Measurement of damping of nuclear shell effect in ^{212}Po

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Introduction

Atomic nucleus is a many-body finite fermionic system and has shell structure analogous to electronic structure in an atom. The nuclei with closed shell show extra stability compared to that of that predicted by liquid drop model(LDM). Many nuclear phenomena such as fission isomers, super-deformed nuclei are explained due to shell effect. Shell effect also affects the nuclear level density, a fundamental property of atomic nucleus, which defined as the number of energy levels per MeV at excitation energy (E_X). The dependence of the NLD on the excitation energy was first derived by Bethe using Fermi gas model which varies as $e^{2\sqrt{aE_X}}$. Here *'a'* is the NLD parameter which is related to the single particle density at the Fermi energy and on an average the level density parameter a increases linearly with the mass number(A) of the nucleus as $a \approx$A/8 MeV^{-1} due to the liquid drop like properties of the nucleus. However, there is a significant departure from this liquid drop value at shell closures. Ramamurthy et al. [1] predicted that the shell effect on the NLD parameter is expected to wash out with excitation energy so that a approaches its liquid drop value at $E_X \geq 40$ MeV. The NLD parameter a, which includes the shell effect and its damping, has been parameterized by Ignatyuk [2] as

$$a = \tilde{a}[1 - \frac{\Delta_S}{U}(1 - e^{-\gamma U})].$$

where $U = E_X - E_{\rm rot} - \Delta_P$, $E_{\rm rot}$ is the rotational energy, Δ_P is the pairing energy, $\tilde{a}$ is the asymptotic value of the NLD parameter in the liquid drop region, Δ_S is the shell correction energy, and γ is the damping parameter. The shell damping factor near ^{208}Pb was measured using a novel experimental techniques and the damping factor γ found to be $(0.060^{+.010}_{-.020})$ MeV^{-1} [3].

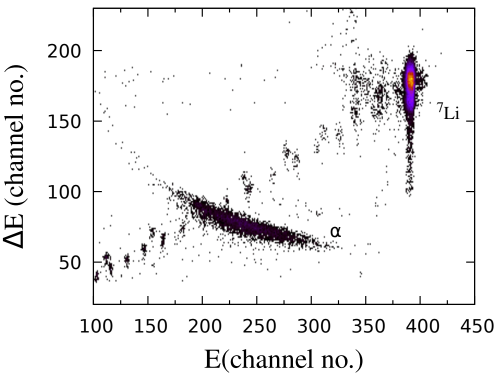

FIG. 1: Particle identification from ΔE-E telescope detector

In this paper we report the measurement of neutron evaporation spectrum from ^{212}Po to study the shell effect and its damping using an improved experimental setup using Liquid scintillation array and si-strip telescope detectors.

Experimental Details

The experiment was carried out using ^{7}Li pulsed beam of 44 MeV bombarding on ^{209}Bi target at the BARC-TIFR Pelletron Linac Facility. Four Silicon strip detectors were placed at grazing angles to detect the outgoing alpha particles while an array of 15 Liquid Scintillation(LS) detectors were used for neutron measurement. Each neutron detector were placed

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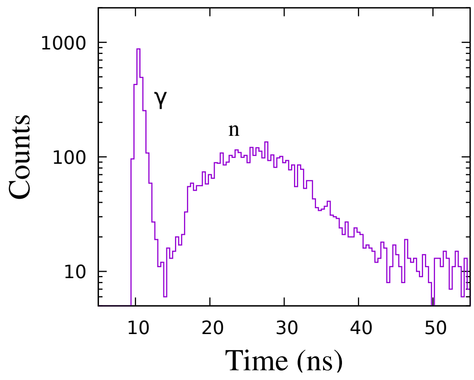

FIG. 2: Measured time of flight (TOF) spectrum of LS detector.

at a flight path of 70 cm. The energy signal from each strip detectors, energy of the LS, Pulse shape discrimination(PSD) of each LS and the time of flight (TOF) with respect to the filtered pulse beam(suitably gated by the charged particles and neutrons) for each LS detector were recorded in an event-by event mode using VME analogue data acquisition system. The energy of the strip detectors were calibrated upto 8.5 MeV using ^{229}Th alpha source and energy of the LS detector were calibrated using Compton edge of gamma rays using gamma sources and the precision time calibrator was used for time calibration.

Results and Discussion

A typical 2D plot between the ΔE and E strips to identify the charged particles produced in the reaction following the Bethe-Bloch energy loss mechanism is shown in Fig 1. It clearly shows the alpha particles are well separated from ^{7}Li. The time spectrum of LS was calibrated and a calibrated TOF spectrum gated with proper alpha energy bin is shown Fig 2. The TOF spectrum which was extracted by applying appropriate PSD gates and alpha energy gates, was converted into the neutron energy spectrum. The derived neutron energy spectrum is shown in Fig 3. This shows exponential energy dependent as per the statistical decay of the compound nucleus.

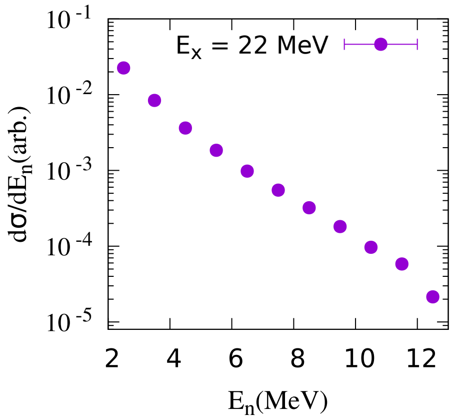

FIG. 3: Typical neutron energy spectra from the compound nucleus evaporation.

Summary

An LS array used to measure exclusive neutron evaporation spectra employing TOF and PSD techniques. The statistical model for decay of compound nucleus will be used to analyse the measured neutron evaporation spectra to infer the damping of the nuclear shell effect.

Acknowledgments

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