Study of the Giant Dipole Resonance in Te-isotopes

Saumanti Sadhukhan[1,2], S. Mukhopadhyay[1,2 *], Debasish Mondal[1], Deepak Pandit[1,2], Surajit Pal[1], Chandrani Sen[1,2], K. Banerjee[1,2], R. Shil[3], D. Paul, T. K. Rana[1,2], S. Kundu[1,2], S. Manna[1], A. Sen[1,2], A. De[5], P. Karmakar[1,2], J. Sadhukhan[1,2], B. Dey[4], Srijit Bhattacharya[6], S. Chakraborty[1], S. Bagchi[7], M. Abdullah[7], K. Khokar[7], D. Kar[7], S. Bhattacharyya[1,2] and C. Bhattacharya[1,2]

[1]Physics Group, Variable Energy Cyclotron Centre, Kolkata -700064, India
[2]Homi Bhabha National Institute, Anushaktinagar, Mumbai – 400085, India
[3]Department of Physics, Siksha Bhavana, Visva-Bharati, Santiniketan - 731235, India
[4]Department of Physics, Bankura University, Bankura - 722155, India
[5]Ex-Department of Physics, Raniganj Girls' College, 713358, India
[6]Department of Physics, Barasat Government College, Barasat, N 24 Parganas, Kolkata - 700124, India
[7]Indian Institute of Technology (Indian School of Mines), Dhanbad, Jharkhand, 826004, India
**email: supm@vecc.gov.in*

Introduction

The isovector giant dipole resonance (IVGDR) in nuclei is the collective mode of vibration which occurs in all atomic nuclei. It is an excellent experimental probe to explore the evolution of nuclear shape as a function of excitation energy and spin [1]. Large number of experiments have been performed over the years to investigate how the GDR width changes with nuclear excitation energy and spin [2]. These experimental studies showed that the GDR width increases as a function of both temperature (*T*) and spin (*J*). The most widely accepted theoretical model for GDR is the thermal shape fluctuation model (TSFM) [3]. TSFM assumes an adiabatic coupling of GDR vibration to quadrupole degrees of freedom and predicts *J* dependence on GDR width quite well [4] and *T* dependence above $T > 1.5$ MeV. However, this model failed to explain the suppression of GDR width at low *T* [5-8]. A critical temperature fluctuation model (CTFM) [6] was introduced to explain this suppression by considering the GDR induced quadrupole moment. The deformation due to thermal shape fluctuation is very small compared to this induced vibration and GDR width should remain constant to its GS value up to a critical temperature T_C. This model is completely empirical. The microscopic Phonon Damping Model (PDM) can successfully explain the experimental trend at low as well as at high *T* [10]. It should be mentioned that for Sn and nearby nuclei shell effect is negligible and experimental data were reproduced by including pairing field fluctuations in TSFM [11]. For A ~ 120 mass region the GDR width was found to be equal to its ground state value up to $T = 1$ MeV. However, such behavior was not observed in an earlier measurement for the nucleus ^{114}Sn [2,9]. Therefore, more studies are required in this region to get deeper insight about the damping mechanism inside the nucleus. Here we report an in-beam experiment performed at Variable Energy Cyclotron Centre (VECC) to study the evolution of GDR width for A ~ 120 mass region at low temperature and its isotopic dependence.

Experimental Details

The experiment was performed at VECC, Kolkata using accelerated alpha beam from K-130 cyclotron. Three different targets ^{112}Sn, ^{116}Sn, ^{124}Sn each having thickness of ~1 mg/cm^2 were bombarded with pulsed beam of ^{4}He of energies 28, 38 and 50 MeV. High energy photon spectrometer LAMBDA [12] was used to measure high-energy gamma (E_γ ~ 5 - 30 MeV). A total of 49 BaF_2 scintillators were arranged in a 7×7 matrix which was positioned at a distance of 50 cm from the target at the angle 90 degree with respect to the beam axis. A multiplicity filter [13] consisting of 50 small BaF_2 detectors were used to estimate the angular momentum of the populated compound nucleus. This filter was splitted into two blocks consisting 25 BaF_2 each and were placed at the top and bottom of the target chamber at a distance of 5 cm from the target position. The diagram of experimental set-up is shown in Fig. 1. The master trigger for data acquisition was generated when at least one detector of the LAMBDA array fired above a threshold of ~4 MeV in coincidence with at least one detector from both the top and bottom multiplicity filters.

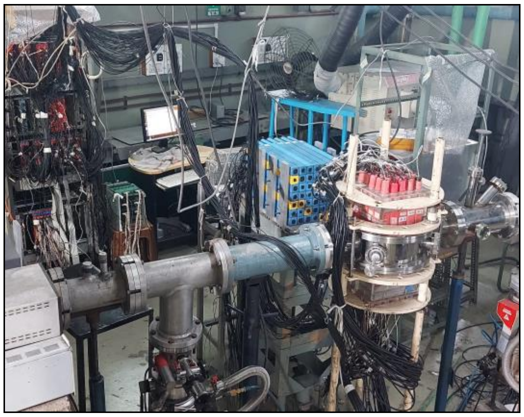

Fig. 1 Experimental setup with LAMBDA and Multiplicity filter.

Data Analysis

A detailed offline analysis has been performed in CERN ROOT to extract the meaningful spectrum from the list mode data after employing different cuts. The neutrons, statistically emitted from the hot nuclear system are the major source of contamination in the high energy γ-ray spectra. The neutrons are rejected by time of flight (TOF) and pile-up events are rejected using pulse shape discrimination (PSD) technique for each detector. The Cosmic events are rejected from its hit pattern in the LAMBDA array, which are quite distinct from actual γ events. The high-energy γ-ray spectrum is generated by using a nearest neighbor cluster summing technique [12]. The preliminary high-energy gamma ray spectra have been shown for ^{116}Te, ^{120}Te and ^{128}Te at 38 MeV in Fig. 2. It can be observed from the shapes of the spectra above $E_\gamma > 10$ MeV are different. The GDR parameters are extracted by fitting the experimental spectra with the results of statistical model calculations which is in progress using the CASCADE code. The detailed results will be presented in the symposium.

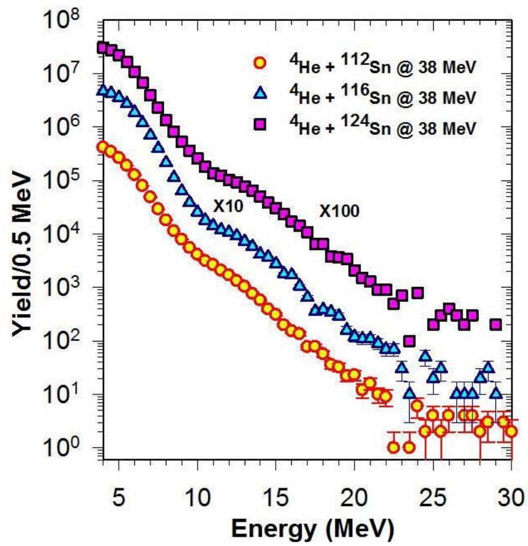

Fig. 2 Experimental high energy γ-ray spectrum for the reaction mentioned.

References

[1] M. N. Harakeh and A. van der Woude, Giant Resonance: Fundamental High-Frequency Modes of Nuclear Excitation, Clarendon press, Oxford, 2001.

[2] D. R. Chakrabarty et al., Eur. Phys. J. A **52** (2016) 143.

[3] Y. Alhassid et al., Phys. Rev. Lett. **61** (1998) 1926.

[4] M. Mattiuzzi et al., Nucl. Phys. A **612** (1997) 262.

[5] S. Mukhopadhyay et al., Phys. Lett. B **709** (2012) 9.

[6] Deepak Pandit et al., Phys. Lett. B **713** (2012) 434.

[7] B. Dey, et al., Phys. Lett. B **731** (2014) 92.

[8] D. Mondal et al., Phys. Lett. B **784** (2018) 423.

[9] A. Stolk et al., Nucl. Phys. A **505** (1989) 241.

[10] N. D. Dang et al., Phys. Rev. C **68** (2003) 044303.

[11] A. K. Rhine Kumar et al., Phys. Rev. C **91** (2015) 044305.

[12] S. Mukhopadhyay et al., NIM A **582** (2007) 603.

[13] Deepak Pandit, et al., Nucl. Instr. Meth. A **624** (2010) 148.