Three-body model calculation of the 2^+ state in ^{26}O†

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We discuss the 2^+ state of ^{26}O using a three-body model of an ^{24}O+n+n system with full account of the continuum. The decay energy spectrum for a given angular momentum I can be evaluated as

$$\frac{dP_I}{dE} = \sum_k |\langle\Psi_k^{(I)}|\Phi_{\rm ref}^{(I)}\rangle|^2\,\delta(E-E_k), \tag{1}$$

where $\Psi_k^{(I)}$ is a solution of the three-body model Hamiltonian with angular momentum I and energy E_k, and $\Phi_{\rm ref}^{(I)}$ is the wave function for a reference state with the same angular momentum. For a reference state we use the uncorrelated state of ^{27}F with the neutron $|[1d_{3/2}\otimes 1d_{3/2}]^{(IM)}\rangle$ configuration, which is dominant in the ground state of ^{27}F.

With a contact interaction, the continuum effects on the decay energy spectrum can be taken into account in terms of the Green's function. Notice that Eq. (1) can be expressed as

$$\begin{aligned}\frac{dP_I}{dE} &= -\frac{1}{\pi}\Im\sum_k\langle\Phi_{\rm ref}^{(I)}|\Psi_k^{(I)}\rangle\,\frac{1}{E_k-E-i\eta}\,\langle\Psi_k^{(I)}|\Phi_{\rm ref}^{(I)}\rangle,\\ &\equiv -\frac{1}{\pi}\Im\langle\Phi_{\rm ref}^{(I)}|G^{(I)}(E)|\Phi_{\rm ref}^{(I)}\rangle,\end{aligned} \tag{2}$$

where $\Im$ denotes the imaginary part and η is an infinitesimal number and $G^{(I)}(E)$ is the correlated Greens's function. The correlated Greens's function will be constructed using the unperturbed Green's function.

The upper panel of Fig. 1 shows the decay energy spectrum of ^{26}O for $I=0$ (dashed line) and I=2 (solid line). For presentation purposes, we set η in Eq. (2) to be a finite value, i.e., $\eta = 0.21$ MeV[1)]. For comparison, we also show the spectrum for the uncorrelated case with a dotted line, which gives the same spectrum both for $I=0$ and $I=2$. For the uncorrelated case, the spectrum has a peak at $E=1.54$ MeV, which is twice the single-particle resonance energy, 0.77 MeV. With the pairing interaction between the valence neutrons, the peak energy shifts towards lower energies. The energy shift ΔE is larger in $I=0$ than in $I=2$, i.e. , the peak in the spectrum appears at $E=0.148$ MeV ($\Delta E=-1.392$ MeV) for $I=0$ and at $E=1.354$ MeV ($\Delta E=-0.186$ MeV) for $I=2$.

We have shown that the 2^+ state appears at approximately $E=1.35$ MeV. This 2^+ energy is close to, but slightly smaller than, the unperturbed energy, $E=1.54$ MeV, and thus the energy shift from the unperturbed energy is much smaller than the energy shift for the 0^+ state. We have argued that this is a typical spectrum well understood by the single-j model with the pairing residual interaction. Many shell model calculations such as the ab initio[3)] and USDA and USDB[4)] calculations have predicted the excitation energy of the 2^+ state in ^{26}O in the opposite trend, i.e., they have predicted a higher energy than the unperturbed energy. The energy of the 2^+ state needs to be urgently confirmed experimentally[5)] in order to clarify the validity of nuclear models and effective interactions in nuclei on and beyond the neutron drip-line.

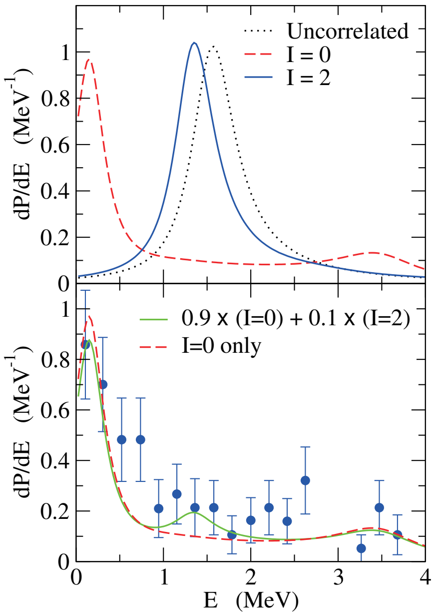

Fig. 1. (upper panel) The decay energy spectrum for the two-neutron emission decay of ^{26}O. The dashed and solid lines represent the 0^+ and 2^+ states, respectively. The dotted line shows the uncorrelated spectrum obtained by ignoring the interaction between the valence neutrons. (lower panel) The decay energy spectrum obtained by superposing the $I=0$ and $I=2$ components. The dashed line is the decay energy spectrum for the pure $I=0$ configuration. The experimental data, normalized to the unit area, are taken from Ref.[2)].

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