Study of GDR width variation at low temperature in ^{28}Si + ^{124}Sn system at E_{Si} = 130 MeV

C. Ghosh[1],* G. Mishra[2], N. Dokania[3], M.S. Pose[1], V. Nanal[1], R.G. Pillay[1], Suresh Kumar[2], P.C. Rout[2], and Sandeep Joshi[2]

[1]*Deptartment of Nuclear and Atomic Physics, Tata Institute of Fundamental Research, Mumbai - 400005, India*
[2]*Nuclear Physics Division, Bhabha Atomic Research Centre, Mumbai - 400085, India and*
[3]*India-based Neutrino Observatory, Tata Institute of Fundamental Research, Mumbai - 400005, India*

Introduction

The Giant Dipole Resonance (GDR) in excited nuclei has proven to be unique tool for studying average nuclear shape and damping mechanism at high temperature (T) and angular momentum (J). The experimental observables associated with GDR studies are the centroid (E_D) and width (Γ_D) of the GDR peak. There are several theoretical efforts to describe the variation of Γ_D with J and T. Kusnezov *et al.* [1] gave phenomenological formula to describe the global dependence of *GDR* width on T and J in the liquid drop regime. The variation of Γ_D with T and J is extensively studied in rare earth region. The GDR width variation in ^{152}Gd for $T > 1.28$ MeV and for J = 26 to 56 $\hbar$ has been studied at PLF, Mumbai using ^{28}Si+ ^{124}Sn reaction at E(^{28}Si) = 149 MeV and 185 MeV[2, 3]. These experiments indicated that inclusion of collisional damping is necessary to explain observed width variation[3]. To investigate the same system at lower T, the experiment was performed at PLF, Mumbai with ^{28}Si beam of E = 130 MeV. The experimental details and preliminary results are given in ref.[4]. The statistical model analysis and extracted GDR parameters from the fold gated exclusive measurements are presented here.

Statistical Model Analysis

For generating fold gated γ-ray spectra a Simulated Monte Carlo CASCADE (SMCC) [5] is used. The Ignatuk level density prescription is used with asymptotic value of level density parameter $\tilde{a}$ = A/8.5 MeV^{-1}[6]. The output of SMCC - $\sigma1(E_\gamma, J_{res})$, is the residue spin ($J_{res}$) distribution for all residues as a function of γ-ray energy, which is obtained by summing over all steps of γ-decay. The multiplicity (M) of low energy γ-rays from J_{res} distribution - $\sigma2(J_{res}, M)$, is calculated for each γ-decay chain considering the level scheme of the residues for incorporating ΔJ=2 and ΔJ=1 transitions and isomers. The multiplicity(M) to fold (F) distribution - $\sigma3(M, F)$, is calculated after incorporating the efficiencies and cross talk probabilities of multiplicity array using Geant3 based simulations[7]. The convolution of above three matrices gives $\sigma(E_\gamma, F)$ and projection of that on E_γ axis gives the fold gated γ-spectra. The GDR strength function to be extracted from the analysis is parametrised as a two-component Lorentzian given by

$$F_L(E_\gamma, E_R, \Gamma) = \frac{\Gamma^2 E_\gamma^2}{(E_\gamma^2 - E_R^2)^2 + \Gamma^2 E_\gamma^2}. \quad (1)$$

Exhaustion of 100% of sum rule strength is assumed in all analysis. The simulated γ-ray spectra are folded with detector response function simulated using Geant and compared with data for each fold window. For searching the GDR parameters, the procedure adopted in ref. [5] is used. For a better visualization, both the experimental and simulated spectra have been divided by simulated spectra with a constant E1 strength of 0.2 W.u.. Fig. 1 shows the divided plots for different fold windows together with the best fit curves from

*Electronic address: chandan.ghosh@tifr.res.in

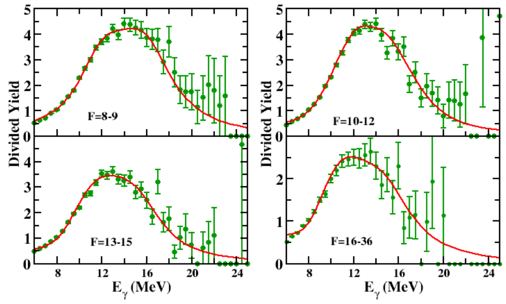

FIG. 1: Divided plots for different fold windows.

the statistical model analysis.

Results and Discussions

The extracted GDR parameters from the best fits in different fold windows are shown in Table I. The GDR centroid energy E_D, defined as $(S_1E_1 + S_2E_2)/(S_1 + S_2)$ and the effective width Γ_D, the FWHM of the two-component strength function extracted from the best fitted parameters are shown in Table II. It should be mentioned that T and J for each fold windows are calculated using a modified version of SMCC. The temperature is defined as $U = aT^2$, where

$$U = E_{xf} - E_{rot}(J_f) - \Delta_P \qquad (2)$$

and $E_{rot}(J_f)$, Δ_P and E_{xf} are the rotational energy, the pairing energy and the final state energy, respectively. The present data and data from refs. [2] and [3] are compared with Kusnezov parametrization and are shown in Fig. 2. It is evident that the present data is consistent with liquid drop regime. The observed discrepancy between 149 and 185 MeV data is not evident in the data between 130 and 149 MeV. The centroid of GDR, E_D remains constant with variation of angular momentum, whereas the width shows weak dependence on J.

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TABLE I: GDR parameters extracted from statistical model analysis

Fold	E_1	Γ_1	E_2	Γ_2	S_2
8-9	12.8(1)	4.8(2)	16.5(2)	5.8(2)	0.67(2)
10-12	12.7(1)	4.6(2)	16.1(2)	6.2(2)	0.70(2)
13-15	12.5(1)	5.6(2)	16.0(2)	6.2(3)	0.70(2)
16-36	12.3(1)	5.9(2)	15.8(2)	6.0(3)	0.70(2)

TABLE II: GDR parameters as a function of J and T

Fold	$< J >$	$< T >$	E_D	Γ_D
8-9	26(18)	1.37(58)	15.3(2)	8.6(3)
10-12	33(17)	1.33(56)	15.1(2)	7.8(3)
13-15	38(14)	1.29(53)	15.0(2)	8.0(4)
16-36	42(12)	1.25(51)	14.8(2)	8.3(4)

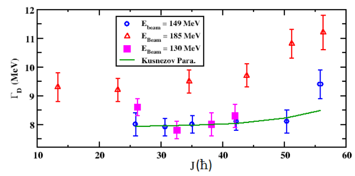

FIG. 2: GDR width as a function of angular momentum. The present data is shown by square, the data shown by open circle and triangle are taken from ref. [2] and [3], respectively. The solid line represents the Kusnezov parametrization with $\Gamma_0 = 3.2$ MeV.

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