Measurement of Collective Enhancement of the Nuclear Level Density in ^{161}Dy nucleus

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Introduction

The atomic nucleus is a many-body fermionic system, shows many nuclear phenomena due to single particle motion and/or collective motion of nucleons in the nucleus. Both these degrees of the freedoms are important for understanding the properties of the atomic nucleus and their influence on nuclear level density(NLD) which is a fundamental property of atomic nucleus. The NLD is thus an important physical quantity for estimation of reaction rates for many application such as in spallation neutron sources and Nucleosynthesis. The NLD is defined as the number of energy levels per MeV at excitation energy (E_X). For the first time, Bethe derived the excitation energy and angular momentum (J) dependent NLD within Fermi gas model. The E_X dependent NLD is proportional to $e^{2\sqrt{aE_X}}$, 'a' is the NLD parameter. Even-though the work on NLD is exclusively studied both experimentally and theoretically over the years, there are many open questions, such as shell effect and it's damping with E_X [1], collective enhancement and its fade out and pairing effect on NLD [2, 3], needs to be addressed experimentally.

It has been predicted by Bjornholm, Bohr, and Motelson that there is a significant increase in the total NLD due to the occurrence of collective rotational motion. The total level density is given by $\rho_{tot} = \rho_{int} K_{coll}$. The aim of the present measurement is to study of the rotational enhancement of the nuclear level density(NLD) in ^{161}Dy and its fade out with E_X . The statistical model analysis of the measured neutron spectra from ^{162}Dy, populates through the breakup-fusion reaction of ^{7}Li with ^{159}Tb target as measured in case of ^{208}Pb [1], will reveal the fade out of rotational enhancement with E_X.

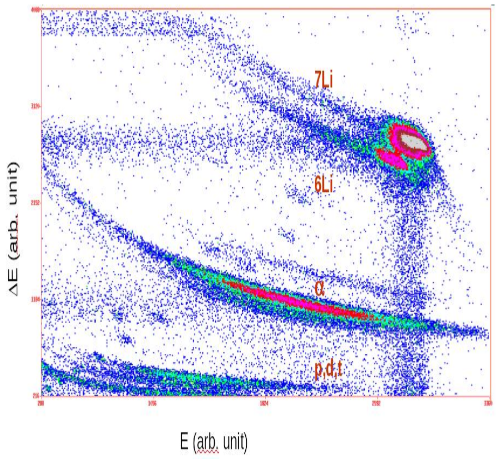

FIG. 1: The Typical 2D spectrum between ΔE and E for one strip of one strip detector telescope. The figure shows clear identification of all the light charged particle up to ^{7}Li

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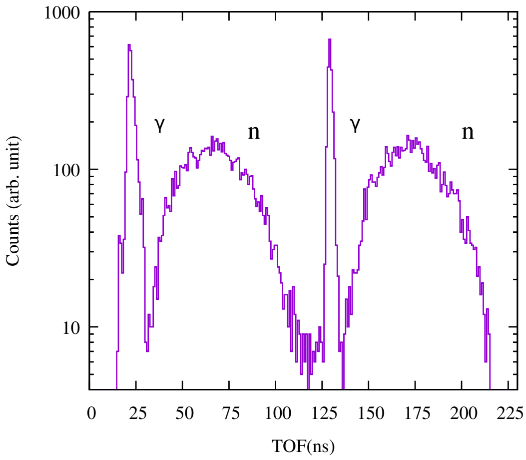

FIG. 2: The neutron time of flight spectrum in ^{7}Li induced reaction on Tb. The two gamma prompts peaks are corresponding to two beam bunches of the pulsed beam within 213 ns

Experimental Details

The experiment was carried out at BARC-TIFR Pelletron Linac Facility, Mumbai using pulsed ^{7}Li beam of 35 MeV energy on self-supported target ^{159}Tb of thickness 2.8 mg/cm2. Three ΔE-E telescope strip detectors (5 cm×5 cm dimension) placed at about 10 cm from the target at mean angles ±60° and 110° used for charged particle detection. The thickness of ΔE detectors is about 50μm while E detectors are 1500μm. Each detector has 16 strips with an angular coverage of 25°. The neutron time of flight(TOF) technique is used to measure the neutron energy using an array of 15 liquid scintillation(LS-EJ301) detectors. Each scintillation detector(5-Inch diameter and 2-Inch long cylindrical shape) was coupled to a 5 inch diameter fast PMT for signal readouts. The LS array having the angular coverage range from 58° to 143° is placed at 70 cm from the target center and there is a 16° separation between each detector. Neutron-gamma discrimination is done by both TOF and pulse shape discrimination (PSD) methods. The neutrons were detected in coincidence with charged particles and data was stored in list mode using VME based data acquisition system. The neutron TOF, PSD, pulse height of liquid scintillator and energy signal from each strip detectors has been recorded in list mode. The TOF was calibrated using a precision time calibrator and the LS pulse-height calibration was done by measuring the Compton edge from ^{137}Cs, ^{22}Na and Am-Be sources. The energy calibration of strip detectors was done for alpha particles using ^{229}Th and ^{241}Am sources.

Results and Discussion

A Typical 2D spectrum between ΔE and E for one strip of one of the strip detector telescope is shown in FIG 1. It shows clear identification of all light charged particles in ^{7}Li induced reaction. The TOF spectra were calibrated and a calibrated TOF spectrum is shown in FIG 2. It shows two prompt gamma-ray peaks corresponding two-beam bunches and broad neutron distribution for each case. Then Alpha particle energy gated neutron TOF spectrum will be converted to energy spectrum with suitable Jacobian factor and also corrected for neutron energy-dependent efficiency. The final results with statistical model analysis will be presented.

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