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EXCITATION OF THE GIANT MONOPOLE RESONANCE BY PROTONS OF ABOUT 60 MeV*

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Abstract

Reanalysis of (p,p') spectra, using a reassessment of the giant dipole cross section provides evidence for a giant monopole resonance at $E_x \approx 80/A^{1/3}$ MeV in nuclei from ^{58}Ni to ^{208}Pb. The data for ^{40}Ca are consistent with the absence of any monopole strength at this excitation.

The existence of a giant quadrupole resonance (GQR) in many nuclei at $E_x \approx 63/A^{1/3}$ MeV has been confirmed previously by studies[1)] at ORNL of the inelastic scattering of protons of about 60 MeV. From this earlier work, it was clear that the observed peak was asymmetric and that its shape varied with angle, indicating the presence of an additional component at a slightly higher excitation energy with multipolarity $L \neq 2$. At that time it was assumed that this was due to excitation of the giant dipole resonance (GDR) and estimates of the cross sections to be expected seemed to be consistent with this assumption. However, recent work[2)] at Texas A & M on (α,α') to small scattering angles has established in an essentially model-independent way the existence of a giant monopole resonance (GMR) in ^{90}Zr, ^{144}Sm and ^{208}Pb at $E_x \approx 80/A^{1/3}$ MeV, i.e. at almost the same excitation energy as the GDR (which is excited with negligible probability by the isoscalar alpha

particle). Consequently, the proton data were re-examined with this in mind.

There are two main features of the present work which are new:

(i) The ambiguity over whether to use the Steinwedel-Jensen (SJ) or the Goldhaber-Teller (GT) model for the GDR form factor[1] was resolved by reference to the recent work of Myers, et al.[3] We simply used the mixture of these models suggested by curve (c) of Fig. 3 in Myers, et al.[3] Fortunately, this ambiguity has only relatively small effects on the predicted cross sections for proton scattering. In addition, the SJ transition potential was taken to be proportional to $j_1(2.08\ r/c)\ U_1(r)$, where c is the radius of the ground state density distribution, a more realistic assumption than the form $r\ U_1(r)$ used previously. Again the effect of this change is small, although it tends to make the SJ and GT predictions more nearly equal for scattering to small angles.

(ii) The isovector interaction term $U_1(r)$ of the optical potential has been a major source of uncertainty in previous calculations, especially since there are no data for (p,n) transitions to analogue states for $E_p \sim 60$ MeV (which would provide the most direct way of determining $U_1(r)$). Fortunately, there has been extensive work recently[4] on these (p,n) transitions for a range of nuclei at energies $E_p = 20$ to 45 MeV. This was accompanied by a global optical potential analysis, starting from the Becchetti-Greenlees global proton potential, and applied to fitting simultaneously data for (p,p), (p,n) and (n,n) in this energy range. This resulted in very good fits with potentials dependent upon N, Z, A and energy including, of course, the isovector term $U_1(r)$. We used these results (we used their set B), extrapolated to a proton energy of 60 MeV, to provide $U_1(r)$ and the optical potentials for the entrance and exit channels in DWBA calculations of the resonance excitation.

This procedure results in a U_1 potential which is considerably weaker than previously assumed,[1] hence it predicts much smaller cross sections for excitation of the GDR. For example, for Sm(p,p') the depth of the real part of U_1 is now 17.7 MeV instead of the 26 MeV used previously, while the imaginary part of U_1 is reduced even further, now 2.8 MeV instead of 15.5 MeV.

Consequently, the new calculations do not provide enough GDR cross section (except in the case of ^{40}Ca) to account for the additional cross section observed above the GQR. Further, the predicted angular distribution for the GDR is not in agreement with the observed results. However, agreement with experiment is obtained, in both cross section magnitude and angular distribution, by adding a contribution from the GMR excitation at the same excitation energy as the GDR ($E_x \approx 80/A^{1/3}$ MeV). The GMR contribution needed is about 100% of the energy weighted sum rule for ^{208}Pb, ^{197}Au, ^{144}Sm, ^{154}Sm and ^{120}Sn, falling to about 60% for ^{90}Zr and then to about 30% for ^{58}Ni. The excitation of the GDR alone is sufficient to account for the ^{40}Ca data. There is no evidence of any marked increase in the width of the GMR peak as A decreases.

Details of the data analysis and further details of the scattering calculations, as well as figures of the results, may be seen in Phys. Rev. C (Bertrand, et al., in press) and Phys. Letters (Bertrand, et al., in press).

References

1) F. E. Bertrand, Ann. Rev. Nucl. Science 26, 457 (1976); G. R. Satchler, in Proc. Int. School of Physics "Enrico Fermi", Course LXIX (North-Holland Publishing Co., Amsterdam, 1977).

2) D. H. Youngblood, et al., Phys. Rev. Lett. 39, 1188 (1977).

3) W. D. Myers, et al., Phys. Rev. C15, 302 (1977).

4) D. M. Patterson, et al., Nucl. Phys. A263, 261 (1976).