EVOLUTION WITH TEMPERATURE OF THE GDR IN ^{120}Sn

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In a hot nucleus (temperature, T, up to 2.5 - 3.0 MeV), the strength and the resonance energy of the Giant Dipole Resonance (GDR) is known to change little if at all, relative to the known values at T = 0. The width, however, generally increases with both spin and temperature. Over a wide range of spin, temperature and nuclear species the GDR width is accounted for in terms of thermal fluctuation theory, in which the shape (quadrupole deformation) of the nucleus couples adiabatically to the GDR vibration.[1] This agreement represents a remarkable simplicity in the hot GDR properties, and indicates, for example, that there is little room for other contributions to the width such as collisional damping.

However, there are a few cases where the measured GDR widths appear to lie below the thermal fluctuation calculations. One of the best examples of this is the decay of Sn and nearby compound nuclei formed in fusion-evaporation reactions at $T < 2$ MeV[2] where the discrepancies are of the order of 1.0 - 1.5 MeV in the width (out of about 8 MeV). This type of discrepancy (measured widths smaller than the adiabatic coupling calculation) is strongly suggestive of a failure in the adiabaticity assumption; i.e. that the quadrupole shape fluctuations of a hot nucleus occur on a timescale which is not long compared to the GDR vibration. The timescale for large amplitude nuclear shape changes is not well understood; hence an improved study of these discrepancies may represent an opportunity to determine this timescale. We have studied the reaction ^{120}Sn(^{17}O,^{17}O') to further explore this important question. The reasons for measuring an inelastic scattering decay reaction such as this one are:

- In principle one can measure GDR decays at lower T than in heavy-ion fusion since in the latter case the minimum excitation energy is determined by the Coulomb barrier in the entrance channel. In the inelastic scattering reaction there is no such limitation.
- Such a measurement would provide independent information to the fusion evaporation results and hence offers the opportunity to put the discrepancy between theory and experiment on a stronger footing.
- Such a measurement should help resolve the concern raised recently that the previously measured reaction ^{120}Sn(α,$\alpha'\gamma$) may suffer from pre-equilibrium effects.[3−5] It should also help us understand apparent differences between the GDR widths inferred from Sn decay formed in fusion-evaporation vs. (α,$\alpha'\gamma$) (The widths from the latter reaction lie somewhat above the fusion-evaporation results).

We measured the excitation-energy dependence of the GDR width with inelastic scattering of 80 A·MeV ^{17}O on a ^{120}Sn target. An important element of our plan was to minimize effects other than equilibrated decay following inelastic target excitation. In our earlier (α,$d\gamma$) experiments both nucleon knock-out and more complex non-equilibrium processes are observed. It is well known that the yield of nucleon knock-out reactions is much smaller in heavy-ion scattering than in α-scattering reactions. The absence of a detectable knock-out process in the scattering of ^{17}O off heavy targets has been verified experimentally at 84 A·MeV.[6] Thus, we believe that the chosen projectile and conditions of bombarding energy and momentum transfer minimized pre-equilibrium effects.

In our measurement, an 80 A·MeV ^{17}O beam bombarded a 7 mg/cm^2 thick ^{120}Sn target. The inelastically scattered ^{17}O was detected with the S800 spectrometer set at a scattering angle of 7°. With the angular acceptance of the S800 of 5° scattering angles between 2° and 12° were covered; the grazing angle for this reaction is about 2.2°. The energy acceptance of the S800 is about 10%, corresponding to about 140 MeV which is sufficient to measure the whole excitation function within one setting.

The high-energy γ-rays were detected with the ORNL - Texas A&M - MSU BaF_2 array, consisting of 152 BaF_2 scintillators, arranged in two close-packed arrays of 72 detectors each. The arrays were placed at a distance of about 50 cm from the target at angles of $\pm 90°$ with respect to the beam axis. Several CsI telescopes were placed inside the scattering chamber at different angles, detecting light particle emissions from the target in order to measure contributions from pre-equilibrium reactions.

We expect this experiment has approximately the same statistics as in our earlier (α, α') experiment which was adequate to extract γ-ray spectra gated on 10 MeV wide bins in the energy loss spectrum.[3,5,7]

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