Lifetime measurements in ^{139}Pr

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Introduction

The transitional nucleus ^{139}Pr has N=80 and Z=59. Therefore, it has two holes in the N=82 neutron closed shell and 9 particles above the Z=50 proton shell closure considering doubly magic ^{132}Sn closed core. The proton space can also be configured as having 5 holes in the Z=64 closed shell when ^{146}Gd is considered a closed shell nucleus. Since the valance quasiparticles of both kinds expand the same configuration space, viz., $1g_{7/2}$, $2d_{5/2}$, $2d_{3/2}$, $3s_{1/2}$ and $1h_{11/2}$, the spectroscopic study of this nucleus offers a good scope to observe a rich variety of inter-nucleonic interactions, specially those which involve the nucleons residing in the strongly shape driving π and ν intruder $h_{11/2}$ orbital. The interplay between the collective and single particle motions of the nucleons causes a rich possibility of generating high spin states that involve the high-j $h_{11/2}$ orbital and also the occurrence of yrast isomers in the level scheme of this nucleus. The study of these isomers gives us the active configurations of the nuclear state, which, in turn, gives an input to a large basis shell model calculation.

Earlier we have developed the level scheme of ^{139}Pr up to ~7.2 MeV excitation and 39/2 ħ spin [1]. In this work, we have conjectured the presence of some medium spin isomers in the level scheme. In a very recent experiment, Petrache et al. [2] has reported about the existence of a long lived isomer (~400 ns) at a very high spin (~20 ħ) in ^{140,139}Nd nuclei and the bands built on it. It has been observed that these bands originate from the excitations of the neutrons across the N=82 shell closure along with the proton quasiparticles in $h_{11/2}$. A Cranked Nilsson Strutinsky (CNS) calculation predicts this kind of bands with high quadrupole deformation and a modest triaxiality by considering the involvement of the deformation-driving intruder $i_{13/2}$ orbital along with $h_{9/2}$ in the neutron space above the shell closure. A similar calculation for the ^{139}Pr nucleus also predicts the existence of such an isomer (~100 ns and ~20 ħ) and highly deformed triaxial band built on it. Therefore, identification of this isomer and putting a tag on this in order to observe the band based on it we need to perform a pulsed beam experiment. This kind of experiment will not only help to observe the weakly populated triaxial bands but also give us the estimate of the lifetime of the yrast isomers present in the lower and medium spin regime.

Experiment

The pulsed beam experiment using Indian National Gamma Array setup at IUAC has been carried out following the reaction ^{14}N(^{130}Te, 5n)^{139}Pr at 75 MeV beam energy. In this experiment a pulsed ^{14}N beam @4MHz was used and data was taken in such a manner that the prompt as well as delayed transitions could be studied in offline analysis. From the preliminary analysis, the TAC spectra corresponding to different transitions in ^{139}Pr have been generated using part of the data and after matching the extracted timing information of individual crystals of the Clover from their TDC.

Analysis of data

For the preliminary analysis only few Clover Ge detectors are included in the analysis to extract the time information.

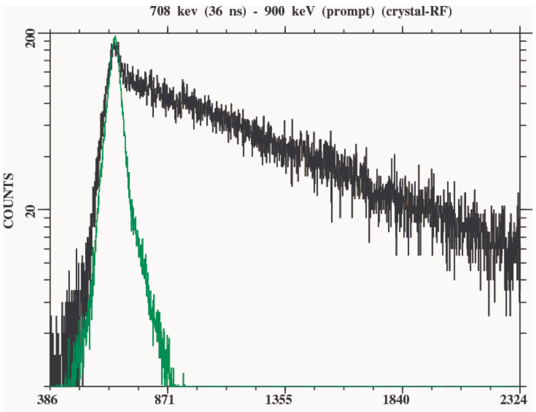

Fig. 1 : Projection of RF-γ TAC in coincidence with 708 keV (^{139}Pr). The corresponding projection for the prompt transition of 900 keV is also shown for comparison.

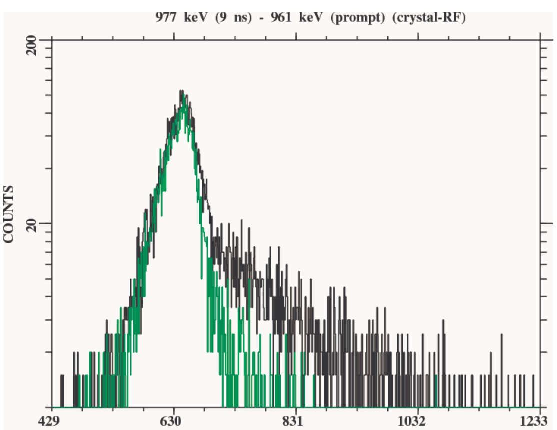

Fig. 2 : Projection of RF-γ TAC in coincidence with 977 keV (^{140}Pr) with respect to the same projection corresponding to 961 keV.

Fig.1 represents the TAC spectrum corresponding to the 708.1 keV transition of ^{139}Pr having a known lifetime of ~36 ns. In fig. 2, the TAC spectra generated only from a single crystal corresponding to the 977 and 961 keV transitions in ^{140}Pr have been shown and compared. It clearly shows the presence of a lifetime for the decay of 977 keV transition and a prompt nature for the 961 keV transition which was not known from the earlier studies. Fig. 3 represents the 1330.7 keV gated spectra belonging to the ^{139}Pr nucleus, in which indication of various new transitions have been observed. A detailed analysis of the data for measurements on lifetime and γ-γ coincidence is in progress.

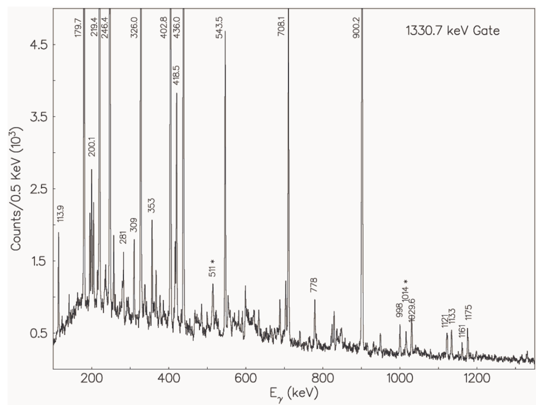

Fig. 3 : Gated spectrum of 1330.7 keV of ^{139}Pr.

Acknowledgement

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Reference :

[1] S. Chanda et al., Pramana Journal of Physics, Vol. 57, p. 175 (2001).

[2] C. M. Petrache et al., Phys. Rev. C 74, 034304 (2006).