Heavy ion induced alpha gated gamma spectroscopy in the A~200 region

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Introduction

Shape co-existence refers to the existence of multiple deformations in a single nucleus. It is a well studied phenomenon, both theoretically as well as experimentally [1]. The mass region (A~200) is a key area where this phenomenon can be observed. A prime example is the ^{186}Pb nucleus that demonstrates triple shape coexistence [2]. In the neighboring mercury (Hg) isotopes, some work has been done that verifies the presence of multiple deformations [3]. There has been theoretical progress in this particular mass region as well that hints towards existence of the phenomenon in multiple mercury isotopes [4]. Therefore, it can be intuitively understood that the isotopes around A~200 region with minor variations in neutron and proton numbers could be possible candidates that display shape coexistence. There remains scope to conduct new observations using modern techniques for the study of ^{182,184}Hg isotopes. These two isotopes lie very close to the magic proton configuration as well as the mid-shell neutron configuration, increasing probability of observing shape coexistence.

Experimental Details

Alpha-decay gated gamma spectroscopy technique has been used in this experiment to study the phenomenon of shape coexistence in ^{182,184}Hg isotopes. The setup has been established at the HYRA (Hybrid Recoil mass Analyzer) beam line at Inter University Accelerator Centre, New Delhi. Using a pulsed beam of 185MeV (Pelletron and LINAC) ^{28}Si, ^{164}Er target [5] has been bombarded to produce ^{190}Pb compound nucleus, which upon proton/neutron evaporation and subsequent alpha decays populates the nucleus of interest. HYRA has been operated in the gas-filled momentum dispersive mode. Detector setup inside the HYRA focal plane (FP) chamber comprises of a combination of multi-wire proportional counter (MWPC) and silicon detector in a ΔE-E telescope design for identification of evaporation residues and their subsequent alpha products. One high purity germanium (HPGe) clover detector has been placed close to the FP chamber. A pair of HPGe detectors has also been placed at the target plane location at angles of 90º and 45º (backward), in order to assist identification and sorting of the cocktail of nuclei produced inside the target chamber. Three different TAC (time to amplitude conversion) spectra each with a range of 10 μs have also been recorded for correlation between silicon detector-focal plane clover, MWPC-focal plane clover and MWPC-target plane clover detectors. Data for both the FP as well as target plane (TP) nuclei have been collected using two standalone data acquisition systems [6]. Each event from both data acquisition system (DAQ) was time-stamped for correlation between TP and FP branches, which can enable observation of isomers over a long time range.

Analysis and Results

There were two separate data streams that were acquired during the experiment, namely the focal plane data and the target plane data. In this manuscript, only the FP data has been discussed. To begin with, data analysis has been performed for the MWPC by extracting its two dimensional position information. Energy loss information in the MWPC was extracted from the cathode signal. Further, energy deposition information was obtained from the Si detector and plotted as a 2-d spectrum with respect to the energy loss information of MWPC (fig 1 (top)). Based on this 2-d, it is clear that there are different groups of events present, and ERs can be distinctly identified. In order to ensure that the main region of interest while detecting alpha particles (5-8 MeV) is well resolved in the Si detector, a high gain factor was introduced electronically. This is the reason there can be seen a clear abrupt cut on the higher side of the 2-d spectrum (fig 1 (top)). Keeping in view the fact that ERs would emit α particles upon implantation in the Si detector, the α spectrum was constructed based on the information from MWPC energy signal (fig 1 (bottom)). Expected α decay half-lives were in the seconds order. The Si spectrum was calibrated based on the offline calibration runs with ^{229}Th α source three times- before, during and after the experiment. This Si data which contains only alpha particle information has then been used to gate the FP clover data.

As previously mentioned, time-stamping technique has been used to acquire the data. The HYRA FP DAQ was the master clock according to which the HYRA TP clock was synchronized. This technique can vastly enhance the observational domain, in terms of enabling the search for long lived isomers that can survive the flight path of ~1.5 µs from TP to FP. In the data collected for the FP clover detector gated by the Si detector (without MWPC counts), besides the background there are some peaks, identification of which is being undertaken. This would help ascertain the different alpha particles detected and their corresponding daughter products. Analysis of gamma rays emitted by these de-exciting daughter nuclei will help detect isomers

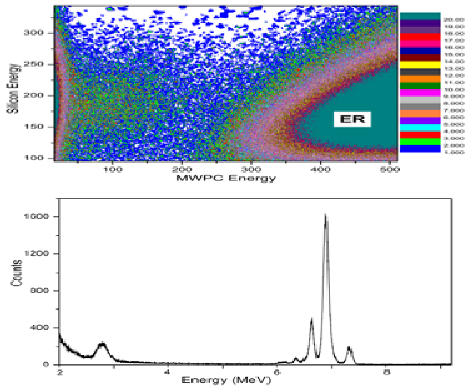

Fig 1: *focal plane spectra (top to bottom) compressed coincidence spectrum between MWPC cathode (x axis) and silicon energy (y axis) and alpha spectrum obtained from silicon detector*

in this mass region. Results regarding the same as well as of those nuclei related to the target plane chamber would be discussed during the conference.

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