Anomalous behavior of the giant monopole resonance

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The energy of the giant monopole resonance (GMR) in ^{48}Ca is higher than in ^{40}Ca, which is not reproducible with self-consistent mean field calculations[1], and the GMR's in both ^{92}Zr and ^{92}Mo are much higher in energy than predicted with mean field calculations that reproduce the energies of the GMR in the other Zr and Mo isotopes.[2] Moreover the GMR's in all Zr and Mo isotopes studied are split into two components separated by several MeV. In the past year we have studied the GMR in ^{44}Ca and ^{94}Mo to further explore these issues.

Fig. 1 shows a plot of the energy of the GMRs in ^{40,44,48}Ca vs A ,and the ^{44}Ca energy falls between the ^{40}Ca and ^{48}Ca energies. Also plotted are calculations using the Leptodermous expansion.

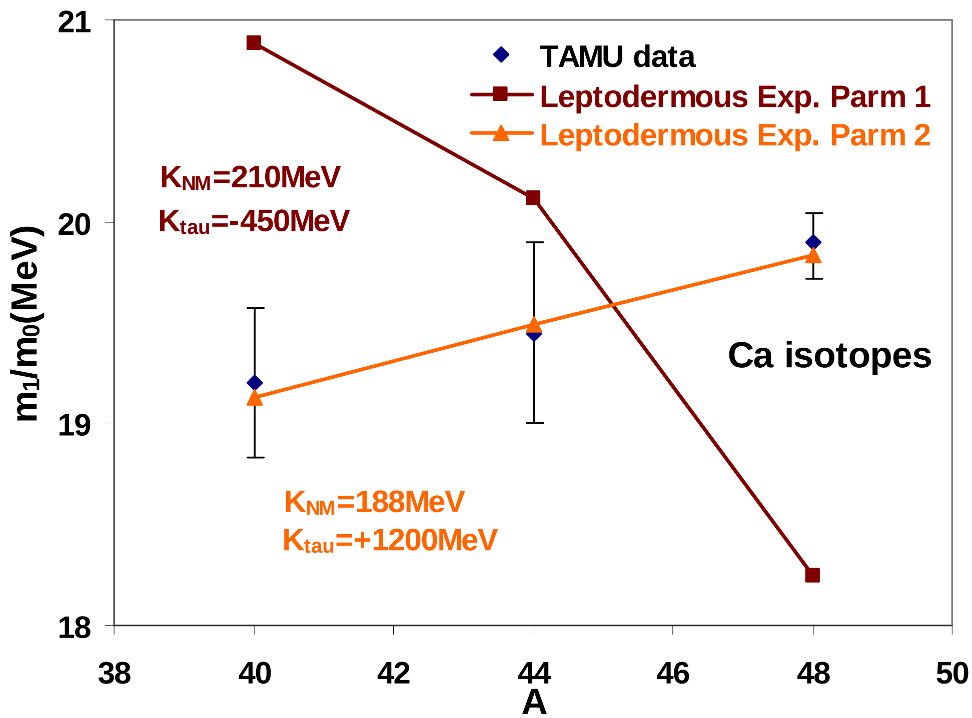

FIG. 1. GMR energy vs A for Ca isotopes. Two calculations using the Leptodermous expansion are shown.

The brown squares were calculated using values for K_{NM} and $K\tau$ obtained in a study of the Sn isotopes [3] , and the A dependence of the GMR energy is opposite that of the data, with the GMR in ^{40}Ca well above that in ^{44}Ca, and the GMR in ^{48}Ca well below that in ^{44}Ca. Varying K_{NM} and K_τ to fit the data (orange triangles) results in K_{NM}=188 MeV and K_τ=+1200 MeV . K_τ is generally accepted to be negative and roughly ~-500MeV, so the +1200MeV necessary to fit the ^{40,44,48}Ca results is badly in disagreement. Fig. 2 shows a comparison of the Ca experimental results with three mean field calculations. The two calculations [4-5] that give an energy for ^{44}Ca agree with the experimental results for ^{44}Ca, and the Anders et al. calculation [4] shows the GMR energy in ^{48}Ca above that for ^{44}Ca in agreement with the data though it shows the ^{40}Ca energy much higher than either ^{44}Ca or ^{48}Ca The HF_QRPA calculation with pairing by Vesely *et al.* [5] shows the energy systematically decreasing as A increases, in contrast to the data. The RMF calculation by Sharma [6] shows the GMR in ^{48}Ca below that in ^{40}Ca.

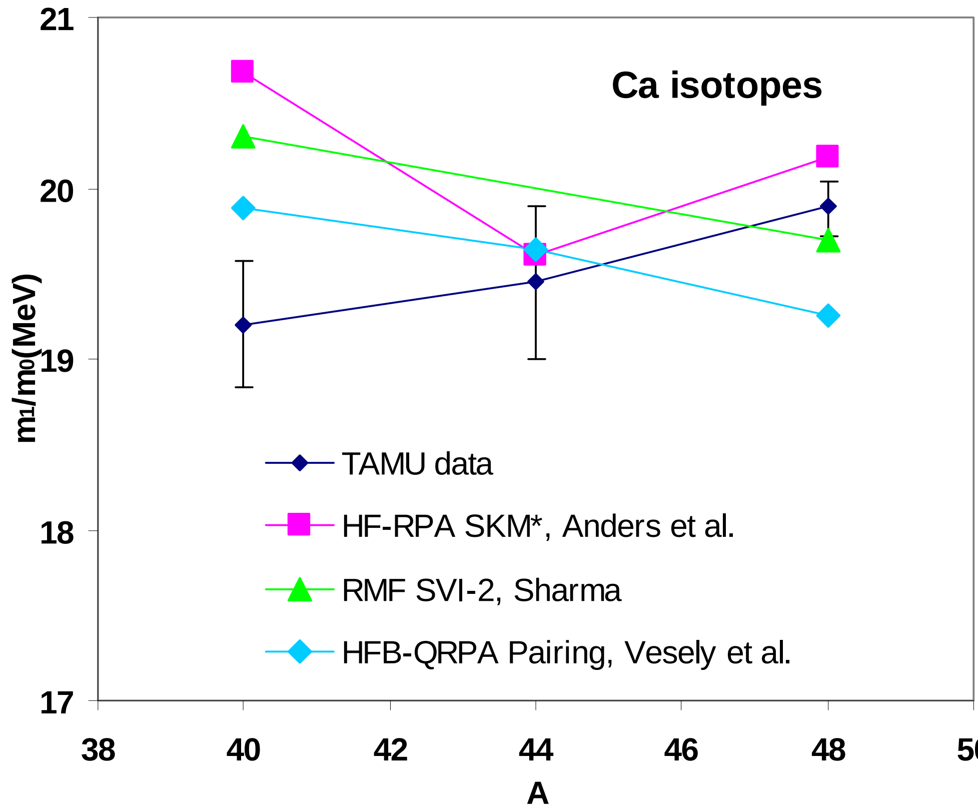

FIG. 2. Experimental GMR energies and three theoretical calculations of the GMR energy vs A for Ca isotopes.

We also studied ^{94}Mo to complement our previous study [2] of ^{92,96,98,100}Mo and ^{90,92,94}Zr. The E0 strength distribution obtained (Fig. 3) is similar to those for ^{96,98,100}Mo and ^{90,94}Zr with a lower energy peak at E_x~16.9MeV containing most of the strength and ~ 20% of the strength in a peak at E_x~ 24MeV. The total E0 strength seen is 108% of the E0 EWSR. The anomalous behavior of the centroid of the GMR is described in ref. [2], with those of both ^{92}Mo and ^{92}Zr well above values expected from mean field or Leptodermous expansion calculations. The GMR in ^{94}Mo is well reproduced by the mean field calculations. In Figs. 4 & 5 we plot the energies of the low and high peaks separately vs A. The energies of the lower peaks have a smooth behavior for both Zr and Mo isotopes and those for Mo are well reproduced by a Leptodermous expansion calculation with K_{NM}=210MeV and K_τ=-750MeV. The Zr data would require a slightly more negative K_τ. The high energy peaks in the Mo isotopes are within errors at the same energy whereas the high energy peak in ^{92}Zr is over an MeV higher than in ^{94}Zr and about 0.5 MeV higher than in ^{90}Zr.

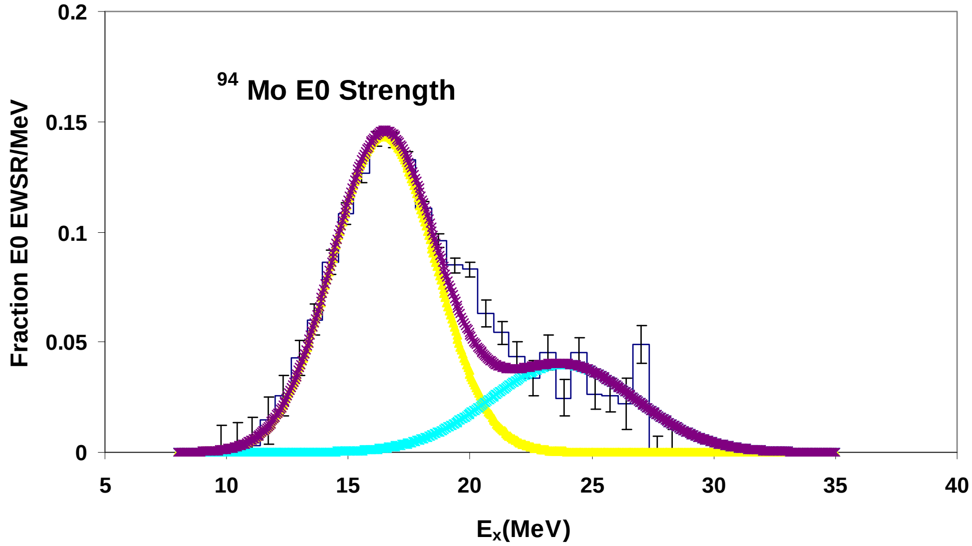

FIG. 3. E0 strength distribution for ^{94}Mo plotted vs excitation energy.

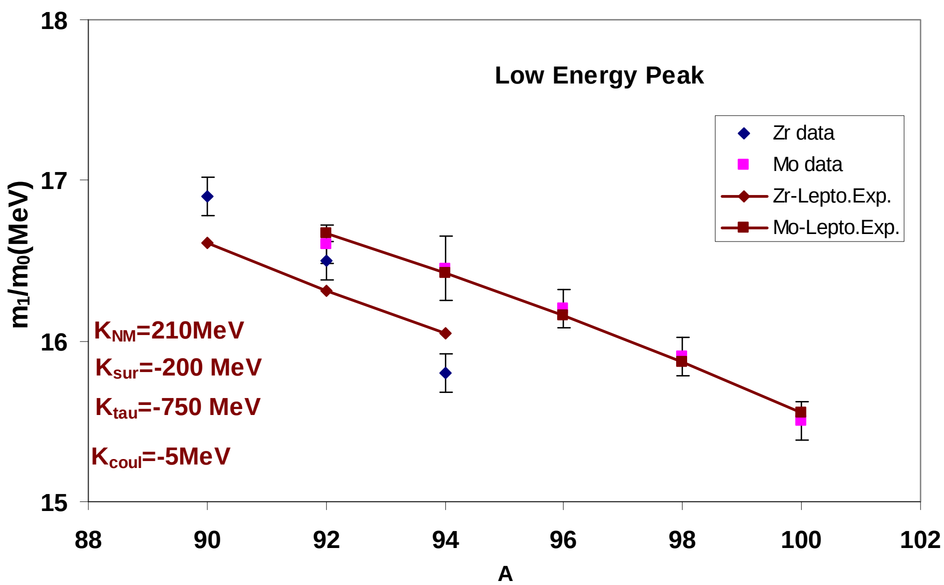

FIG. 4. Plot of energy of the low energy E0 peaks in the Mo and Zr isotopes vs A. The uncertainties are indicated by the error bars. Also shown are Leptodermous calculations using the parameters indicated in the figure.

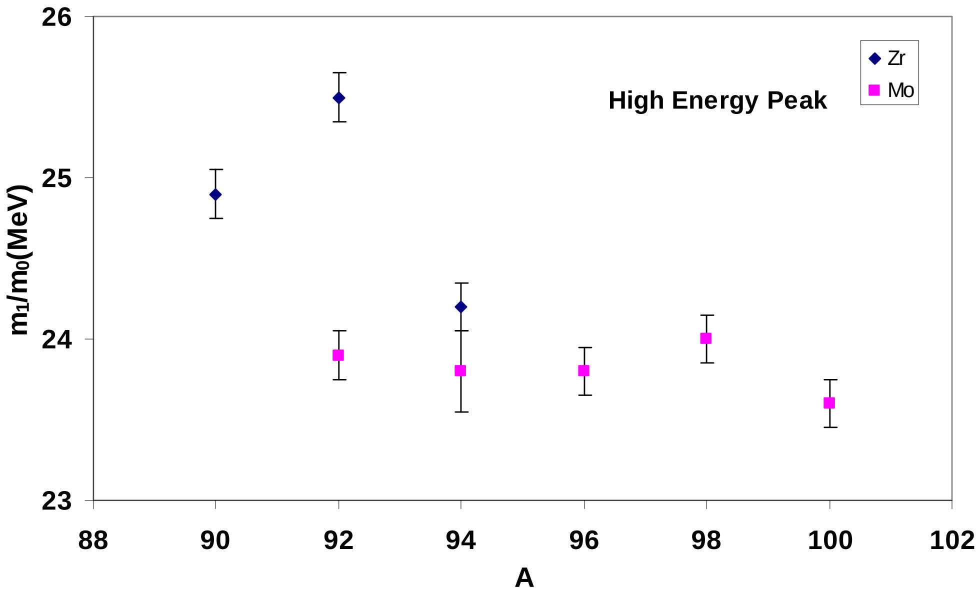

FIG. 5. Plot of energy of the high energy E0 peaks in the Mo and Zr isotopes vs A.

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