Comments

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Comment on the evidence for a monopole resonance at approximately 20 MeV in ^{58}Ni

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Small-angle inelastic α scattering data for ^{58}Ni at 129 MeV have been reanalyzed with the giant resonance peak parameters suggested by Bertrand *et al.* The two components of the giant resonance peak, assumed by them to correspond to $L=0$ and $L=2$, respectively, are found to have similar angular distributions between 0°–8° where large differences between these multipolarities should exist. This is not in agreement with their interpretation of (p,p') and large-angle (α,α') data wherein a concentration of $L=0$ strength was suggested at 20 MeV in ^{58}Ni. Their data for the assumed $L=0$ component are shown in our analysis to be consistent with an $L=2$ transfer.

[NUCLEAR REACTIONS ^{58}Ni(α,α'); $E_\alpha=129$ MeV. Measured E_x, $\sigma(\theta)$, giant resonances; deduced L.]

Bertrand *et al.*,[1] using inelastic proton scattering and drawing upon the systematics for the giant monopole resonance (GMR) in heavier nuclei, reported evidence in ^{58}Ni for $30\pm10\%$ of the isoscalar $E0$ energy weighted sum rule (EWSR) in a peak at $E_x\simeq20.0$ MeV with $\Gamma\simeq3.5$ MeV. Recently, Bertrand *et al.*[2] have reported an analysis of inelastic α-scattering measurements at 152 MeV between 5°–7° and 12°–25°. They suggest that a component of the giant resonance (GR) peak at $E_x\simeq20$ MeV in ^{58}Ni could be assumed to be the GMR depleting $40\pm10\%$ of the $L=0$ EWSR, which is consistent with the earlier proton work. Their assumptions regarding the GMR are consistent with other measurements except for ^{58}Ni. Results from the inelastic scattering of deuterons,[3] ^{3}He (Ref. 4), and α's (Ref. 5) have suggested that although there might be some evidence for a small $L=0$ strength spread over the entire GR region, the peak in the GR region in ^{58}Ni contains predominantly the giant quadrupole resonance (GQR) and corresponds to roughly 50% of the $L=2$ EWSR. In the only other measurement implying a concentrated $L=0$ strength in ^{58}Ni, Lebrun *et al.*[6] have reported a small amount of $L=0$ strength ($10\pm2\%$ EWSR) in a peak at 17.1 ± 0.2 MeV.

Several works[5,7] have demonstrated that inelastic α-scattering angular distributions may be readily used to distinguish $L=0$ from $L=2$ transfer if the first minimum in the $L=0$ distribution can be observed. For 152 MeV α's, this occurs at approximately 3°, which is well below the angular region measured in Ref. 2. At larger angles, the $L=0$ and $L=2$ distributions differ primarily in the relative peak/valley heights, a feature that is strongly dependent upon the continuum subtraction. As the authors of Ref. 2 point out, in their analysis of proton data they must account for the giant dipole resonance (GDR) which is almost coincident with the reported monopole strength; the featurelessness of the angular distributions in proton scattering at their energy increases the difficulty of separating the GR peaks.

We had earlier presented results from inelastic scattering of 129 MeV α's from ^{58}Ni over the angular range 0°–8° which contains the first minimum in the $L=0$ distribution.[5] A reanalysis of our data in the GR region, using the parameters of the two GR components assumed in Refs. 1 and 2 to correspond to $L=2$ and $L=0$ transfer, respectively, shows that these components have similar angular distributions in the angular range 0°–8°. Moreover, both distributions can be fitted reasonably well assuming an $L=2$ transfer only.

The experimental procedure for these measurements, including data-reduction techniques and the

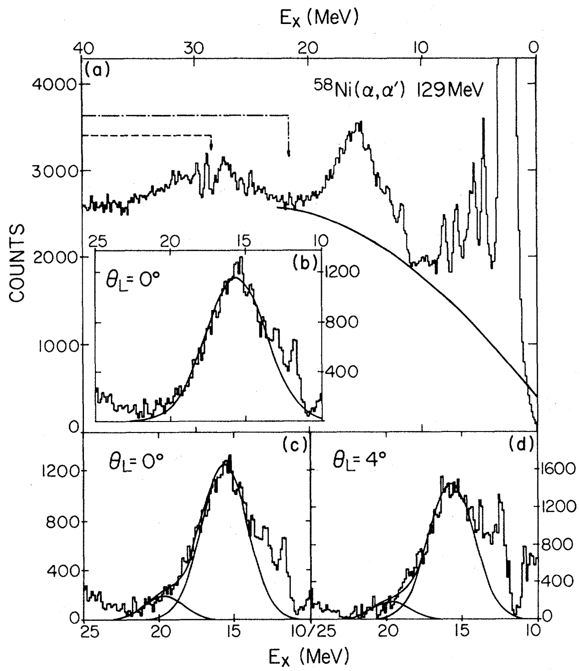

FIG. 1. (a) Inelastic α spectrum for ^{58}Ni at 0°. The assumed background is shown superimposed. The dashed and dotted-dashed lines, respectively, show kinematic limits for the ^{5}He and ^{5}Li pickup and decay channels. It should be noted that there was a drafting error in showing these limits in Fig. 5 of Ref. 5. (b) Subtracted spectrum in the GR region at 0°. One-peak fit is shown superimposed. (c) Same as (b) with the two-peak fit, as described in the text, shown superimposed. (d) Same as (c) for 4°.

distorted wave Born approximation (DWBA) calculations, has been described in detail in Ref. 7. For ^{58}Ni, data were taken at 0° and at seven angles between 3° and 8°. The spectrum at 0°, where the GMR strength should be maximal, is shown in Fig. 1(a); the solid line shows the assumed shape for the continuum. After subtracting this background, the GR regions in all of the spectra were fitted simultaneously using a multiple-spectrum fitting routine. It should be noted that there are clearly several narrow peaks on the low-energy side of the GR. Extensive attempts to obtain consistent fits to these lower excitation peaks in all of our spectra proved unsuccessful. Hence, the GR peak was fit in the region above $E_x \approx 14.0$ MeV. The best fit was obtained for a single peak with $E_x = 15.6 \pm 0.3$ MeV and $\Gamma = 4.7 \pm 0.3$ MeV; the fit for 0° is shown superimposed on the data in Fig. 1(b). The angular distribution for this peak is consistent with $L = 2$ transfer and corresponds to the depletion of $45 \pm 15\,\%$ of the EWSR. Two-peak fits were also obtained for the same region in the spectra, with the parameters of the two components fixed at the values given in Ref. 2. The resulting fit for 0°, where the monopole should be maximal, is shown in Fig. 1(c), and compared with 4°, where the monopole should be minimal [Fig. 1(d)]. As can be seen, the relative yields of the upper and lower peaks in the two spectra are about the same. Moreover, the two-peak fits are of poorer quality than the single-peak fit. The same holds true for all angles for which data has been obtained in our work. In fact, the only way we could obtain fits to the data with two relatively narrow peaks spaced approximately as suggested in Ref. 2 was by fixing the peak parameters E and Γ. "Free" fits invariably resulted in a small and very broad peak superimposed on the dominant peak. The fits shown in Figs. 1(c) and (d) correspond to a shift in the excitation energy of both the peaks by 300 keV from the values given in Ref. 2. This is within the combined experimental errors. Fixing the peak positions at the values given in Ref. 2 produces worse fits.

Using the results of the fixed-parameter, two-peak fits described above, we obtained the ratio of the cross sections of the higher (HE) and lower (LE) excitation-energy components, $(d\sigma/d\Omega)_{\rm HE}/(d\sigma/d\Omega)_{\rm LE}$, which is shown in Fig. 2(a). This ratio follows, more or less, a straight line within the error limits. Analyses of the small-angle data by regions[5] also produce the same conclusions. Except for the low-energy side of the GR where multiple structure is apparent, each portion of the GR peak has virtually the same angular distribution over 0°–8°. This is in contrast with the calculated ratio using the strengths quoted in Ref. 2 (40% $L=0$ and 45% $L=2$ EWSR, respectively) shown superimposed in Fig. 2(a). This affords clear evidence that the two GR components referred to in Refs. 1 and 2 are primarily of the same character ($L=2$) and is in agreement with other previously reported results.[3–5]

It is important to note that the alpha scattering measurements of Ref. 2 were made primarily at larger angles (> 10°) where both $L=0$ and $L=2$ have similar angular distributions. In fact, their data for the HE component is fitted well with an $L=2$ DWBA calculation. Figure 2(b) shows the data for ^{58}Ni from Ref. 2 along with the reported $L=0$ calculation (dashed line), and an $L=2$ curve corresponding to $\approx 11\%$ EWSR obtained by scaling the $L=2$ calculation for ^{58}Ni in Ref. 2 (solid line). The $L=2$ fit appears in fact to be somewhat better. Similarly, for the (p,p') data of Ref. 1, a combina-

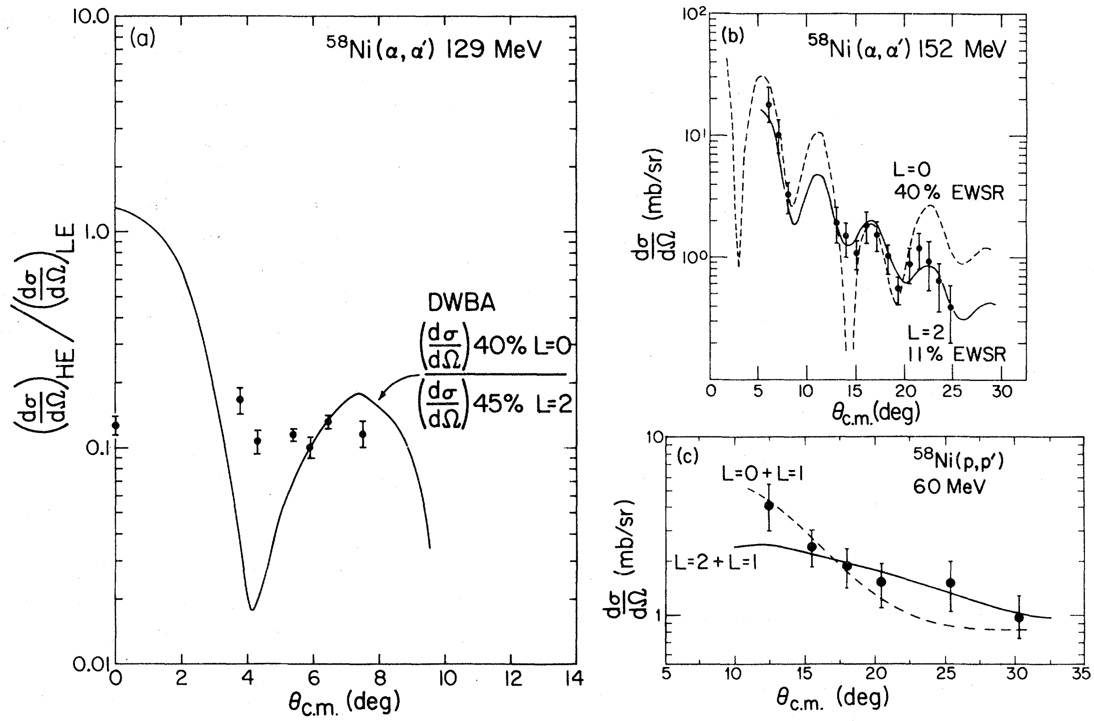

FIG. 2. (a) Ratio of the cross sections of the higher and lower excitation-energy components of the GR peak. The DWBA prediction for this ratio is also shown. (b) (α,α') data from Ref. 2 along with the DWBA fits for $L=0$ (dashed line) and $L=2$ (solid line) transfer with EWSR depletions as noted. (c) (p,p') data from Ref. 1 along with the fit reported therein (dashed line). Also shown is the DWBA prediction for a combination of 70° $L=1$ and 7% $L=2$ EWSR (solid line).

tion of $L=2$ (7% EWSR) and $L=1$ (70% EWSR) gives a fit which has a χ^2 value essentially the same as that for the fit corresponding to 70% $L=1$ and 30% $L=0$ EWSR. For the former calculation, the $L=2$ angular distribution was obtained by scaling the calculation shown in Ref. 8 and the $L=1$ component was taken directly from Ref. 1. These fits are shown in Fig. 2(c). Considering the uncertainties involved in the extraction of the EWSR percentages, the values thus obtained for the percentage of $L=2$ EWSR exhausted by the HE component in the (α,α') and (p,p') data are consistent.

These small-angle measurements indicate that the GR observed in ^{58}Ni is predominantly $L=2$ with no clear evidence for any concentrated monopole strength. However, similar measurements on ^{64,66}Zn (Ref. 9), in contrast with the ^{58}Ni results, do reveal a monopole state on the high side of the GQR containing approximately 30% of the $E0$ EWSR. The reasons for this difference need to be explored in terms of possible nuclear structure effects. As pointed out earlier, recent results from small-angle $(^3\text{He},^3\text{He}')$ measurements[6] have indicated a small concentration of monopole strength $(10\pm2\%$ $E0$ EWSR) in ^{58}Ni at 17.1 ± 0.2 MeV. This $L=0$ resonance is 2.9 MeV lower than that suggested by Bertrand *et al.*, [1,2] well outside the combined experimental error. Our data are not in disagreement with the conclusion of Ref. 6; however, fits to our data with the parameters of Ref. 6 result in a strength of the 17 MeV $L=0$ component consistent with zero. In fact, the $(^3\text{He},^3\text{He}')$ results are consistent with the earlier suggestions[3-5] of a small $L=0$ strength spread over the entire GR region.

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