Exclusive Measurements of GDR Gamma Rays from Hot Rotating ^{196}Hg Nucleus

I. Mazumdar[1],* D.A. Gothe[1], P.B. Chavan[1], N. Madhavan[2], S. Nath[2], J. Gehlot[2], T. Varughese[2], P. Sugathan[2], I. Mukul[2], G. Mohanto[2], V. Singh[3], M. Kaur[3], and A.K. Sinha[4]
[1]*Department of Nuclear and Atomic Physics, Tata Institute of Fundamental Research, Mumbai - 400005, INDIA*
[2]*Dept. of Physics, IIT-Roorkee, Roorkee-247667*
[3]*Dept. of Physics, Panjab University, Chandigarh and*
[4]*UGC-DAE-CSR, kolkata Centre, Kolkata*

Introduction

The studies in Giant Dipole Resonance (GDR) decay of high energy gamma rays have established itself as one of the primary tools to understand the dynamics of the hot rotating nuclei. The spectral shape and angular anisotropies of the GDR gamma rays are expected to manifest variety of shape-phase transitions in the atomic nuclei with increasing temperature and angular momentum. The selection of the nuclei to be studied and the region of phase space to be probed, are guided by the predictions of theoretical calculations, both microscopic and macroscopic. It is now well established, that all mean field calculations predict a transition temperature T_{c1}, at which the nucleus, irrespective of its ground state deformation, becomes spherical and on rotation becomes oblate, rotating about its symmetry axis [1]. A series of calculations by Goodman have resulted in the prediction of a second transition temperature T_{c2}, where $T_{c2} > T_{c1}$, in some heavy nuclei [2]. According to these calculations the nucleus is expected to rotate about its symmetry axis with a prolate shape in a narrow region of the phase space demarcated by the two angular momentum dependent transition temperatures T_{c1} and T_{c2}. Our previous measurements of phase space selected GDR gamma rays from ^{194}Au provided a definite indication of shape transition [3]. This provided further impetus to carry out the investigations in other neighbouring nuclei. Here we report on the measurements of GDR decay in ^{196}Hg.

*Electronic address: indra@tifr.res.in

Measurements of GDR spectrum from hot rotating ^{196}Hg

We report about two different experiments carried out to measure high energy Giant Dipole Resonance (GDR) gamma rays from excited ^{196}Hg nucleus. The primary aim was two fold. To search for rare shape phase transition in the hot and rotating ^{196}Hg nucleus and also to extract high energy gamma rays from the decay of the Isovector Giant Quadrupole Resonance (IVGQR). The ^{196}Hg compound nucleus was populated by bombarding a 1.1 mg/cm^2 self-supporting ^{180}Hf target by ^{16}O beam from the Pelletron-LINAC facility at the Inter University Accelerator Centre, New Delhi. In the first experiment 120 MeV ^{16}O beam was delivered from the Pelletron and the first module of the newly commissioned super-conducting LINAC booster. The second experiment used 100 MeV beam only from the Pelletron accelerator. The high energy gamma rays were detected in the large NaI(Tl) High Energy Gamma Ray spectrometer (HIGRASP) [5] kept at 90^o with respect to the beam direction and at a distance of 75 cm from the target position. The multiplicity and total energy of the low energy discrete gamma rays were measured using the TIFR 4π Sum-Spin Spectrometer consisting of 30 conical NaI(Tl) detectors in spherical configuration. The pileup events were removed by zero crossover technique and the neutrons were rejected by time-of fight. The cosmic ray events were rejected using plastic anti-coincidence shields around the NaI(Tl) (HIGRASP). The GDR spectrum was also measured in a large volume combined assembly of cylindrical $LaBr_3$:Ce inside an annular NaI(Tl). The front surface of the outer NaI(Tl) detector was covered by 6 thick annular lead shielding and the high energy gamma rays were allowed to hit only the central $LaBr_3$:Ce. The Compton-scattered gamma rays escaping out of the $LaBr_3$:Ce were detected in the annular NaI(Tl). The energy signals from the detectors were gain matched and added back to get the total energy deposition in the system. Both the large NaI(Tl) (HIGRASP) and the $LaBr_3$:Ce were kept at two different angles with respect to the beam direction to measure the angular anisotropy of the GDR gamma rays. The scattering chamber and the 4π spin spectrometer were installed on the Hybrid Recoil Analyser (HYRA) beam line at IUAC in order to detect the GDR gamma rays in coincidence with the evaporation residues detected at the focal plane of HYRA [**?**]. For the 120 MeV beam energy HYRA was used in the gas filled mode and the high energy gamma rays were independently detected in the two gamma rays spectrometers (NaI(Tl) and $LaBr_3$:Ce in coincidence with the low energy discrete gamma rays in the 4π spin spectrometer and the evaporation residues detected at the focal plane of the HYRA. For the 100 MeV beam in the second experiment HYRA was not used. The contribution of the cosmic rays in the 10 to 30 MeV region of the gamma ray spectrum was estimated by measuring background without the beam for extended period of few days. The final data reduced and angular momentum gated GDR gamma ray spectra for both the detectors (HIGRASP and LaBr+NaI assembly) at different beam energies and angles were extracted. The statistical model analysis of the spectra and the angular anisotropy are in progress and will be reported in the symposium. Fig. 1 shows the final data reduced GDR spectrum measured at 90^o with respect to the beam direction in the LaBr+NaI assembly at 100 MeV beam energy. Fig. 2 shows a typical n-γ TOF spectrum measured in the LaBr+NaI assembly.

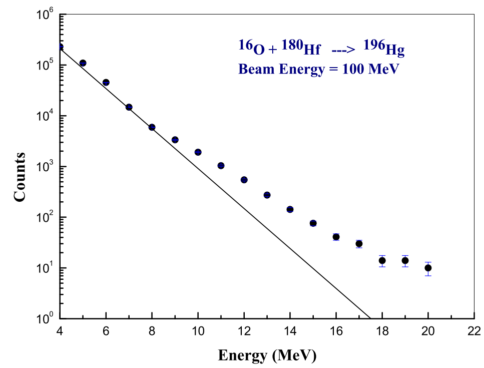

FIG. 1: The GDR gamma ray spectrum using the combined assembly of the $LaBr_3$ and annular NaI(Tl).

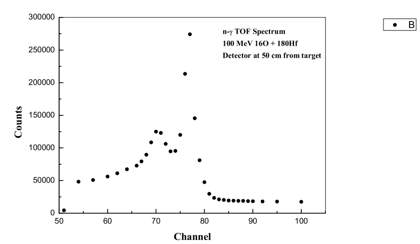

FIG. 2: The n-γ time of flight spectrum recorded in the combined assembly of $LaBr_3$:Ce and NaI(Tl).

References

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