COMMENTS

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Comment on ''Continuum Tamm-Dancoff approximation calculations for the escape widths of the isobaric analog state and Gamow-Teller resonance in ^{208}Bi''

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We comment on a recent paper by Knobles, Stotts, and Udagawa [Phys. Rev. C **52**, 2257 (1995)]. It is pointed out that this model is inconsistent as far as the relationship between the mean field and effective residual interaction is concerned. Furthermore, the conclusions drawn by these authors about the validity of other treatments of continuum effects are incorrect. [S0556-2813(96)04309-9]

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In a recent paper [1] a calculation of proton escape widths from the isobaric analog resonance (IAR) and Gamow-Teller resonance (GTR) of the nucleus ^{208}Bi has been presented. The model which is used is a simple one-particle–one-hole Tamm-Dancoff approximation (TDA) where the effects of the single-particle continuum are fully treated by calculating the strength functions in coordinate space. However, in order to simulate some physical damping effects which lie outside the one-particle–one-hole space the authors of [1] have also included in the model a one-body complex optical potential acting only on the particle, in the GTR case (but not in the IAR case). Furthermore, it is contended that other calculations of particle escape widths where the projection operator method is used [2,3] do not treat accurately the continuum coupling and consequently they predict the wrong relative magnitudes of $\Gamma^{\uparrow}_{p1/2}$ and $\Gamma^{\uparrow}_{p3/2}$ for the IAR. In this Comment, we would like first to draw attention to the fact that it is unjustified in general and, more especially in the GTR case, to have optical potential insertions in the particle lines, and second, to re-establish the facts as far as the treatment of the continuum by the projection operator method is concerned.

The question of how to incorporate damping mechanisms in a microscopic theory has been extensively studied in the literature for both the general case and the particular case of the GTR in ^{208}Bi. In models based on a one-particle–one-hole space like the TDA or random phase approximation (RPA) there is no other effect which can broaden the line shape apart from particle escape due to continuum coupling and the so-called Landau damping which reflects the dispersion of the particle-hole energies. To go beyond the simple TDA or RPA, one may try to open up the configuration space to include two-particle–two-hole states and solve a much heavier numerical problem (second TDA or second RPA). Alternatively, one may decide to modify in a heuristic way the effective Hamiltonian in the one-particle–one-hole subspace. In the latter method there are general guidelines which restrict the freedom of changing the Hamiltonian. These guidelines are provided by the requirement of a ''gauge-invariant'' theory. The result is that self-energy insertions in particle and hole lines are in general accompanied by vertex renormalizations [4]. In other words, if the original Hamiltonian contains a self-energy Σ and a particle-hole interaction V_{ph}, then an additional self-energy term $\Delta\Sigma$ will produce a vertex correction ΔV_{ph} related to the functional derivative of $\Delta\Sigma$. In giant resonance studies some attempts have been made to introduce phenomenologically [5] a complex ΔV_{ph} interaction which is determined in relation to $\Delta\Sigma$.

In Ref. [1] a $\Delta\Sigma$ term is indeed introduced in the form of an imaginary potential acting on the particle line in the GTR case and $\Delta\Sigma = 0$ in the IAR case. Because the interactions V_{ph} are phenomenologically adjusted, it is not possible to check the consistency between self-energies and vertex functions. However, one may wonder about the physical justifications of treating the particle and the hole on different footings or using different prescriptions for different modes of excitation. For instance, to apply this approach to the isovector monopole resonance (IVMR) would require one to use the same V_{ph} as for the IAR, since both IVMR and IAR are isovector non-spin-flip modes, but to choose $\Delta\Sigma = 0$ would give no damping width while a nonzero value of $\Delta\Sigma$ would raise the question of consistency between self-energies and the residual interaction.

The microscopic approach where a well-defined Hamiltonian is solved in a two-particle–two-hole space [2] or in a one-particle–one-hole plus phonon space [6] is free from the above mentioned inconsistencies. In Ref. [2] it is shown that the right order of magnitude for the energy and damping

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width of the IAR can be obtained with an effective Skyrme interaction as the only input. In that work the proton escape widths are also correctly calculated by the projection operator method (our criteria of correctness of results are not related to a good fit of the data, as we shall discuss below). The interplay between the self-energy insertion and vertex renormalization is more easily understood if one considers the particle- (hole-) phonon coupling model [6]. There is generally some degree of cancellation between insertion diagrams (a phonon is emitted and reabsorbed by the same particle or hole line) and crossed diagrams (a phonon is exchanged between a particle and a hole line). An extreme case occurs for the isoscalar monopole resonance where the cancellation is complete in a rather model-independent way [7]. This has been confirmed by detailed calculations where it is found [8] that the damping width of the isoscalar monopole resonance is indeed small, most of the 2 MeV calculated total width being due to Landau and escape widths. For the GTR, detailed analyses [9,10] show that the sum of crossed diagrams cancels about one-half of the summed insertion diagrams. It seems unlikely that keeping only an imaginary $\Delta\Sigma$ acting on the particle can be a correct prescription for the GTR even though reasonable numerical results can be obtained by adjusting the parameters. Note that the same Hamiltonian as that of Ref. [8] has been applied to calculate the damping of the GTR [11], resulting in a damping width of about 2.5 MeV. Thus, damping widths of collective excitations can be understood systematically, at least qualitatively, without *ad hoc* adjustments of the models.

It could be argued that two-particle–two-hole calculations or the particle-phonon coupling model do not lend themselves to an accurate treatment of the single-particle continuum and that only a coordinate space solution of the TDA or RPA equations is capable of handling correctly the continuum effects whereas the projection operator method neglects some important continuum coupling. This opinion is expressed by the authors of Ref. [1] but we would like to point out that this belief is not well founded. It is observed in Ref. [1] that their model predicts $\Gamma^{\uparrow}_{p1/2} \leqslant \Gamma^{\uparrow}_{p3/2}$ whereas earlier calculations using the projection operator method [2,3] obtain $\Gamma^{\uparrow}_{p1/2} \geqslant \Gamma^{\uparrow}_{p3/2}$ for the IAR, a result that Ref. [1] could also reproduce if the diagonal coupling to continuum is neglected and thus it was concluded that the same neglect had been done in [2,3]. In fact, the difference in numerical results simply comes from the very different inputs of the three calculations, namely, the Skyrme force SIII in the case of [2,3] and a Woods-Saxon potential plus an adjusted $V_{\rm ph}$ for Ref. [1]. Partial escape widths depend sensitively on the mean field and the structure of the decaying state. This is illustrated in Ref. [3] where the same calculation performed with the Skyrme force SGII gives $\Gamma^{\uparrow}_{p1/2} \leqslant \Gamma^{\uparrow}_{p3/2}$.

The heart of the problem lies in the fact that the coupling between the discrete space Q and the continuum space P is described exactly by the operator

$$W^{\uparrow} \equiv Q(H_0+V)P\,\frac{1}{E^{(+)}-P(H_0+V)P}\,P(H_0+V)Q, \quad (1)$$

where H_0 and V are, respectively, the mean field and residual two-body interaction, but in practical calculations $W^{\uparrow}$ is calculated without V [12]. Of course, the accuracy of this approximation has been checked in the past. The general reason why this method of calculating $W^{\uparrow}$ should be valid is that the single-particle wave functions spanning Q space and P space are concentrated, respectively, in the inner and outer regions and, therefore, matrix elements of QVP must be small if V is short ranged. This argument is fully supported by case studies [13,14] where it is found that RPA nuclear response functions calculated either in coordinate space or using this approximation in the projection operator method coincide to a high level of accuracy.

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