Splitting of the GMR and GQR in ^{154}Sm

D.H. Youngblood, Y.-W. Lui and H.L. Clark

It was shown from experimental data a number of years ago that the isoscalar giant quadrupole (GQR) [1] and giant monopole resonances (GMR) [2] split in deformed nuclei. Several theoretical descriptions have been published [1,3,4] and the GMR splitting was demonstrated in the actinides [5], however the actual splitting of the GQR has not been observed, but rather only inferred indirectly.

We have investigated the giant resonance region in ^{154}Sm using inelastic scattering of 240 MeV α particles where excellent peak to continuum ratios are obtained [6,7] and where the competing pickup-breakup reactions are well above the region where GQR and GMR strength is expected. The experimental technique has been described thoroughly in Ref. [6] and [7]. The multipole components of the giant resonance peak were obtained by dividing the peak into multiple energy bins and then comparing the angular distributions obtained for each of these bins to DWBA calculations to obtain the multipole components.

The transition densities and sum rules for various multipolarities are described by Satchler [8] and the versions used in this work are given in Ref. [6]. Optical model parameters obtained for ^{116}Sn [9] were used in deformed potential model calculations with the code PTOLEMY [10]. Input parameters for PTOLEMY were modified [11] to obtain a relativistic kinematically correct calculation. Radial moments were obtained by numerical integration of the Fermi mass distribution.

Fits to the angular distributions were carried out with a sum of isoscalar 0^+, 1^-, 2^+, 3^-, and at higher excitation, 4^+ strengths. The isovector giant dipole resonance contribution was calculated from the known distribution. The strengths of the multipoles were varied to minimize χ^2. The errors in strengths were estimated by changing the magnitude of the strength of one component until refitting by varying the other components resulted in a χ^2 twice that of the best fit.

The E0 and E2 distributions obtained from the multipole analysis for ^{154}Sm are shown in Fig.1. Both clearly consist of more than one component. A multiple peak fit is superimposed assuming 2 components for the GMR and three components for the GQR (K=0,2 for the GMR and K=0,1,2 for the GQR) and provides an excellent description of the data. The positions and strengths of the components are compared with those predicted by Adgrall *et al.* in Fig.2 and they are in fair agreement.

References

[1] T. Kishimoto *et al.* Phys. Rev. Lett. **35**, 552 (1975).

[2] U. Garg *et al.* Phys. Rev . Let. **45**, 1670 (1980).

[3] Y. Abgrall *et al.* Nucl. Phys. **A346**, 431 (1980).

[4] S. Jang, Nucl. Phys. **A401**, 303 (1983).

[5] H.P. Morsch *et al.* Phys. Rev. C 25, 2939 (1982).

[6] D.H. Youngblood, Y.-W. Lui and H.L. Clark, Phys. Rev. C **55**, 2811 (1997).

[7] D.H. Youngblood, H.L. Clark and Y.-W. Lui, Phys. Rev. C **57**, 1134 (1998).

[8] G.R. Satchler, Nucl. Phys. **A472**, 215(1987).

[9] H.L. Clark, D.H. Youngblood, and Y.-W. Lui, Nucl. Phys. **A589**, 416 (1995).

[10] M. Rhoades-Brown, M.H. Macfarlane and S.C. Pieper, Phys. Rev. C **21**, 2417 (1980); M.H. Macfarlane and S.C. Pieper, Argonne National Laboratory Report No. ANL-76-11, Rev. 1, (1978), Unpublished.

[11] G. R. Satchler, Nucl. Phys. **A540**, 533 (1992).

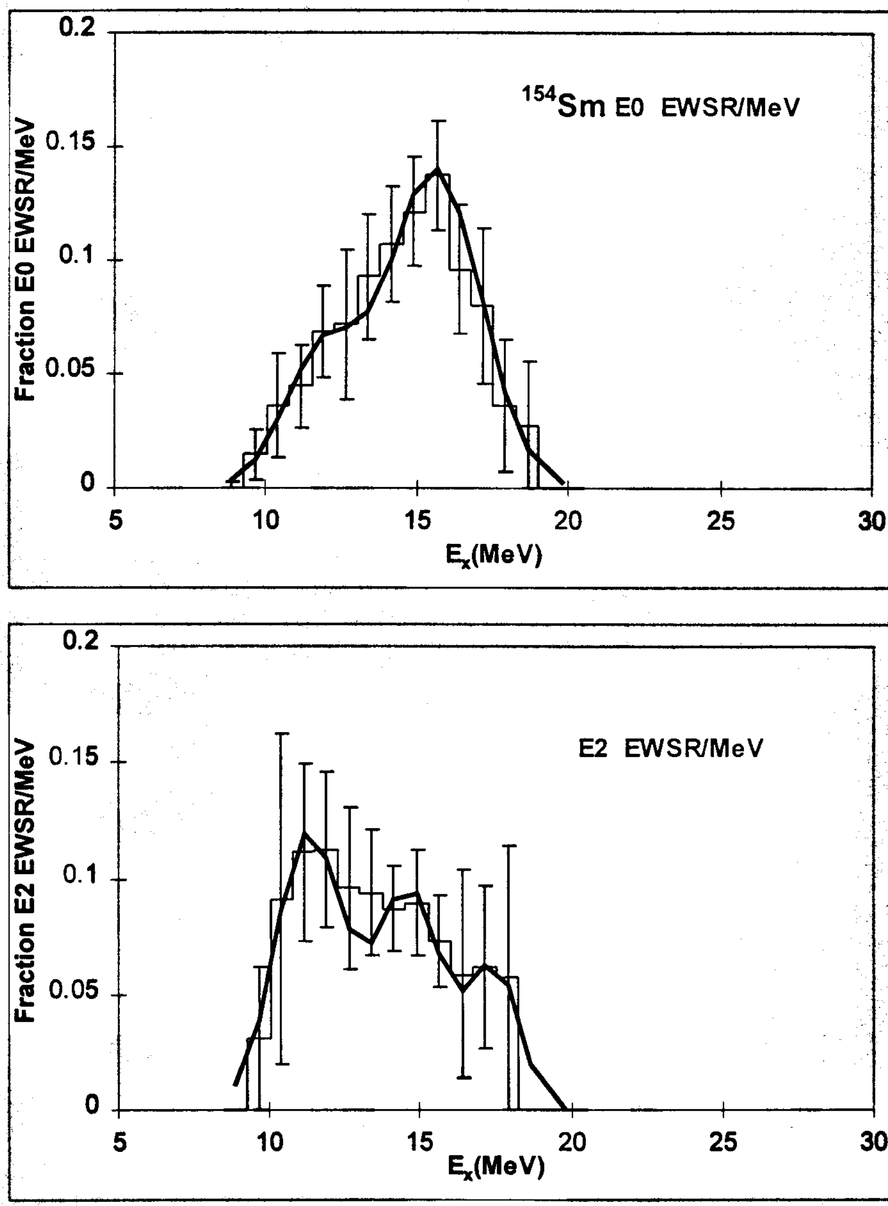

Fig. 1. E0 and E2 distributions for ^{154}Sm obtained from a multipole analysis. The lines show peak fits as described in the text.

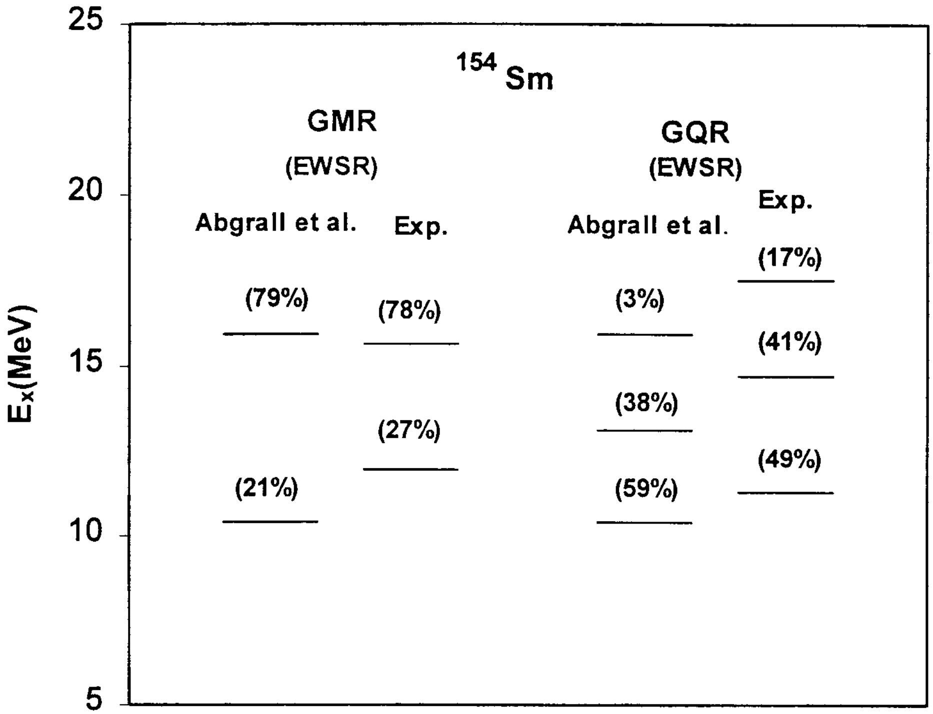

Fig. 2. Comparison of the positions and sum rule strengths predicted by Abgrall *et al.* [3] to the parameters obtained from the fits shown in Fig. 1.