The evolution of Giant Dipole Resonance width at low temperature in ^{63}Cu using alpha induced fusion reaction

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Introduction

The study of Giant Dipole Resonance (GDR) properties at finite excitation energy and angular momentum has been the objective of many experimental investigations during the past decades. The wide range of experiments performed so far have established that the resonance width increases with both temperature (T) and angular momentum (J). This increase of GDR width in hot nuclei is successfully explained by the theoretical model based on large amplitude thermal fluctuation of nuclear shape under the assumption that the time scale associated with thermal fluctuation is slow compared to GDR vibrations and the observed GDR strength function is the weighted average of all the shapes and orientation [1,2]. However, it has been found that the thermal shape fluctuation model (TSFM) fails to explain the temperature dependence of GDR width below T~ 1.5 MeV in A ~ 120 mass region [3,4]. It would be an interesting study to investigate whether similar suppression of GDR width relative to TSFM is observed in low mass region too.

Experimentally it is very difficult to populate the compound nuclei at low temperature in heavy ion reaction due to large coulomb barrier in the entrance channel and it is also associated with broad angular momentum distribution. Inelastic scattering has been adopted as an alternate process to populate the nuclei at low excitation energy but due to large excitation energy windows the estimated temperatures are less precise. Keeping in mind the experimental difficulties, we have used alpha induced fusion reaction to study the evolution of GDR width at low temperature since the compound nuclei will be populated at fixed excitation energy and the associated angular momentum will be small. In this paper, we present the measurement of GDR gamma rays from ^{63}Cu nucleus using alpha induced fusion reaction to investigate the temperature evolution of GDR width at low temperature in low mass region.

Experimental Details

The experiment was performed at the Variable Energy Cyclotron Centre using the K-130 room temperature cyclotron. A self-supporting 3 mg/cm^2 thick target of ^{59}Co was bombarded with 35 MeV alpha beam to produce the ^{63}Cu nucleus at 38.55 MeV excitation energy. The critical angular momentum of the reaction was 14.3$\hbar$. The high-energy gamma rays from ^{63}Cu* were detected at a lab angle of 90° with respect to the beam axis by employing the LAMBDA spectrometer [5]. The array was arranged in a 7x7 matrix and kept at a distance of 50 cm from the target. Lead sheets of 5 mm thickness were placed in front and sides of the array, to cut down the intensity of the low energy gamma rays. The beam dump, located 3.5 metres downstream, was heavily shielded with borated paraffin blocks and lead bricks to cut down the gamma and neutron background. Apart from the LAMBDA array, a 50-element BaF_2 multiplicity filter [6] was used to measure the discrete low energy multiplicity gamma rays in coincidence with the high-energy gamma rays to extract the angular momentum of the compound nucleus as well as to get the start time trigger for time of flight (TOF) measurement. The multiplicity filter was split in two blocks of 25 detectors each and was placed on top and bottom of the scattering chamber at a distance of 5 cm from the target covering 56 % of 4π. The neutrons were eliminated from the high-energy gamma rays by

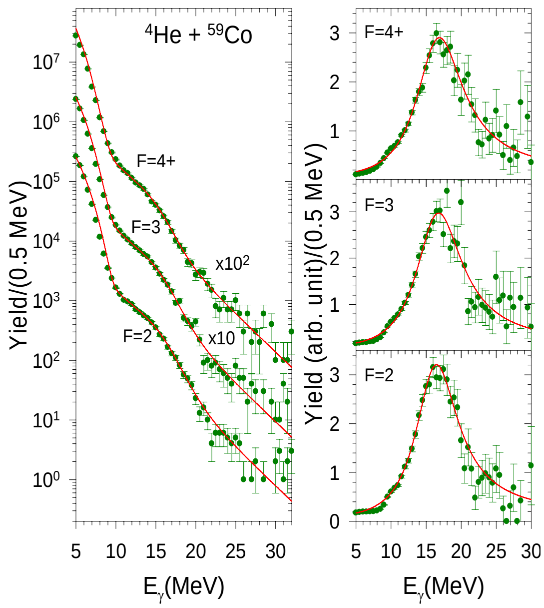

Fig.1. (Left) High-energy gamma spectra (filled circles) for various folds along with CASCADE prediction (continuous line). (Right) The linearized GDR plots.

TOF technique while the pile-up events were rejected using the pulse shape discrimination technique in each detector element.

Results

The high-energy gamma ray spectrum was reconstructed using the nearest neighbor (cluster) summing algorithm. The resultant high-energy gamma spectra along with the linearzed GDR lineshapes for different folds are shown in Fig.1. The GDR parameters were extracted from the experimental data by comparing with the predictions from a modified version of the statistical model code CASCADE [7]. In the statistical calculation, the Ignatyuk-Reisdorf level density prescription has been used with the asymptotic level density parameter a = A/8.0. The average temperature was calculated from the initial excitation energy after subtracting the GDR resonance energy and the rotational energy extracted using Monte Carlo GEANT3 simulation for corresponding fold. The measured GDR width as function of T is shown in Fig. 2 along with earlier measurements on ^{63}Cu using heavy-ion fusion reaction [8]. The data has been

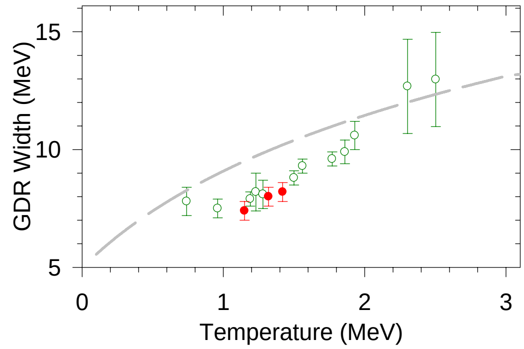

Fig.2. The GDR width plotted as a function of temperature. The filled circles are the data from this work. The open circles represent the data from earlier work on ^{63}Cu. The dashed line corresponds to the TSFM calculation.

compared with the predictions of TSFM (dashed line). Interestingly, the theoretical model fails completely to explain the trend of the data at low temperature. The model predicts gradual increase of the GDR width with temperature whereas the experimental results show the GDR width to be constant at ground state value at low temperature and increases subsequently after T ~ 1.3 MeV. The discrepancy between the experimental data and TSFM indicates the failure of the model in the present form in describing the evolution of the GDR width at low temperature. Since the GDR width has been found to be suppressed in other nuclei also, it appears that the suppression at low temperature is a general trend.

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