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ABSTRACT

A comment is made on the calculation of Wang _et_ _al_. [Chinese J. of Phys. (Taipei) _11_, 65 (1973], where admixture of $3\hbar\omega$ excitations in the dipole resonance of ^{16}O was considered.

A recent calculation of Wang et al.,[1] hereafter referred to as I, shows little admixture of $3\hbar\omega$ excitations in the giant dipole region (20-26 MeV) of ^{16}O. This calculation does not reproduce the intermediate structure in the giant resonance region due to very weak couplings of the $3\hbar\omega$ excitations to the $1\hbar\omega$ excitations. The discrepancy between the theory and experiments were attributed to the following reasons: 1) the truncation of the $3\hbar\omega$ excitations at $1d_{3/2}$ state in their model spaces, 2) ground-state correlations of ^{16}O, and 3) interferences due to E2 and M1 excitations.

In this comment, we would like to show that the above reasons may not be well-founded and, therefore, a more detailed study of the approximations used in I is of interest. The comments to be presented are based on a continuum shell-model calculation,[2] where $3\hbar\omega$-$1\hbar\omega$ configuration mixings were considered and were found sufficient to interpret the intermediate structure in the photodisintegration of ^{16}O (this work will be referred to as II). The results of the calculation II are the following. The two main peaks in the giant dipole resonance region at 22.3 and 24.5 MeV are mainly $1\hbar\omega$ excitations (1 particle-1 hole states), as found in I. The resonances at 21, 23 and 25 MeV are mainly $3\hbar\omega$ excitations (3 particle-3 hole states). For details, one should refer to II.

In II, we have considered essentially the same model space as that used in I. Although we have also included the $p_{3/2}$ hole state in the $3\hbar\omega$ excitations, the state was found to be not important. We believe that the truncation of the model space at $1d_{3/2}$ is consistent with the continuum shell model approach to nuclear reactions and should be particularly sufficient for the analysis of the relatively narrow resonances as the dipole states in ^{16}O. Single particle states at higher energies are in the continuum (with no pronounced resonance) and, therefore, should not have strong effect in producing narrow resonances.

Within the above model space, the mixing between odd-$\hbar\omega$ and even-$\hbar\omega$ excitations is completely forbidden. The ground-state correlations are generally of even-$\hbar\omega$ excitations (normal parity) in ^{16}O. The effects of the ground-state correlation may renormalize the effective particle-particle and the electromagnetic interactions. These effects are partially taken into account by the force determined from experimental levels, as done in I. It is important to note that, e.g. in RPA calculations, the couplings between the 1$\hbar\omega$ and 3$\hbar\omega$ excitations are not affected by the ground-state correlations. These features may be more transparent in the interacting-boson approximation (IBA) as proposed by Feshbach and Iachello,[3] which was used in II. The ground-state correlations are reproduced by mixing only the even-$\hbar\omega$ states (completely ignoring the odd-$\hbar\omega$ states). The odd-$\hbar\omega$ states are then treated separately. So, the ground-state correlations have no effect on the mixing of 3$\hbar\omega$ to 1$\hbar\omega$ excitations, except for an overall energy normalization. Generally we believe that the ground-state correlations do not cause any <u>sharp</u> resonances in the dipole strength distributions.

It is also not possible to attribute the intermediate structure in the dipole region to the interference of other multipoles, such as E2 or M1 amplitudes. Since the total absorption cross section depends only on the <u>squares</u> of the amplitudes, there is no interference effect. In order to produce resonances in the total cross section, we need narrow resonances in the M1 or E2 amplitudes. Experimentally, such a possibility does not seem to exist, as shown by the angular distribution,[4] and the polarized proton capture by ^{15}N leading to the giant resonance states of ^{16}O.[5] A theoretical investigation also does not support a sharp E2 resonance.[6]

From the above considerations, the most likely reason for the difference in the mixing strength of $3\hbar\omega$ and $1\hbar\omega$ in I and II is in the approximations used in the shell model calculations. There is already a similarity between I and II in that the residual interaction could bring the $3\hbar\omega$ excitations down to the giant dipole region. This feature is very crucial in our understanding of the structure of ^{16}O. Since an exact shell-model calculation is quite formidable, the approximations used in I should be of interest as a comparison to the IBA, despite the fact that there is little mixing in I.

The comparison between I and the IBA may also be extended to induce the low-lying non-normal parity states, which are shown to contain rather important admixture of $3\hbar\omega$ and also $5\hbar\omega$ states.[3]

In conclusion, we would like to point out the importance of the above suggestions: 1) The structure of the giant resonance of ^{16}O is very important in the understanding of the properties of nuclear excited states, as indicated by the early development of the particle-hole interpretation of the gross structure of the giant resonance; and 2) the calculation of I seems to support the importance of the particle-particle and hole-hole interaction as shown in the IBA calculations. Since the exact relation between the IBA and the usual shell model approximations is not yet clear, a more detailed study of I and its comparison to the IBA should be useful.

FOOTNOTES AND REFERENCES

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