Evolution of GDR width with angular momentum

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Introduction

The phenomenon of giant dipole resonance (GDR) built on excited states in nuclei [1] continues to be a subject of active research by many groups. Experiments have been carried out to study the dependence of temperature and angular momentum on GDR observables like centroid, width and strength. High energy GDR γ rays measured in coincidence with a multiplicity filter provides a good tool to disentangle the effect of angular momentum and temperature at a given excitation energy. With a need to study the evolution of GDR width and nuclear deformation as a function of angular momentum and temperature, we initiated a program to study ^{144}Sm at different excitation energies. The initial results of the program were reported in Ref. [2]. The results of our previous measurements to study the evolution of GDR width and deformations in ^{144}Sm, with detailed theoretical calculations, have been reported in Ref. [3]. The GDR cross sections and widths have been found to be consistent with thermal shape fluctuation model (TSFM) in the temperature range of 1.1 to 1.5 MeV. The phenomenological parametrization of Kusnezov et al. [4] also holds true in this temperature range. Following these results, we conducted experiment with higher beam energy to study GDR width evolution at higher temperatures and check the consistency of application of TSFM. In this paper, we report the results of experiment conducted on same compound nucleus at an excitation energy of 105 MeV.

Experimental details

The experiment was performed using the 15UD Pelletron and superconducting linear accelerator facility at the IUAC, New Delhi. Self supporting targets of ^{116}Cd, with more than 98.3 % enrichment were rolled to a thickness of 1.6 - 1.8 mg/cm^2 at IUAC target laboratory. 170 MeV ^{28}Si pulsed beam was bombarded on ^{116}Cd target to populate compound nucleus ^{144}Sm at an excitation energy of 105 MeV. The high energy γ rays were detected using the high energy gamma ray spectrometer consisting 10" × 12" NaI(Tl) crystal [5]. Plastic scintillators were used for active shielding and lead bricks for passive shielding. The detector system was positioned at a distance of 80 cm from target position at an angle of 90° w.r.t. beam axis. The experimental response function of detector was generated using laboratory sources and same was verified with responses generated using monte-carlo simulation package GEANT4 [6]. Fold distribution of low energy γ rays was measured using sum-spin spectrometer [7]. The complete multiplicity filter consists of 32 NaI(Tl) detectors in soccer ball geometry and covers a solid angle of nearly 4π sr. For the present experiment only 29 detectors were used. The target was positioned at the geometrical center of the 4π array. To eliminate the chance of beam hitting the target frame, a collimator was placed in beam line at a distance of ∼50 cm upstream from target center. The time of flight (TOF) method was used to discriminate

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between neutrons and γ rays. The zero cross method was used to filter piled up events in the high energy γ ray spectra. The electronics used in the experiment has been detailed in Ref. [8].

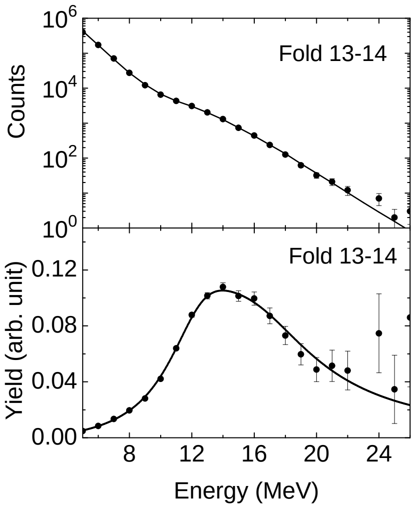

FIG. 1: (top) Fold gated high energy γ ray spectra in the reaction ^{28}Si+^{116}Cd @ 170 MeV, and (bottom) its corresponding linearized plot.

Results

Statistical model code CASCADE [9] was used to analyze fold gated high energy γ ray spectra. Fold to angular momentum conversion process is detailed in Ref. [3]. Asymptotic level density parameter was kept same as in other energy data, i.e. A/8.5. The Energy per nucleon for this reaction was $\sim$ 5.9, thus bremstrahlung contribution was neglected. The linearised plots were generated as $(Y_{exp}/Y_{cal}) \times F_{2L}$ [10] where Y_{exp} is the experimental yield, Y_{cal} is the CASCADE output folded with detector response and F_{2L} is the two component lorentzian function. Fig. 1 shows fold gated γ ray spectra and its corresponding linearized plot. The GDR widths extracted experimentally were converted to reduced width as proposed by Kusnezov et al. [4] and plotted as a function of reduced angular momentum as shown in Fig. 2. Present calculations shows the consistency of Kusnezov parametrization. Detailed TSFM calculations at this energy are in progress.

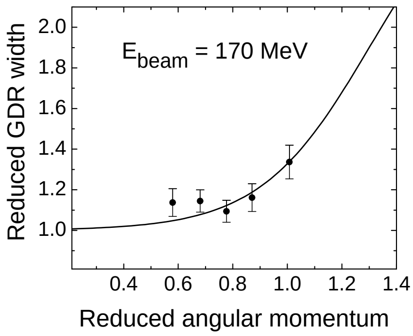

FIG. 2: Reduced GDR width as a function of reduced angular momentum. Solid line is the universal dependence based on Kusnezov's phenomenological parametrization.

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