α-correlation in ^{108}Cd excitation energy spectrum of α removal from ^{112}Sn

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We employed number- and angular-momentum-constrained Hartree-Fock-Bogoliubov (CHFB) equations for ^{108}Cd and ^{112}Sn using the same set of parameters. The parameters were quadrupole-quadrupole force strength $\chi_p = \chi_n = -0.04$ and $\chi_{pn} = -0.13$ in unit of MeV/b^4, monopole-pairing force $g_p = -0.24$ and $g_n = -0.18$ in unit of MeV, and quadrupole-pairing force with 10% g in unit of MeV/b^4, where b is the oscillator length. We excluded a tensor-type force between proton-neutron pairs. Figure 1(A) shows a comparison of the theoretical and experimental backbending curves[1] of ^{108}Cd (circles) and ^{112}Sn (triangles). The theoretical values (solid) match the experimental ones (open) reasonably well for both nuclei. For ^{112}Sn, a vibrational level scheme with a constant energy shift after the 2^+ state is observed, whereas ^{108}Cd shows a rotational one in which the proton pairing gap reoccures at the 10^+ state. For ^{108}Cd, the deformation parameter β_2 is almost constant (~ 0.15) in the range of $0^+ \sim 16^+$ states, whereas γ ranges from $-2°$ to $5°$ depending on total angular momentum I (almost prolate shape). In contrast, for ^{112}Sn, β_2 remains zero, and γ is zero in the 0^+ state (prolate shape) and approximately $60°$ in the $2^+ \sim 10^+$ states (oblate shape). For ^{112}Sn, the proton pairing gap vanishes as a natural result of the magic number, and its neutron pairing gap of 1.61 MeV is 1.2 times that of ^{108}Cd in the 0^+ state. We consider that the microscopic process creates an α-particle by the reaction, ^{112}Sn$(p, p\alpha)^{108}$Cd[2] is as follows. We assume a physical picture that ^{112}Sn is composed of excited ^{108}Cd and an α particle, and that the final stage is the energy spectrum of the observed ^{108}Cd. The overlap between the initial and final states includes the α-correlation, $\langle \sum_{i>0}(4/(2j_i+1))C_{i\in p}C_{\hat{i}\in p}C_{i\in n}C_{\hat{i}\in n} \rangle = \sum_{i>0}(4/(2j_i+1))\kappa^p_{ii}\kappa^n_{ii}$. In the expression, the factor comes from the Clebsch−Gordan coefficient to form iso-triplet pairs, $C_{i\in\tau}$ is the spherical single-particle operator belonging to τ (proton or neutron), ket $\rangle$ is the quasivacuum of the yrast state of I, and κ^τ_{ii} is the pairing matrix for the τ-shell in ^{108}Cd. In Fig. 1(B), the square of the α-correlation is shown as a function of the excitation energy. Owing to the recurrence of the proton pairing gap, the square of the α-correlation has two peaks as a function of I, one at the 0^+ state and another bump at the 10^+ state (~ 3.4 MeV). The highly excited state corresponds to the high-spin states of Cd in the final stage of the reaction. The ratio of the ground state peak to the second peak at 3.4 MeV is approximately 0.45, which coincides with the experimental value of 0.43 from Fig. 3A in Ref. 2). Summarizing we show that the CHFB calculation reproduces the basic feature of the reaction as well as the high spin states of ^{112}Sn and ^{108}Cd; however, the r-coordinate and/or a finite range formalism are required particularly for the description of an α particle.

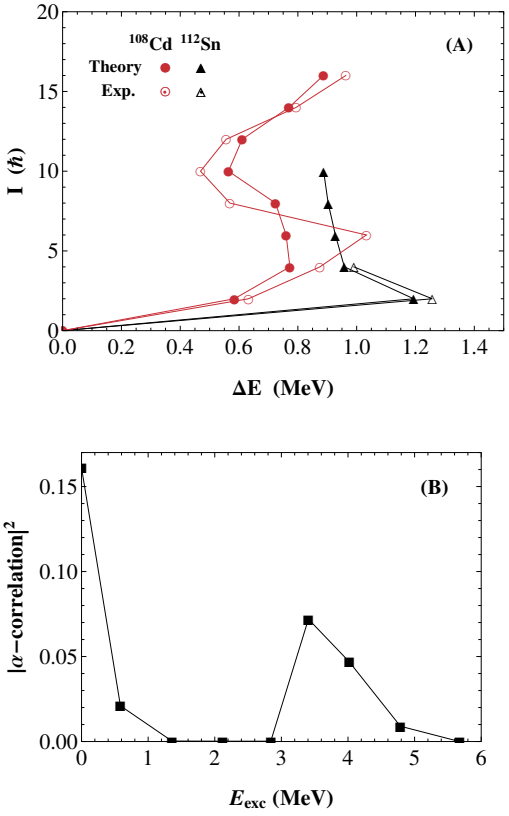

Fig. 1. (A): Comparison of theoretical backbending plots of ^{108}Cd (closed circles) and ^{112}Sn (closed triangles) with experimental data (open symbols) from isotope table.[1] Abscissa is total energy difference $\Delta E = E(I) - E(I-2)$ for $I \geq 2$. Ordinate is for total angular momentum I. (B): A square of α-correlation in ^{108}Cd as functions of $E_{\rm exc} = E(I) - E(0)$, where $E(I)$ is the total energy of $\langle H \rangle$ at I.

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References
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