Giant Dipole Resonance width at very low temperature in ^{119}Sb

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Introduction

In an earlier paper [1], we reported the investigation of GDR width in the temperature range 1-1.2 MeV for ^{119}Sb using alpha induced fusion reaction. It was shown that the measured GDR widths (Γ_{gdr}) differed significantly at low temperature from the adiabatic Thermal Shape Fluctuation Model (TSFM) [2] predictions. Here we report a more detailed systematic study of GDR width with temperature for ^{119}Sb in the temperature range 0.9 – 1.4 MeV to have a precise experimental data set at low temperature that has been scarce for a long time. This new data at low temperature can be utilized to propose a new model or to make necessary modifications of the existing ones to predict the correct variation of GDR width at low and high temperatures uniformly.

Experimental Details & Analysis

The hot ^{119}Sb compound nucleus was populated at 31.4 & 43.0 MeV excitation energies by bombarding 30 & 42 MeV alpha beams respectively on 1 mg/cm^2 thick target of ^{115}In. The high-energy photons from GDR decay were measured using the LAMBDA spectrometer [3]. The array was arranged in 7x7 matrix and placed at distance of 50 cm from the target at an angle of 90^0 to the beam direction. The 50-element multiplicity filter [4] split in two blocks of 25 detectors each were kept on top and bottom of the scattering chamber to measure the angular momentum as well as to get the start trigger for time of flight (TOF) measurement. The pulse shape discrimination (PSD) technique was applied to reject the pile up events while TOF was used to separate the neutrons from the high-energy gamma rays.

The high-energy gamma ray spectra were generated in offline analysis after all necessary rejections using the cluster summing technique (Fig.1). The data were compared with a modified version of the statistical model code CASCADE [5] to extract the GDR parameters. The level density prescription of Ignatyuk was used with the asymptotic level density parameter as A/8.0 and A/8.5 for 30 and 42 MeV respectively. The individual experimental folds were mapped onto the angular momentum space using Monte Carlo GEANT3 simulation [4] and used in CASCADE.

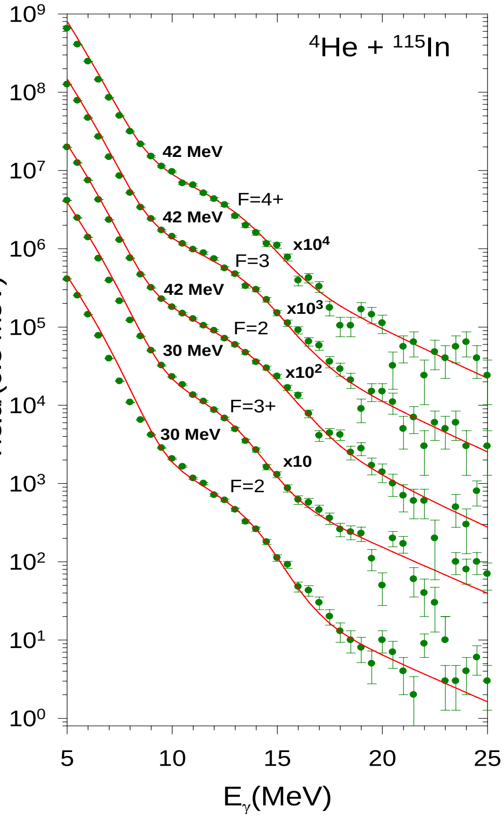

Fig.1. High energy gamma spectra (filled circles) for various folds along with CASCADE prediction (continuous line) for 30 MeV and 42 MeV incident energy.

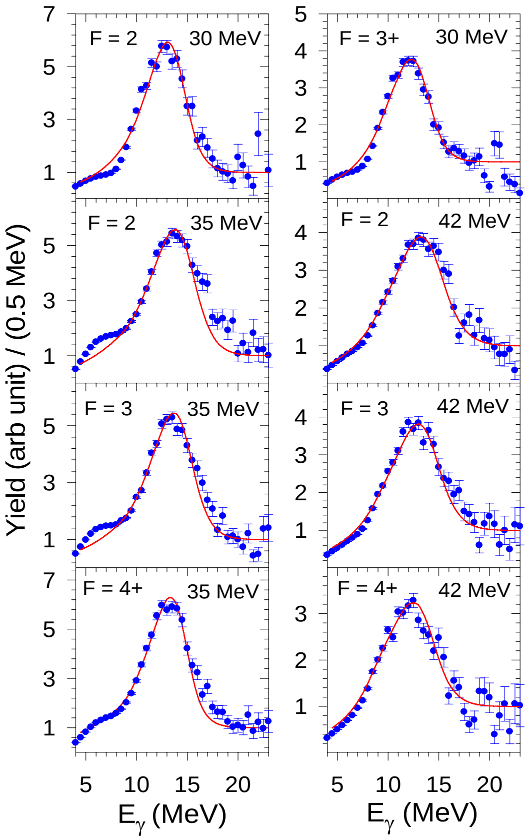

Fig.2. The linearized GDR plots for 30, 35 & 42 MeV incident energies. The filled circles are the experimental data while the continuous line represents the CASCADE prediction

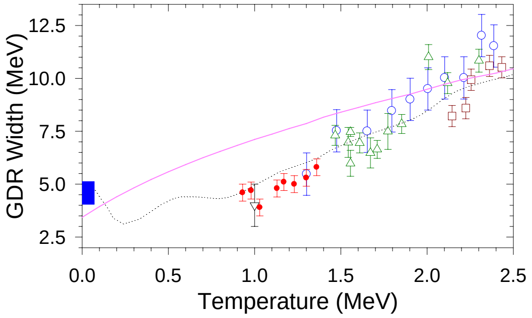

Fig.3. The evolution of GDR width with temperature. The filled circles are the data for ^{119}Sb from the present experiment. It has been compared with other data for ^{120}Sn taken from ref [6]. The continuous line corresponds to TSFM calculation [2] while the dotted line represents PDM calculation [7].

Results

The linearised GDR plots for 30 and 42 MeV data are shown in Fig 2 together with that of the earlier measurement at 35 MeV. The measured GDR widths in the low temperature range of 0.9 - 1.4 MeV in the present study are shown in Fig 3 along with the other measurements done earlier for ^{120}Sn. The data have been compared with the predictions of the theoretical models of TSFM [2] (continuous line) and phonon damping model (PDM) (dotted line) [7]. It is evident that the temperature dependence of GDR width determined from this experiment differs substantially from the adiabatic TSFM at low temperature. This clearly suggests that the calculations overestimate the influence of shape fluctuations at low temperature and points toward the failure of adiabatic assumption of thermal fluctuation theory. The microscopic phonon damping model [7] (the dotted curve in Fig 3), though not used widely, better explains the trend of the data at this low temperature range compared to TSFM. However, the PDM does not have a built in angular momentum dependence of the GDR width at finite temperatures and may therefore be used only to describe the temperature dependence at zero spin. This exciting result opens up a new question regarding the basic understanding of the damping mechanisms of GDR in the complex quantal nuclear many body system at low temperature and is left for further theoretical insight.

References

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