Folding Model Analysis of the Giant Resonance Region of ^{116}Sn

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The giant resonance region of ^{116}Sn was investigated using 240 MeV alpha particle scattering. Data were acquired over lab angles of 0 to 6 degrees where the angular distributions from excitations of L=0, 1, 2, 3 and 4 multipoles are distinctive. Figure 1 illustrates the excellent peak-to-continuum ratio obtained and the presence of high-lying giant resonance structure.

Beams of 240 MeV alpha particles from the Texas A&M K500 superconducting cyclotron bombarded a self-supporting ^{116}Sn foil mounted in the target chamber of the multipole-dipole-multipole spectrometer [1]. The thickness of the target was 11.44 mg/cm^2 and was enriched to 95%. The acceptance of the spectrometer was $\Delta\theta$=4.0° and $\Delta\phi$=±2.0°. Data were taken at spectrometer angles of 0 and 4°. At 0°, the beam was stopped on a carbon-block Faraday cup mounted 1 meter behind the detector while at 4 degrees the beam was stopped by the solid angle defining slits. The absolute cross section was determined from a combination of target thickness, computer live time, solid angle and charge collected by the Faraday cup. The details of the detector and calibration of the data are reported in Refs. [2,3].

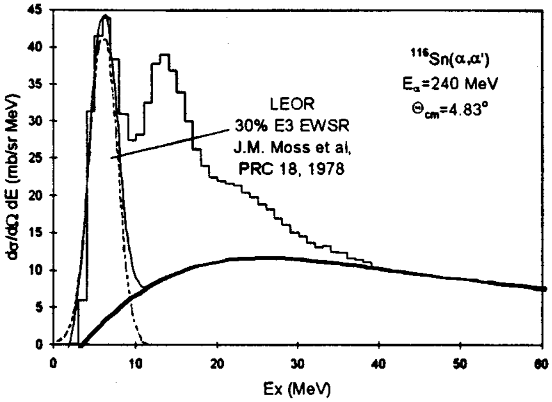

Figure 1 Excitation spectra for ^{116}Sn at 4.83° by 240 MeV inelastic scattering. The thick line shows the assumption for the underlying continuum made in the analysis. The Gaussian peak illustrates the location for the low energy octupole resonance.

Raytracing was used to divide each data set into ten spectra, each corresponding to $\Delta\theta\approx0.4°$. For each spectrum, the giant resonance structure was determined by removing the underlying continuum. The shape of each continuum was determined by extrapolating the slope of the spectrum from high excitation (between 40 to 50 MeV) to the low excitation region. At approximately 16 MeV, the straight line was then curved downward towards the particle threshold barrier at ~9 MeV. The thick line in Fig. 1 shows the assumption for the continuum at 4.83°. The Gaussian peak at ~7 MeV represents the position and amplitude of the "well known" low energy octupole resonance [4] which exhausts ~30% of the E3 energy-weighted sum rule (EWSR).

The multipole strength distributions, in the giant resonance region, were determined by "slicing" each spectra into 1 MeV bins for each angle and then fitting the angular distributions with various amounts of isoscalar L=0, 1, 2, 3, and 4 multipole strength. The strength distribution for the isovector L=1 multipole was fixed and was determined from photonuclear cross sections.

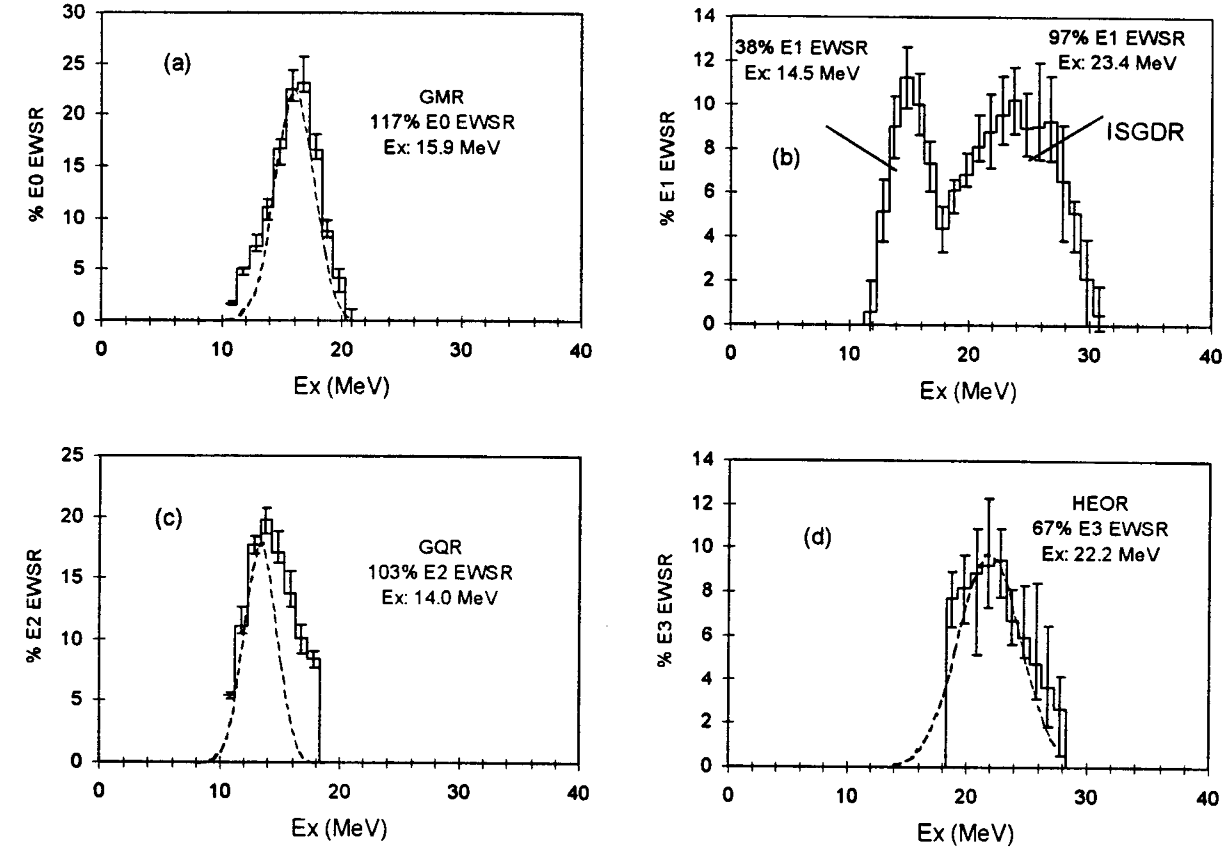

Fig 2 L=0, 1, 2 and 3 strength distributions.

The transition densities were determined from a single folding model in which the interaction is described by a Gaussian shaped alpha-nucleon form. The details of single folding are described in Refs. [5-7]. DWBA calculations were carried out using PTOLEMY[8] with appropriate form factors read in as input. The calculations were averaged over the angular acceptance of the data ($\Delta\theta$=0.4° and $\Delta\phi$=±2.0°). Comparisons to deformed potential model calculations show that the amplitudes and phases for each multipole may differ by as much as 20% between the two models, except for L=0 and L=1(T=1) transitions which only differ by ~1%. The optical model potentials used in the calculations were taken from Ref. [6].

Table I. Values obtained from fits to the data.

Multipole (T=0)	Ex (MeV)	Γ_{RMS} (MeV)	EWSR (%)
L=0	15.9 (0.1)	2.2 (0.1)	117 (10)
*L=1	23.4 (1.5)	3.6 (0.1)	97 (15)
L=2	14.0 (0.2)	1.7 (0.1)	103 (10)
L=3	22.2 (1.5)	3.0 (0.2)	67 (15)

* Upper peak only.

Figure 2 illustrates the multipole strength distributions obtained from the analysis. The positions, widths and sum rule strengths are listed in Table I. The positions and strengths obtained for the giant monopole resonance (GMR) and giant quadrupole resonance (GQR) are in good agreement with previous measurements made with 129 MeV alpha beams [9] and are illustrated in Figs. 2a and c by the dashed Gaussian peaks. The position and strength of the high energy octupole resonance (HEOR) is also (remarkably) in good agreement with our previous measurement made with 240

MeV alpha beams [10] and is shown by the dashed Gaussian peak in Fig. 2d. Measurements from that work did not include data into small angles (angle range $3° \leq \theta_{lab} \leq 8°$) and therefore in the analysis it was difficult to distinguish between L=1 and L=3 transitions. Figure 2b shows the L=1 (T=0) strength distribution obtained from the fits and contains two peaks. The broad peak at 23.4 MeV exhausts 97% of the E1 EWSR. While the narrow peak at 14.5 MeV exhausts 38% of the E1 EWSR.

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