Reentrant of the pairing gap and α-correlation in ^{108}Cd

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Motivated by the experimental data of the reaction ^{112}Sn$(p,p\alpha)^{108}$Cd,[1] we solved the number- and angular-momentum-constrained Hartree–Fock–Bogo liubov equation for ^{108}Cd by using the signature-invariant representation. We started from the spherical single-particle energies and included all the direct and exchange contributions from the residual monopole and quadrupole pairing, and quadrupole–quadrupole interactions among the same isospin shells and between the proton (p) and neutron (n) shells. The canonical base represents the diagonalization of densities in the generalized density matrix[2] at the minimum point of the total Hamiltonian determined under the constraints self-consistently. We found, for the first time, the canonical base including the Coriolis coupling term, which provides details of the nuclear structure that depends not only on the particle number, but also on the angular-momentum I.

In Fig. 1(A), we compare the theoretical backbending curve with the experimental one.[3] The theoretical values (squares) reproduce the experimental ones (circles) reasonably well. The backbending appears from the 6^+ state and the yrast level jumps to the new band at the 10^+ state. In Fig. 1(B), the average pairing gap $\bar{\Delta}_{\tau\pm} = \sum_{i\epsilon\tau\pm} \bar{\Delta}_{\hat{i}i}/N_{\tau\pm}$ is calculated for each shell, where $\bar{\Delta}_{\hat{i}i}$ represents the level-dependent gap in the canonical base, τ indicates p or n shell, and $\pm$ the parity of the shell. $N_{\tau\pm}$ is the total level number belonging to the $\tau\pm$ shell. The gradual decrease in $\bar{\Delta}_{\tau\pm}$ for $\tau = p$ or n is due to the Coriolis anti-pairing effect. The figure shows a sudden increase in the proton gap between the 8^+ and 10^+ states, which indicates that the reentrant of the proton pairing gap appears in high-spin states in ^{108}Cd. The single-particle energies in the canonical base, which includes self-energy, chemical potential, and the cranking term, show that the $1g_{7/2,\,1/2}$ level in the $p+$ shell comes down to the Fermi surface suddenly from the 8^+ state to the 10^+ state. This triggers the reentrant of the proton gap. The single-particle energy in the canonical base also indicates that the $1h_{11/2,\,1/2}$ level in the $n-$ shell causes the backbending.

Owing to the reentrant of the proton pairing gap, the α-correlation defined by $\langle \sum_{i>0} C_{i\epsilon p} C_{\hat{i}\epsilon p} C_{i\epsilon n} C_{\hat{i}\epsilon n} \rangle = \sum_{i>0} \kappa^{p}_{\hat{i}i} \kappa^{n}_{\hat{i}i}$ as a function of I has two peaks, one at the 0^+ state and the bump at the 10^+ state (~3.4 MeV), where $C_{i\epsilon\tau}$ denotes the spherical single-particle operator, $\rangle$ denotes the quasiparticle vacuum corresponding to I, and $\kappa^{\tau}_{\hat{i}i}$ denotes the pairing matrix in the τ-shell.

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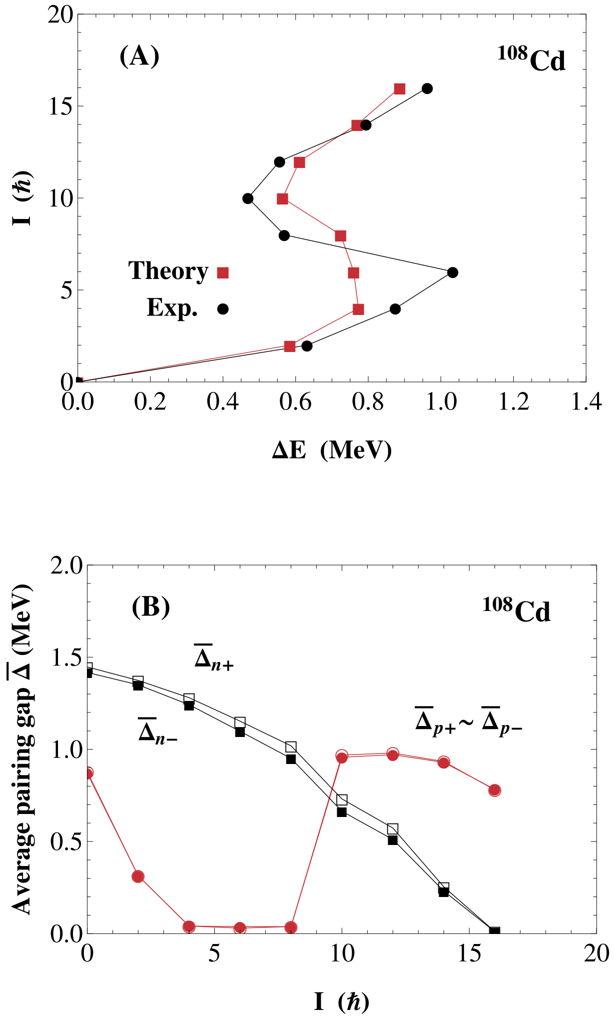

Fig. 1. (A): Comparison of the theoretical backbending plot for ^{108}Cd with the experimental data.[3] The abscissa represents the total energy difference $\Delta E = E(I) - E(I-2)$ for $I \geq 2$, and the ordinate the total angular momentum I. Theoretical values are indicated by squares, and experimental ones by circles. (B): The average pairing gap $\bar{\Delta}$ in each shell as a function of angular momentum I. Solid and open symbols indicate the results on "−" and "+" parity shells, respectively. The squares indicate the values for the n shell, and the circles for the p shell.

References

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