Giant monopole resonances in nuclei around A ~ 90 region

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The giant resonances are small amplitude collective modes of excitations of nuclei and have been extensively studied for several decades over a wide mass region. The study of the isoscalar giant monopole resonance (ISGMR), in which protons and neutrons in a nucleus move in-phase and oscillate with spherical symmetry, is important because its energy (E_{GMR}) is related to the incompressibility of nuclear matter (K_{nm}). In the scaling model, the energy of GMR is given by $E_{GMR} = (m_3/m_1)^{1/2}$, where $m_k = \Sigma(E_n - E_0)^k|<0|r^2|n>|^2$. Using alpha inelastic scattering we have studied giant resonances in nuclei over a wide range of A ($12 \leq A \leq 208$) using the Texas A&M K500 cyclotron facility.

In a previous report [1], we discussed the results of measurements of the ISGMR in Zr and Mo isotopes (^{90,92}Zr, ^{92,96,100}Mo), emphasizing the occurrence of the broad peaks in the higher side of excitation energy. Whereas in ^{90}Zr, higher component contains ~ 22% of the E0 EWSR, in ^{92}Zr, the higher component at E_x = 25.5 MeV contains 38% of the E0 strength and in ^{92}Mo, the higher broad peak contains 65% of the E0 EWSR. Due to the strength of this higher energy component, the centroid energy for the ISGMR in ^{92}Mo is 2 MeV higher than in ^{90}Zr. High energy components of ISGMR in ^{96,100}Mo isotopes were also apparent, but with strengths comparable to ^{90}Zr.

In order to confirm those results we re-measured the E0 strength in ^{92}Mo and in the same experimental run studied ^{94}Zr, and ^{98}Mo to provide additional ISGMR information on ZR and Mo isotopes. The GR data for these nuclei were collected with inelastic scattering of 240 MeV alpha particles using the MDM spectrometer at small angles including 0^o. The horizontal acceptance of the spectrometer was 4^o and ray tracing was used to reconstruct the scattering angle. The vertical acceptance was set at 2^o. The focal plane detector measured position and angle in the scattering plane and covered from E_x ~ 8 MeV to E_x > 55 MeV, depending on the scattering angle. Position resolution of approximately 0.9 mm and scattering angle resolution of about 0.09^o were obtained. The multipole components of the giant resonance peak were obtained by dividing the peak into multiple regions (bins) by excitation energy [2] and then comparing the angular distributions obtained for each of these bins to distorted wave Born approximation (DWBA) calculations. There are some subjective elements to this analysis, particularly the choice of shapes and amplitudes for the continuum, which we try to mitigate somewhat by doing a number of analyses with different background choices, then averaging the final results. The analysis of the previous data was done by one of us (Youngblood), so in an attempt to remove any personal bias, the analysis of this data was done by Krishichayan. As an additional check, Krishichayan also did the DWBA calculations used in his multipole fits.

Fig. 1 shows the E0 strengths Krishichayan obtained for ^{94}Zr and ^{92,98}Mo. The results for ^{92}Mo are in good agreement with those reported in Ref. [1], with ~ 57% of the E0 EWSR contained in a high energy component of ISGMR centered at 24.1 MeV, while the lower peak at 16.7 MeV contains only ~ 43 % of total E0 strength. In ^{98}Mo the upper component at 23.9 MeV contains 17% of the E0 EWSR, right between the 20% in ^{96}Mo and the 14% in ^{100}Mo. The distribution of E0 strength in ^{94}Zr is similar to ^{90}Zr with the higher component containing 22% of E0 strength whereas lower narrow peak contains 84%

of E0 EWSR. The lower peak in ^{94}Zr is somewhat broader than in ^{90}Zr, consistent with the trend in the Mo isotopes where the lower peak broadens considerably as the neutron number increases.

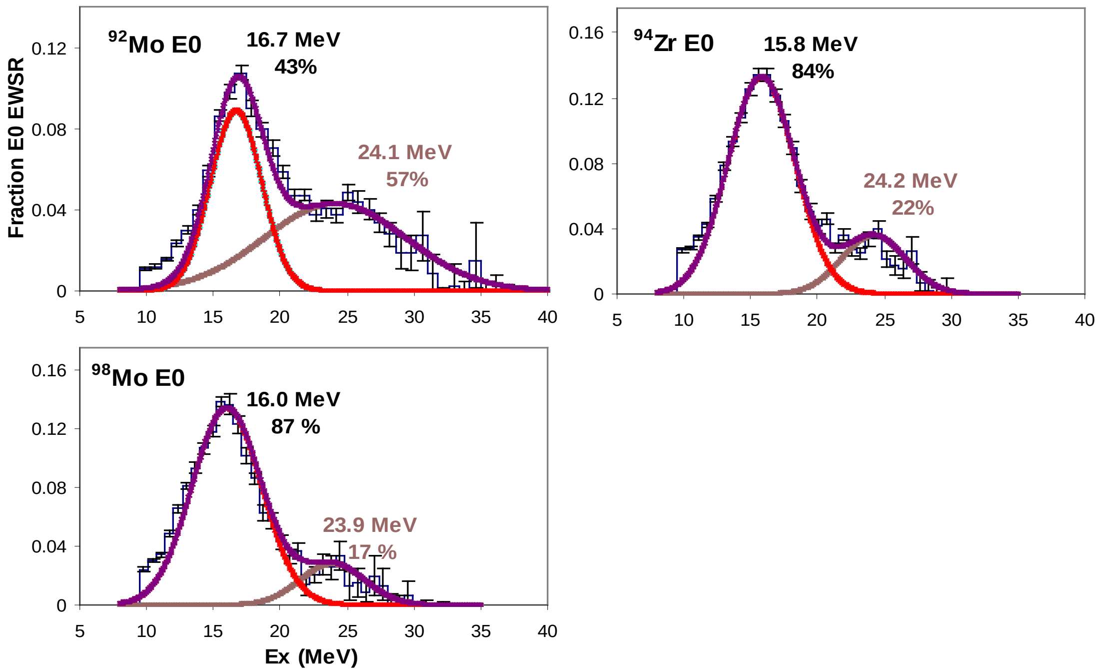

FIG. 1. ISGMR strength in ^{92}Mo, ^{98}Mo, and ^{94}Zr nuclei. The centroids and E0 EWSR strengths of the two components obtained with collective model transition densities are shown.

[1] D.H. Youngblood, Y.-W. Lui, Krishichayan, J. Button, and R. Polis, *Progress in Research*, Cyclotron Institute, Texas A&M University (2008-2009), p. I-1.

[2] D.H. Youngblood *et al.*, Phys. Rev. C **69**, 054312 (2004).