Brief Reports

Gamow-Teller strength in the continuum

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We present the results of a decomposition of the angular distribution of the continuum observed in the ^{90}Zr(p,n) reaction at 200 MeV into different angular momentum transfers. We found significant amounts of $L = 0$ strength over a wide range of excitation energies in the continuum, which sums up to more than half of the missing Gamow-Teller strength.

NUCLEAR REACTIONS Continuum Gamow-Teller strength in (p,n) reaction.

Recently a simple model has been proposed[1] for the continuum part of the spectra as observed in medium energy proton scattering. This model, which considers the quasielastic scattering from the nuclear surface, is in good quantitative agreement with the data for 800 MeV (p,p').[2] For 200 MeV (p,n) on ^{90}Zr (Ref. 3) the same model calculation underpredicts the cross section at forward angles by about 2.0 mb/sr MeV at an excitation energy of 30 MeV. At larger angles ($\theta > 15°$) the calculation agrees with experiment. This discrepancy at forward angles might imply that the continuum contains a considerable amount of $L = 0$ transfer strength in addition to a real "background" due to quasielastic scattering. Since only about 30–40% of the Gamow-Teller (GT) strength (about 55% if all the cross sections under the GT peak are included[4]) is identified in the peak region,[5] the remaining fraction could be hidden in the background. In this Brief Report we will present an empirical estimate of the continuum strength, based on the measured angular distribution in the continuum.

In order to be more quantitative we have made a decomposition of the experimental angular distribution into several angular momentum transfer components, using the distorted-wave Born approximation (DWBA) angular distributions for individual L transfers. The optical model parameters were taken from Ref. 6, and we used as a form factor the derivative of a real Woods-Saxon potential with $V = 10$ MeV, $R_0 = 1.15$ fm, and $a = 0.16$ fm. At the momentum transfers ($q \lesssim 70$ MeV/c) in which we are interested, we can neglect the tensor force in the direct channel. The strength of the tensor force in the exchange channel is, however, highly uncertain. A strength comparable to that taken in Ref. 7 does not significantly alter the shape of the angular distributions. Since our results do not depend on an overall normalization factor, we have neglected the tensor force altogether. Because only $L = 0$ peaks at 0° the unfolding procedure works reasonably well for assigning the $L = 0$ strength.

We have made two different fits to the data. In the first we have fitted the excess cross section over the predicted quasielastic background at $E_x = 30$ MeV with a sum of $L = 0$, 1, and 2 angular distributions. As is shown in Fig. 1, this fit reproduces the data at all angles. In the second approach we fitted the experimental cross section as a sum of $L = 0$, 1, and 2 but disregarded the quasielastic background. Since the $L = 2$ angular distribution falls off sharply beyond $\theta = 10°$, we considered only the data at $\theta < 10°$ in our fit. Both procedures resulted in the same amount of $L = 0$ cross section, which is about 40% of the total cross section at $\theta = 0°$. Since the latter method is independent of the model of the background, we repeated the same analysis also at $E_x = 15$ and 45 MeV. We found almost the same $L = 0$ spectroscopic strength at these energies, although the actual $L = 0$ cross section at 0° is falling sharply with increasing excitation energy. We should note here that the extraction of the $L = 0$ strength at higher energies
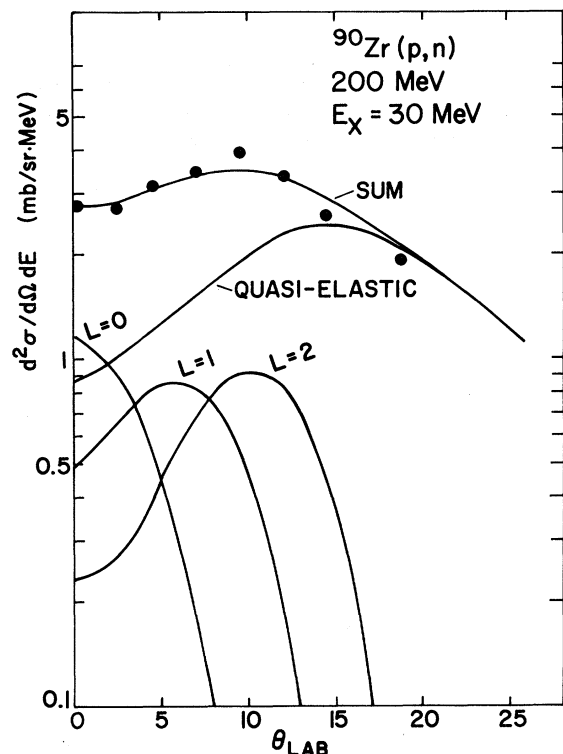
FIG. 1. Decomposition of the angular distribution into several angular momentum transfers observed in the 200 MeV (p,n) reaction on ^{90}Zr at $E_x = 30$ MeV in excess of the quasielastic background as calculated in Ref. 1.

$(E_x \gtrsim 50$ MeV) in this method becomes difficult because the $L = 1$ angular distribution becomes forward peaked also, due to large momentum transfer even at $\theta = 0°$. The extracted $L = 0$ strength would correspond to the cross section of 2 mb/sr MeV at $\theta = 0°$ at the energy loss of the Gamow-Teller resonance. The estimated uncertainty in the determined $L = 0$ cross section is estimated to be 30%. The determined $L = 0$ strength does not change if higher angular momenta transfers, $L > 2$, are included in the fit since their strength vanishes at small angles. If we assume the same strength over the energy interval between 15 and 45 MeV as supported by our analysis, we could account for about half of the missing GT strength.[5] The remaining $L = 0$ strength could lie above $E_x \geq 50$ MeV but its identification becomes impossible at this high energy as mentioned above.

In conclusion, we found a significant amount of the $L = 0$ strength in the continuum over a wide range of excitation energy. This finding agrees with the result of the recent calculation of Bertsch and Hamamoto[8] where the large fraction of the GT strength is predicted to move into the continuum due to the coupling to the two-particle two-hole configurations. It would be useful to extend this analysis to other cases, to better understand the problem of the missing Gamow-Teller strength.

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