Giant Dipole Resonance width evolution in A∼128 mass region

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Introduction

The heavy ion fusion reaction is used as a route to study the evolution of Giant Dipole Resonance (GDR) built on excited states over a wide range of angular momentum (J$\hbar$) and temperature (T). Once a compound nucleus (CN) is formed in such a reaction, it decays via particles and γ ray emission. Angular momentum driven shape evolution and its thermal fluctuation make the decaying nuclei explore various shape and orientation at a finite J and T value. This leads to inhomogenous damping of the GDR. The Thermal Shape Fluctuation Model (TSFM) [1] provides a theoretical framework to understand the shape driven inhomogenous damping over a certain range of J and T. At a finite T the contribution from collisional damping via nucleon-nucleon collision has also been considered in various theoretical models [2]. To separate the contribution from different damping mechanisms has become a central issue in understanding the GDR width (Γ_D) dependence on J and T.

In a previous measurement in A∼150 mass region [3], the inadequacy of inhomogenous damping in explaining the observed Γ_D variation with J and T was reported. Inclusion of the collisional damping term in TSFM was found necessary to fit the observed Γ_D. On the other hand, in a recent work [4] in A∼130 mass region, it was reported that the contribution from TSFM and decay widths of initial and final states are sufficient to reproduce the results. To address the contribution from collisional damping, a systematic series of measurements has been planned to study the Γ_D dependence on J and T in A∼130 region at different excitation energy spanning a wide range of J and T. This paper presents the results obtained for the CN ^{128}Ba populated at an excitation energy (E_X) ∼93 MeV and critical angular momentum (L_c) ∼64$\hbar$.

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Experimental Details

The experiment was performed using a 150 MeV pulsed ^{28}Si beam bombarding an enriched (>98%) 0.97 mg/cm^2 ^{100}Mo target at the Pelletron Linac Facility(PLF), Mumbai. To assess the contribution from impurities (mainly C and O), measurements were also done with a 100 μg/cm^2 carbon and a 500 μg/cm^2 WO_3 (on carbon backing) targets at the same beam energy.

High energy γ rays (5-30) MeV were detected in an array of seven close packed hexagonal BaF_2 detectors [5]. Active cosmic rejection was achieved using an annular plastic detector around it. The time of flight (TOF) technique was employed for n-γ discrimination. To measure multiplicity of low energy γ rays an assembly of 38 element BGO detectors was placed symmetrically above and below the target chamber in groups of 19 each. The measurement was done in coincidence with evaporation residues to select CN events. These were detected in an annular parallel plate avalanche counter with 12 anode sectors and having an angular span of 4-11°.

Results

The statistical model code CASCADE [6] has been used to analyse the experimental γ spectra for various fold windows. Fig(1) shows the divided spectra for a low(4-7) and high(14-38) fold window. These plots were derived by

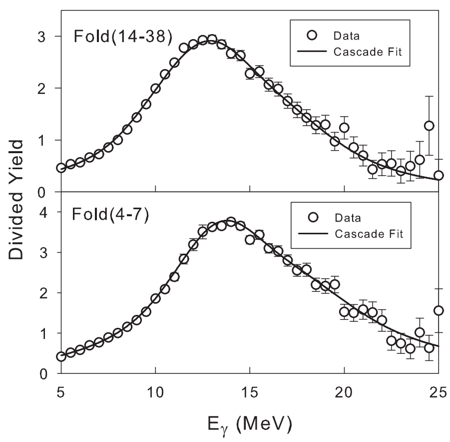

FIG. 1: Divided plots of data and calculation with best fit GDR parameters.

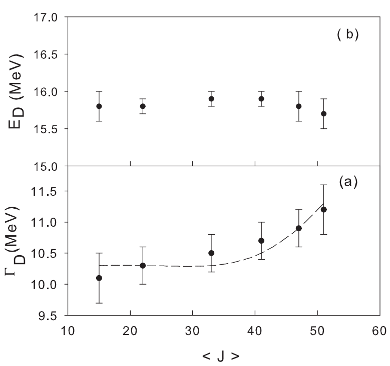

FIG. 2: (a) GDR centroid energy obtained from best Lorentzian fit parameters.(b) GDR width as a function of J. Dashed lines are results from TSFM calculation.

dividing the experimental γ spectrum by one calculated using constant strength (0.2 WU). The spectra were fitted using two component Lorentzian strength functions. The centroid energy E_D and Γ_D were deduced from the GDR parameters used in the fits shown in Fig.1. A simulated Monte Carlo version of CASCADE (SMCC) [7] has been used to estimate the average $< J >$ and $< T >$ in different fold windows. In all calculations, the prescription of Ref. [8] was employed for the nuclear level density(NLD), with the asymptotic NLD parameter $\tilde{a}$=A/9.5 MeV^{-1}.

The values of $< J >$ and $< T >$ along with the extracted E_D and Γ_D, in various fold windows, are listed in Table I and pictorially presented in Fig.2. The GDR energies are reasonably stable for various folds as has been seen in almost all the previous works.

TABLE I:

Fold	$< J >$	$< T >$(MeV)	Γ_D(MeV)	E_D(MeV)
1 - 5	15	1.69	10.1±.4	15.8±.2
4 - 7	22	1.65	10.3±.3	15.8±.1
8 - 10	33	1.54	10.5±.3	15.9±.1
11 - 13	41	1.45	10.7±.3	15.9±.1
14 - 38	47	1.38	10.9±.3	15.8±.2
18 - 38	51	1.32	11.2±.4	15.7±.2

The experimentally observed Γ_D values are compared in Fig.2(b) with the results from phenomenological expression of TSFM (dashed line) as given in Ref. [9]. The Γ_0 parameter in the expression was chosen as 5.1 MeV in this calculation. Here it may be noted that both J and T change with the change of fold. Although the present results seem to be consistent with the TSFM for the above choice of Γ_0, the test of the model will come from fitting the data at widely different beam energies with the same Γ_0 parameter. Future experiments, planned at other beam energies in the same reaction, will thus address this important issue.

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