Isoscaler E0-E3 Strength in A ≥ 90 Nuclei

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We have carried out (α,α') studies of many nuclei at 240 MeV and measured inelastic scattering into 0^o originally to extract E0 strength distributions and determine the incompressibility of nuclear matter. E0 strength distributions in ^{90}Zr, ^{116}Sn, ^{144}Sm and ^{208}Pb have been reported [1] as having E0 and E2 distributions for the deformed nucleus ^{154}Sm [2] and isoscalar E1 distributions in ^{90}Zr, ^{116}Sn and ^{208}Pb[3] where the observation of a low energy component of the isoscalar giant dipole resonance was reported for the first time. However the ISGDR EWSR values reported in Ref. 3 are a factor of 3 too high because the form factor used, that reported for α particle excitation of the ISGDR by Harakeh and Dieprink [4], is normalized for one magnetic substate rather than 3. Thus, less that 50% of the ISGDR sum rule was actually identified in these nuclei.

With this data the peak/(continuum + background) ratio for the E0 and E2 resonances is excellent (generally >1.5) and the E0 and E2 strength distributions extracted were relatively insensitive to the treatment of the continuum in the analysis. However the isoscalar E1 and E3 strengths are spread much more broadly than the E0 and E2 strengths and hence the peak/(continuum + background) ratios are much smaller (0.05-0.3).

In this work we have empirically separated each spectrum into a "peak" and a "continuum" and obtained the distribution of the multipole components of the peak. The shape of the continuum we used is described in Ref. 5, and consists of two components: a Woods-Saxon shape starting at about the nucleon threshold rising to intersect a straight line generally with a negative slope. We begin by requiring that the continuum intercept the data in the E_x = 25-30 MeV region and requiring the slope of the straight line take on the slope of the data in this region. This resulted in "reasonable" results for the E0 and E2 distributions (about 100% of the appropriate EWSR's and centroids in agreement with earlier works), but generally gave relatively small fractions of the isoscalar E1 and E3 sum rules. After several analyses of each nucleus, it became clear that the continuum must be significantly lower if the "peak" contains most of the expected E1 and E3 strength. It was decided to adopt as a criteria for the continuum choice, that the multipole distributions obtained from analysis of the "peak" must contain (approximately) the expected fractions of the EWSR. The general shape of the continuum would remain a straight line at high excitation transitioning to a Woods-Saxon shape above the particle threshold. Sample spectra with the continua chosen using this method are shown in Fig. 1.

The resultant E0, E1, E2, and E3 distributions obtained are shown in Figs. 2 and 3. In all cases the E2 distributions consist of a narrow peak at about E_x= $62/A^{1/3}$ and contain approximately 100% of the E2 EWSR, in agreement with many previous works. The E0 distributions are also peaked around E_x= $66/A^{1/3}$ MeV, but in ^{90}Zr the E0 distribution extends up to around E_x= 25 MeV [as reported in Ref. 1], whereas in the other nuclei the E0 strength is limited to a narrow peak. In each case approximately 100% of the E0 EWSR is observed. The centroids of the E3 distributions are approximately at $93/A^{1/3}$ MeV, and from 2/3 to ¾ of the strength is identified, consistent with approximately 1/3-1/4 of the E3 strength located in the low energy octupole resonance. The isoscalar E1 strength distribution obtained is of particular interest. For each nucleus the strength is split into an upper component ($E_x \sim 109/A^{1/3}$ MeV) and a lower component ($E_x \sim 63/A^{1/3}$ MeV) generally as reported in Ref. 3, except that now 40 ± 7, 79 ± 29, 87 ± 23 and 116 ± 40% of the ISGDR sum rule have been located in ^{90}Zr, ^{116}Sn, ^{144}Sm and ^{208}Pb respectively below $E_x \sim 30$ MeV and the location of the upper component of the ISGDR in ^{208}Pb is close to agreement with predictions obtained using compressibilities obtained from GMR data [6-8].

References

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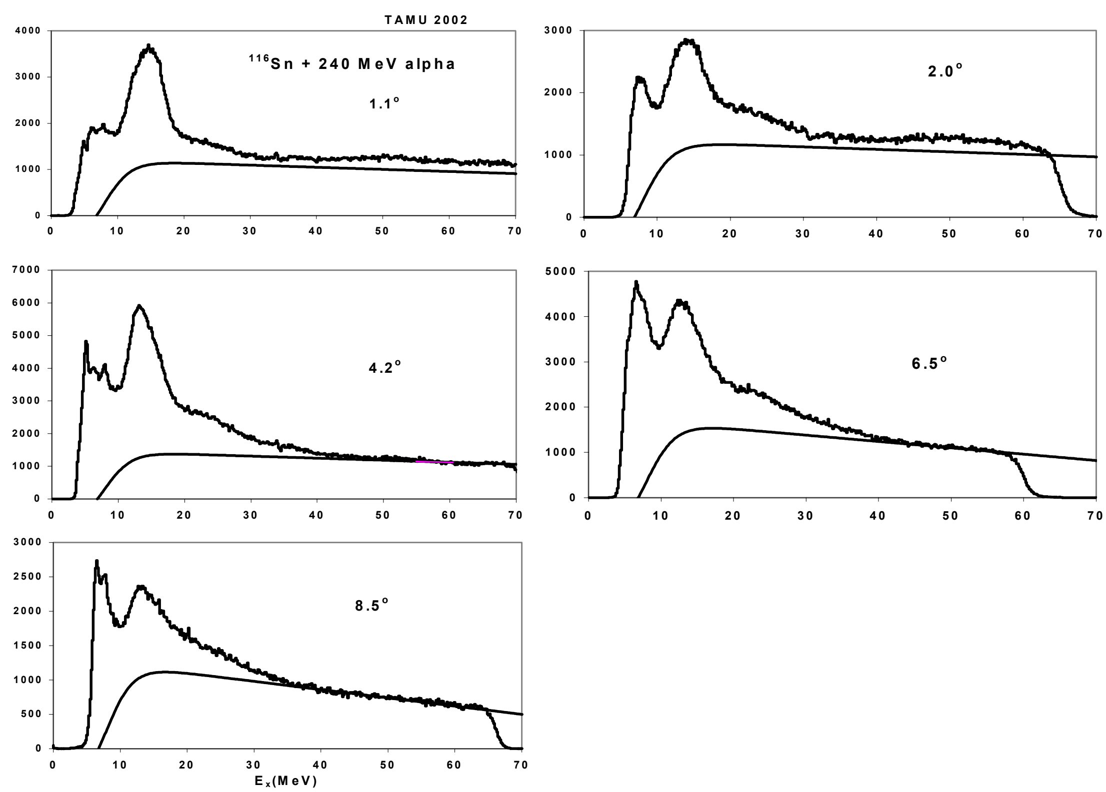

Figure 1: ^{116}Sn spectra at various angles. The lines show the continua chosen.

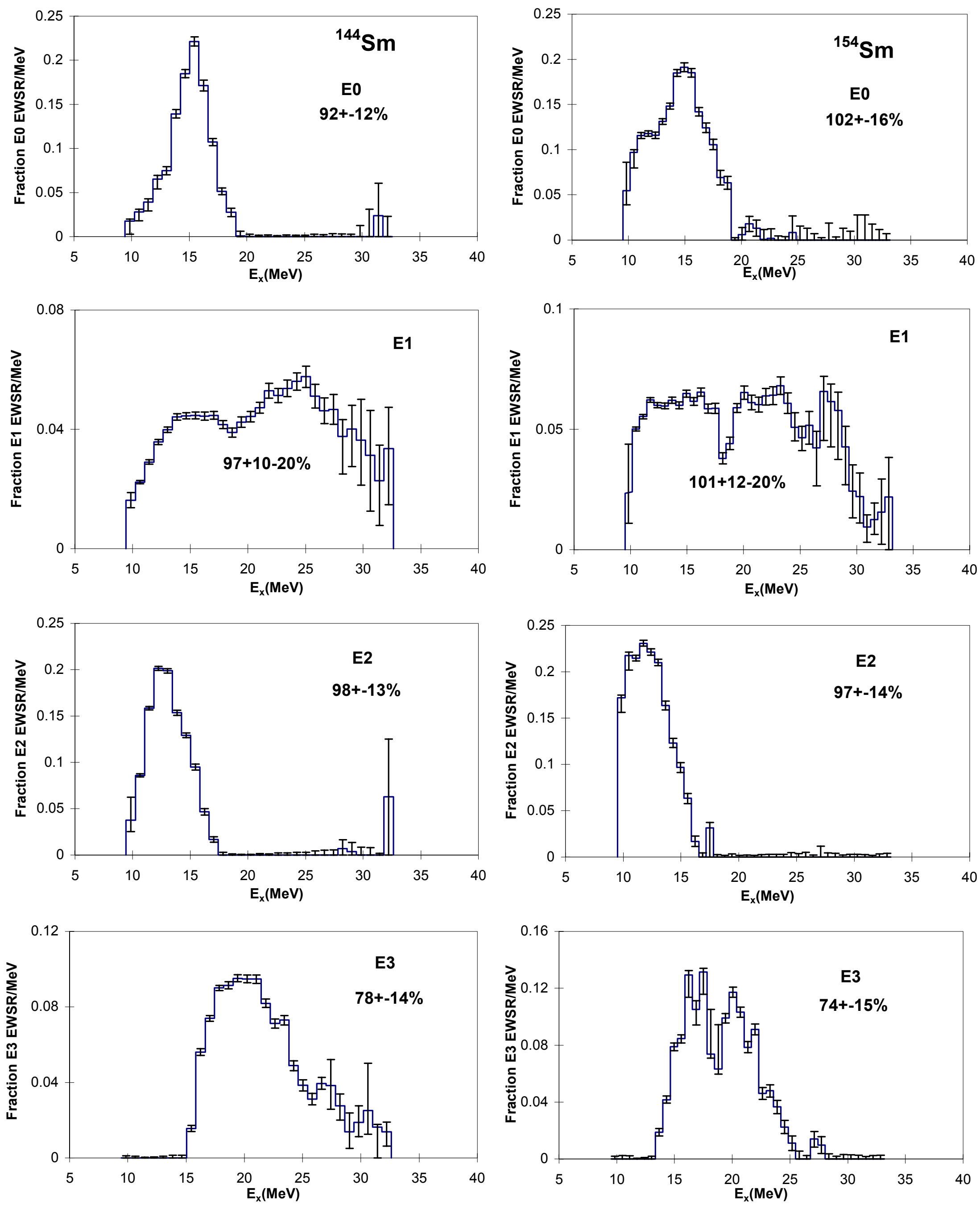

Figure 2: Multipole distributions obtained for Sm isotopes.

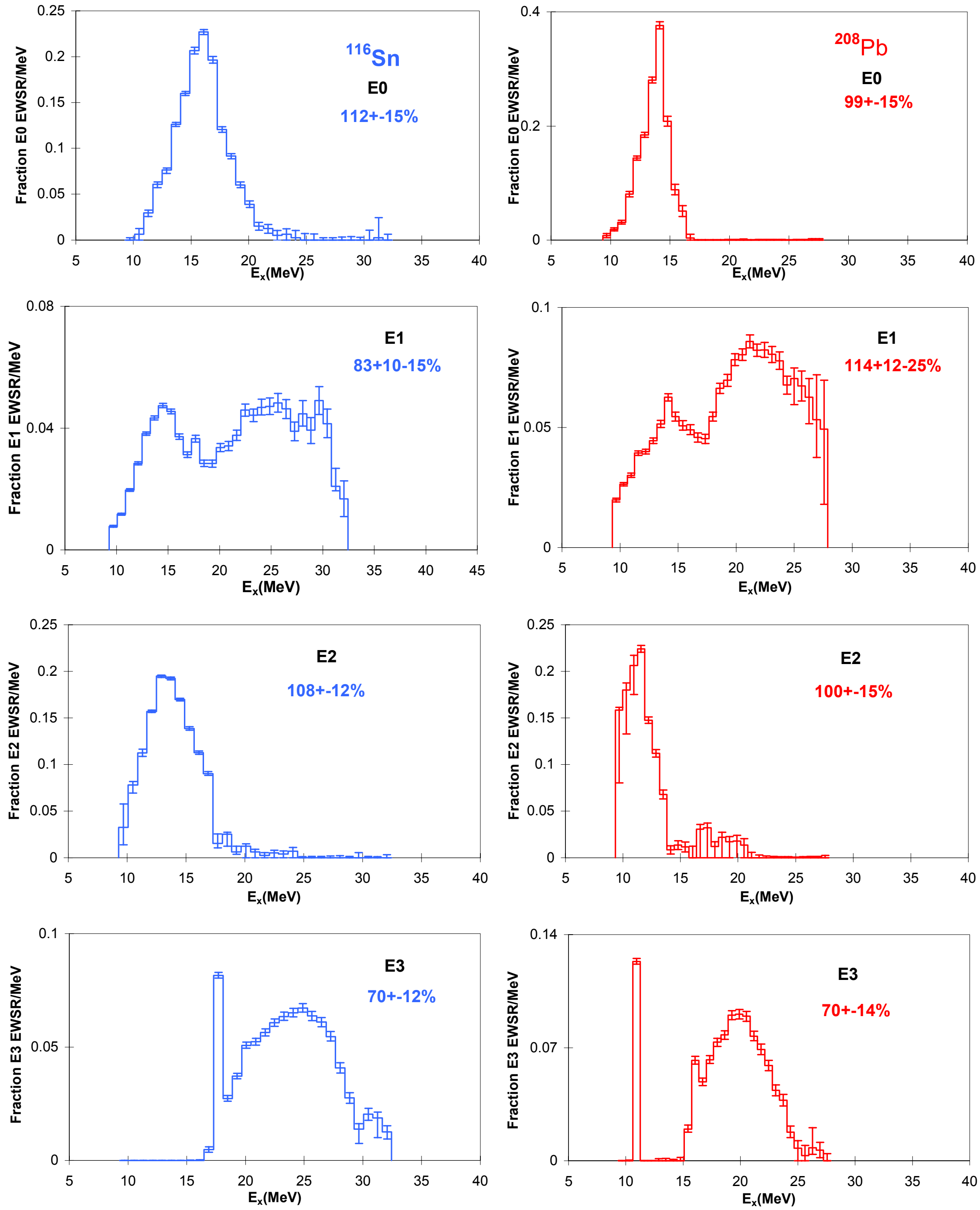

Figure 3: Multipole distributions obtained for ^{116}Sn and ^{208}Pb.