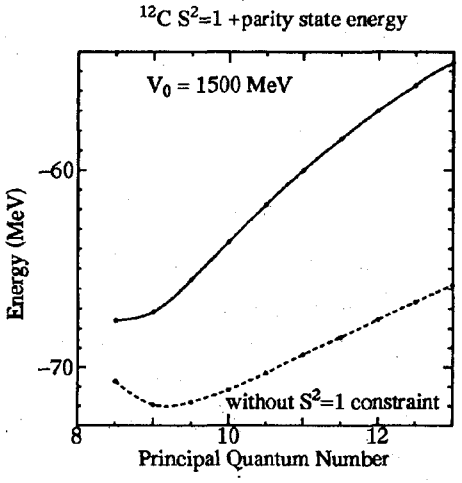

Figure 1: Principal quantum number n dependence of energy in ^{12}C. $S^2 = 1$ wave function (solid line) and without this constraint(dotted line).

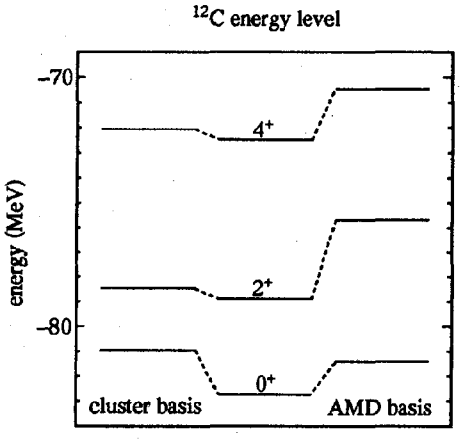

Figure 2: The 0^+, 2^+ and 4^+ energy levels of ^{12}C, α-cluster basis states (left), α-breaking states (right) and coupled calculation (center). The strength of G3RS force 1500 MeV is used.