Decay Spectroscopy of neutron rich odd-odd Pm isotope

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Introduction

The N = 89 Pm isotope has been of very recent interest because of several aspects. Along with the fact that only the ground state of the nucleus, having a half life of 2.68 hrs, was known until very recently, this nucleus provides the intermediate state for the double beta decay of ^{150}Nd [1,2]. The neighbouring odd-odd ^{148}Pm has been known as the branch point nuclei and has been understood to have a significant neutron capture cross section [3] that produces the next Pm isotope via s-process. There is not much understanding on the stellar production and abundance of ^{150}Pm which warrants measurement of various reaction cross sections for reaching the nucleus. Very recently O. Lebeda et al., have measured the excitation functions of proton induced reactions on natural Nd target[4].

The structure of odd-odd Pm nuclei around N = 90, are governed by the $d_{5/2}$ / $g_{7/2}$ and $h_{11/2}$ proton orbitals in Z = 50 - 82 subshell space along with the $h_{9/2}$ neutron orbitals in Z = 80-126 subshell space. The negative parity states are observed at low spin with configurations like $\pi g_{7/2}/d_{5/2} \otimes \nu h_{9/2}$, whereas the two particle coupled structure consisting of negative parity proton $h_{11/2}$ orbital is also expected. The systematic study of these neutron rich Pm isotopes reveals the presence of a high spin isomer that undergoes beta decay with a half life more than or of the order of the half life of the ground state of these nuclei. Till date, there is almost no information regarding the configuration of the ground state as well as high spin states including the isomeric state of these nuclei which are indeed very important component in understanding the structure. Most importantly, such high spin isomeric state could not yet be confirmed in the N = 89 ^{150}Pm. However, recent in beam studies [5, 6] on ^{150}Pm has given a little knowledge on the excited states and the off-beam study has given an indication on the possibility of the existence of an isomer at high spin having a half life which is few minutes more than the half life of the ground state [6].

The detection of such a long lived isomeric state is not possible from the prompt in-beam spectroscopy. The decay spectroscopy has been known to be an efficient tool for this purpose [7, 8]. In the present work, we report the decay spectroscopy of ^{150}Pm in order to identify the high spin isomeric state in ^{150}Pm by beta gamma coincidence technique and by measuring the (p, n) cross section corresponding to the decay of the ground state and isomeric state of the nucleus.

Experiment

The ^{150}Pm nucleus has been produced by ^{150}Nd (p, n) reaction at proton energies from 7 to 15 MeV, provided by K = 130 cyclotron of VECC, Kolkata, by using target irradiation technique. Five target stacks were used in the experiment and were prepared by putting appropriate degrader foils in between the targets and aluminium catcher foils in front of all the targets as well as the degraders. The latter was done in order to ensure that the activities of the degraders do not contaminate the targets as well as the activities produced from the target which are recoiled out can be considered for counting. For the measurement of incident beam flux, the Cu monitor foils were used as well as the current from the electron suppressed Faraday cup was recorded. The oxide Nd targets were prepared by electro-deposition technique on 0.3 mil aluminium backing foils starting from the 97% enriched Nd_2O_3 powdered sample. Neutron activation technique has been used in order to estimate the number of Nd nucleus in the prepared target by using the available facility at BARC, Mumbai. The irradiated targets along

with their catchers have been counted by using the efficiency and energy calibrated (i) a 50% HPGe detector and (ii) a 10% HPGe detector in order to follow the decay of ^{150}Pm. The beta decay from the irradiated target, one from each stack, were also recorded using the beta-gamma coincidence setup [9], consisting of a 11 mm thin LEPS detector with 300 μm Be entrance window and a 10% coaxial HPGe detector, in order to identify the beta decay branches and to measure the end point energies corresponding to different de-exciting levels of the ^{150}Sm daughter nucleus.

Analysis and Results:

The decay has been followed for different gamma rays of the daughter nucleus and the two groups of gamma rays have been identified having different half lives, as observed in our earlier work [6]. The absolute cross section for the ^{150}Nd (p, n) ^{150Pm} reaction has been measured following the decay of gamma rays belonging to the two said groups. The result obtained with the 1324 keV gamma ray has been shown in Fig. 1 along with a theoretical calculation made with EMPIRE- 3.1. The results for the obtained cross sections for different proton induced reaction will be discussed during the presentation.

In order to identify the isomeric state and to measure its energy, gates were put at 1165, 1170, 439 and 2033 keV gamma rays belonging to ^{150}Sm in the 10% detector of the beta-gamma coincidence setup and the corresponding beta spectra have been extracted using the procedure described in [9]. The Fermi-Kurie (FK) plots corresponding to these beta decays have been plotted in Fig. 2 and have been fitted to obtain the endpoint energies. The endpoint energy corresponding to 1165 keV agrees with the difference in the Q_β value of ^{150}Pm ground state beta decay and the energy of the level de-exciting the 1165 keV transition, corrected for the degradation at the Be window. However, the end point energies corresponding to other transitions, viz. 1170, 439 and 2033 keV, show larger values than what one expects if the beta decay is considered to be from the ground state of ^{150}Pm. The calculated and expected endpoint energies corrected for degradation in Be window of LEPS have been indicated in Fig. 2. This indicates the presence of a high spin isomer in ^{150}Pm from the present analysis. The detail data analysis is in progress.

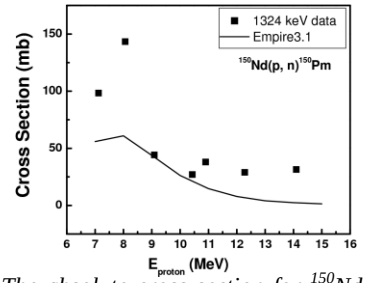

Figure 1: The absolute cross section for ^{150}Nd (p, n) ^{150}Pm

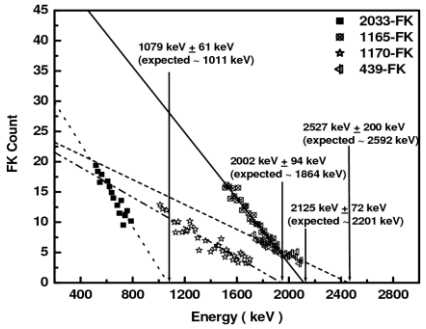

Figure 2: The FK plot corresponding to some of the gamma ray of ^{150}Sm.

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