4 Nuclear Structure

4.1 Testing the isospin multiplet mass equation and its implications

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The isospin multiplet mass equation (IMME) relates the masses of the members of an isospin multiplet: $M(T_z) = a + bT_z + cT_z{}^2$. Recently, a precise determination of the mass of ^{33}Ar led to the conclusion that an unexpectedly large cubic term was needed to fit the members of the lowest T=3/2 state in the A=33 system.[1] Later we found out that the problem originated in an incorrect determination of the mass of the lowest T=3/2 state in ^{33}Cl. Using the more recent measurements of both ^{33}Ar and ^{33}Cl we found excellent agreement with the parabola.[2] We are presently setting up an experiment to determine the mass of the lowest T=2 state in ^{32}S whose uncertainty is claimed to be ±3 keV.[3] There is a paper presented at a conference claiming an uncertainty of ±0.4 keV with no published details on how the small uncertainty was achieved.[4] We aim to determine the energy of this state with ±0.1 keV uncertainty. As a result, the T=2 multiplet in the A=32 system would constitute the most accurately known quintuplet and it would be interesting to show that the IMME holds to this level of accuracy. On the other hand, we want to pursue measurements in the beta decay of ^{32}Ar (both of the electron-neutrino correlation and of the log ft for the $0^+ \rightarrow 0^+$ decay) for which the IMME may help determining the Q value for the decay.

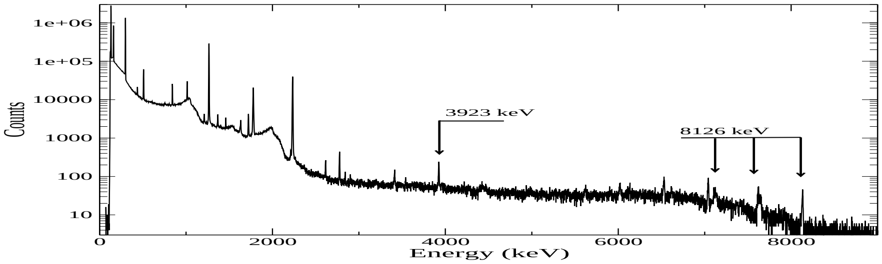

Figure 4.1-1. Gamma ray spectrum from ^{31}P(p,γ) at the T=2 resonance. The arrows indicate gammas from the decay of the T=2 state.

Using the sputter ion source, we produced an implanted ^{31}P target with a thickness of approximately 4 keV, measured using the ^{31}P(p,γ) reaction to produce the narrow T=2 state. Fig. 4.1-1 shows a γ spectrum taken at the T=2 resonance. We have performed Monte Carlo simulations that calculate Doppler effects on the gammas keeping in mind the energy losses, detector resolution, detector angle with respect to the beam and the gamma-ray angular correlations to help us understand potential problems. To reduce our systematic uncertainties we shall check for Doppler effects in two oppositely placed Ge detectors.

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[1] F. Herfurth *et al.*, Phys. Rev. Lett. **87**, 142501-1 (2001).

[2] M. C. Pyle *et al.*, Phys. Rev. Lett. **88**, 122501-1 (2002).

[3] G. Audi and A. H. Wapstra, Nucl. Phys. A **595**, 409 (1995).

[4] M. S. Antony, A. Huck, G. Klotz, A. Knipper, C. Miehé and G. Walter, in *Proceedings of the International Conference on Nuclear Physics*, Lawrence Berkeley Laboratory, Berkeley, CA, Vol. 1 (1980).

4.2 Low-temperature measurement of the giant dipole resonance width

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We have made a new determination of the width of the Giant Dipole Resonance in the inelastic scattering of ^{17}O particles from ^{120}Sn at 80 MeV/u.[1] The experiment was carried out at the National Superconducting Cyclotron Laboratory at Michigan State University. The inelastically scattered ^{17}O particles were detected at forward angles in the S800 spectrometer, and the γ rays were detected in the ORNL - Texas A&M - MSU BaF_2 array in coincidence with the S800. γ-ray spectra were recorded for different inelasticities ranging from 20 to 90 MeV.

The spectrum of inelastically scattered ^{17}O particles in coincidence with all γ rays exhibits strong peaks corresponding to the opening of the 1n, 2n and 3n channels, up to 30 MeV of ^{17}O energy loss, suggesting a close correspondence between inelasticity and residual excitation energy over this range. This conclusion is also consistent with a recent inelastic α-scattering study. Accordingly, we performed a CASCADE analysis of the spectral shape measured for energy losses in the range 20 - 30 MeV, assuming equality between energy loss and residual (initial) excitation energy. The spectrum is fitted well by including a bremsstrahlung component and allowing the GDR strength, width and energy to vary. The result is a width $\Gamma = 4 \pm 1$ MeV for decays with a mean excitation energy following GDR decay of 9.7 MeV, corresponding to a mean (final-state) temperature of 1.0 MeV.

This result for the GDR width is comparable to the width of the GDR built on the ground state of similar mass nuclei, and is much narrower than the value calculated in the adiabatic shape fluctuation model. This new data confirms the trend suggested by other experiments in this mass region, in which the GDR width was found to be narrower than the model predictions for temperatures in the range ~ 1.3 - 1.7 MeV, and shows clearly that the GDR width increases much more slowly with temperature than predicted by the model. Since pairing corrections should not be important at these temperatures, and shell effects are small for ^{117}Sn and nearby nuclides, this seems to be a clear failure of the adiabatic shape fluctuation model.

Deviations from the adiabatic approximation, which assumes that the time scale for shape fluctuations is long compared to the inverse frequency spread associated with the deformation broadening of the GDR, would result in a smaller GDR width; however, it would be surprising if such deviations occured only at low temperature. Attempts to explain the observed GDR widths by mechanisms other than deformation broadening also do not agree with the data. Hence we conclude that narrow GDR widths observed in Sn and nearby nuclides at low temperature are not understood.

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*For current address, see reference 1.

[1] P. Heckman *et al.*, Phys. Lett. B **555**, 43 (2003).