Excited states of neutron rich ^{150}Pm using (p, nγ) reaction

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Introduction

The odd-odd lighter rare earth nuclei around the line of stability exhibit a variety of nuclear shapes and excitations, arising from the competing shape driving effects of high-j orbital [1]. The Promethium (Pm) nuclei are unique in some respect as there is no stable isotope of Pm in nature. These nuclei are synthesized in s-process either via (n,γ) reactions or by β-decay following (n,γ) reactions. Of the known Pm nuclei, the neutron-rich ^{147,148}Pm are suggested to be "branch point" nuclei in s-process path and has, therefore, drawn special attention in the recent past [2]. The next odd-odd isotope, i.e, ^{150}Pm [3] is known to be situated on the line of β-stability and is completely unknown till date; except for the half life (2.68 h) and tentative spin-parity (1^-) of the ground state. This is mainly because of the scarcity in the proper target projectile combination that can produce the excited states with a reasonable cross section. Only a few possible fusion evaporation reaction, viz., (p, nγ); (d, 2nγ); (^{3}He, d) populate the low spin states of this nucleus. In the present work, we have investigated the excited levels of ^{150}Pm for the first time using ^{150}Nd (p, nγ) reaction with an emphasis to identify the possible excited isomers, whose presence may be crucial in s-process nucleosynthesis.

Experiment and Data Analysis

The excited states in ^{150}Pm were produced by using the proton beams in the energy range 8-11 MeV, obtained from the K=130 AVF cyclotron of VECC, Kolkata. The enriched (97%) ^{150}Nd target on aluminized Mylar, having ~1mg/cm^2 thickness, was prepared by electro-deposition technique. The Q-values for ^{150}Nd (p, nγ) ^{150}Pm and ^{150}Nd (p, 2nγ) ^{149}Pm are known to be –0.868(20) MeV and -6.472(4) MeV, respectively, from the 2003 Atomic Mass Evaluation [4]. In our experiment, both ^{149,150}Pm were produced at above energies with different relative yields. This has been confirmed by studying the off-beam decay of the γ-rays, identified to be of ^{149}Sm and ^{150}Sm, produced via β-decay of ^{149}Pm (53 h) and ^{150}Pm (2.68 h) respectively. Two sets of known γ-rays have been seen, one from the 2.68 h decay of ^{150}Pm to the levels with spin $\leq 2\hbar$ in ^{150}Sm and the other set to levels with spin $\geq 4\hbar$, besides the weakly populated γ-rays from the 53 h ^{149}Pm decay. This observation suggests that there may be an isomer in ^{150}Pm with spin ≥ 4. The spin-parity of such an isomer is likely to be either 5^- or 6^-, based on available orbital for odd proton/neutron and Nordheim's rule. From the measured half life of decay γ-rays (cf. fig. 1), it is apparent that the latter set of γ-rays originate from the likely decay of an excited isomer in ^{150}Pm with $T_{1/2}$ ~ 3.1 h. For in-beam singles and γγ coincidence measurements, one segmented LEPS, one Clover HPGe and one standard (50%) HPGe detectors were placed at 135^0, 90^0 and 45^0 respectively, around the target to identify the prompt γ-rays produced in the above reactions. The relative yields of some of the prompt γ-rays in both the residues, normalized to the intensity of 114 keV γ-ray from ^{149m}Pm decay, are shown in fig. 2 against the incident proton energies. It is seen that the γ-rays belonging to ^{149}Pm show a relatively constant yield which is apparent from Q-value considerations, whereas the γ-rays, tentatively assigned to ^{150}Pm, show a decreasing trend with increasing proton energy, as expected.

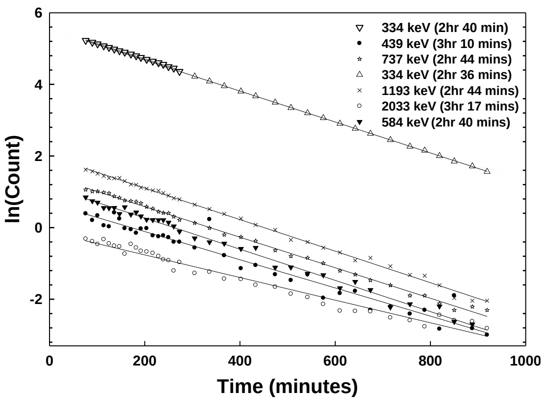

Fig. 1: *Decay curves for the gamma rays de-exciting the excited states of ^{150}Sm, produced via β- decay of ^{150}Pm; two sets of gamma rays are observed, one with a half life of ^{150}Pm ground state and the other with a longer half life*

From a preliminary analysis of single γ and γγ coincidence data, the following γ-rays (tabulated in Table I) have been assigned in ^{150}Pm. The detailed results and the proposed level scheme of ^{150}Pm would be presented.

Table I: *List of gamma rays tentatively assigned to ^{150}Pm along with their relative intensities estimated from total projection obtained with 8.5 MeV beam energy.*

E_γ (keV)	I_γ	E_γ (keV)	I_γ
59	54.10	130	46.63
69	5.84	140	6.57
75	79.59	158	21.62
77	94.80	406	8.55
87	36.19	832	19.33
90	10.43	834	20.72
101	6.86	876	15.30
111	4.83		

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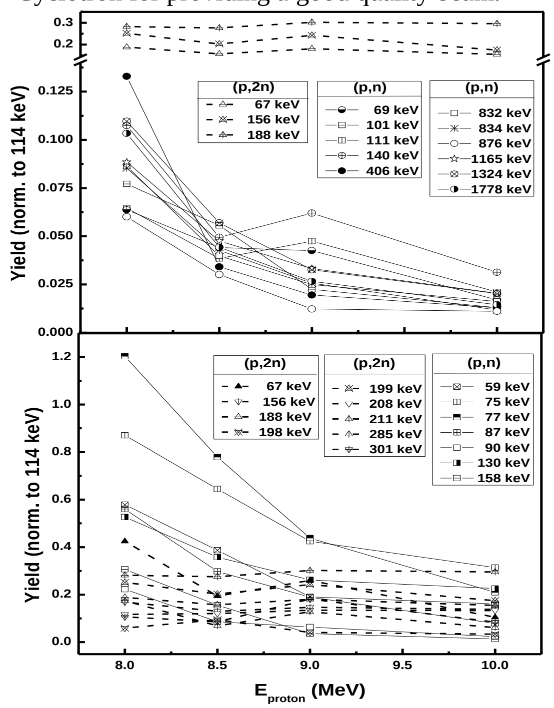

Fig. 2: *Plots for excitation function of the in-beam gamma rays; Gamma rays belonging to ^{149}Pm shows a flat nature when normalized to 114 keV de-exciting a μs isomer of the nucleus. The gamma rays, showing decreasing nature, are assigned to ^{150}Pm produced via (p, nγ) channel.*

References

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