Comment on "Question of low-lying intruder states in ^{8}Be and neighboring nuclei"

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Calculations by Fayache *et al.* [Phys. Rev. C **57**, 2351 (1998)] find no low-lying intruder states in ^{8}Be, in contrast with the situation in ^{10}Be and ^{12}C. It is argued that the models they used are not sufficiently realistic for their results to settle the question of whether or not such states exist in ^{8}Be. [S0556-2813(99)02005-1]

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Fayache *et al.* [1] use various models to calculate the energies of states in ^{8}Be, ^{10}Be, and ^{12}C, in order to see if there are low-lying intruder states in ^{8}Be, similar to the known 0^+ states at 6.18 MeV in ^{10}Be and 7.65 MeV in ^{12}C. Fayache *et al.* do not find such states in ^{8}Be.

Fayache *et al.* imply that I suggested [2,3] that there should be low-lying intruder states in ^{8}Be on the basis of the systematics of intruder states in neighboring nuclei, and that this suggestion was made in response to the statement by Warburton [4]: "It is found that satisfactory fits are obtained without introducing intruder states [in ^{8}Be] below 26 MeV excitation."

Actually the suggestion regarding ^{8}Be intruder states was made much earlier [5], and the main basis for it was that consistent *R*-matrix fits to $\alpha+\alpha$ scattering phase shifts and data from reactions such as ^{9}Be$(p,d)^8$Be and ^{8}Li$(\beta^-)^8$Be$(\alpha)^4$He required large $\alpha+\alpha$ channel radii (≈ 7 fm) and consequently low-lying ($\lesssim 10$ MeV) 0^+ and 2^+ states, with large α-particle reduced widths. Warburton [4] avoided such low-lying states by using a smaller channel radius (4.5 fm), but he could then obtain "satisfactory fits" only by using different values of the *R*-matrix parameters for the scattering and the reaction data [2].

In Ref. [5], the *R*-matrix states were interpreted as intruder states, because the $0\hbar\omega$ shell model calculations that were available then [6] predicted small α-particle reduced widths for all 0^+ and 2^+ states of ^{8}Be except the lowest, and gave the second 0^+ state above the lowest $T=1$ state, known to be at about 16.8 MeV. In these calculations, the 0^+ levels observed at 6.18 MeV in ^{10}Be and 7.65 MeV in ^{12}C also have to be considered as intruder states.

Fayache *et al.* have made shell model calculations with three different interactions. For two of these (but not the third), they find intruder states in ^{10}Be at much lower energies than those in ^{8}Be, and conclude that "the presence of a low-lying intruder state in ^{10}Be does not imply that there should be a low-lying intruder state in ^{8}Be." These interactions, however, also predict low-lying nonintruder states in ^{10}Be that are not seen experimentally, and to that extent they are not very realistic. A recent calculation with a more realistic interaction [7] finds no low-lying intruder states in either ^{8}Be or ^{10}Be; as noted there, such calculations (including those of Fayache *et al.*) using a harmonic-oscillator basis would not be expected to predict states of the type suggested by the *R*-matrix fits to ^{8}Be data, as they are very unbound.

Fayache *et al.* also used the deformed oscillator model with volume conservation and self-consistent frequencies to calculate the energies of intruder states in ^{8}Be, and in order to check the model, they did similar calculations for ^{10}Be and ^{12}C, for which low-lying intruder states are assumed known. They found 0^+ intruder states at 6.55 MeV in ^{12}C, close to the experimental value of 7.65 MeV, and at 6.36 MeV in ^{10}Be, in good agreement with the experimental 6.18 MeV. For ^{8}Be, their lowest 0^+ intruder state was at 17.23 MeV. They again conclude that the presence of low-lying intruder states in ^{10}Be and ^{12}C does not imply that there will be low-lying intruders in ^{8}Be, and seek to understand this by considering the Nilsson diagram.

The diagram that Fayache *et al.* show in their Fig. 1 is, however, only half of the Nilsson diagram, corresponding to prolate deformations. By labeling the abscissa $|\beta|$, they imply that the diagram is symmetric about $\beta=0$, but this is not so. It is difficult to see how an argument based on the prolate side of the Nilsson diagram can be used to compare ^{12}C and ^{8}Be, as ^{12}C is oblate.

There appear to be some errors and omissions in Table VIII of Fayache *et al.* One of the errors is that, for ^{10}Be, $\langle J_y^2\rangle$ for the $(0\text{p-}0\text{h})_{\text{triaxial}}$ state should be 6.35 (rather than 2.3). As a consequence, the predicted energy of the 0^+ intruder state should be 9.55 MeV, rather than 6.36 MeV. It seems, however, that a factor of 1/2 is missing from the right-hand side of Eq. (16) of Fayache *et al.*; when this is corrected, the predicted energy of the 0^+ intruder state becomes 2.48 MeV, and that of the $(0\text{p-}0\text{h})_{\text{axial}}$ nonintruder state 4.76 MeV (instead of 10.39 MeV as given in Table VIII). Each of these energies is appreciably less than the observed 6.18 MeV. For ^{12}C, the formulas of Fayache *et al.* (with the factor of 1/2) predict 0^+ nonintruder states, omitted from Table VIII, at 4.06 MeV (triaxial) and 8.20 MeV (axial); such low-lying states are not observed.

For ^{8}Be, in addition to the states considered by Fayache *et al.*, their model predicts 0^+ nonintruder states at 7.22 MeV (triaxial) and 11.88 MeV (axial). Both lie well below the lowest 0^+ intruder state calculated with this model, but they have small α-particle reduced widths and so cannot be interpreted as the 0^+ *R*-matrix state.

These predictions of low-lying 0p-0h 0^+ states in ^{8}Be,

^{10}Be, and ^{12}C, in disagreement with experiment, suggest that this deformed oscillator model is not appropriate for these nuclei.

In summary, it seems that the shell model interactions and the deformed oscillator model used by Fayache *et al.* [1] in their calculations are not sufficiently realistic for their results to have much bearing on the question of whether or not there are low-lying intruder states in ^{8}Be.

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