A 150 ms 10+ Isomer in $^{146}$Dy*

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In the course of systematic studies of very proton rich nuclei in the $N \approx 82$ region with Ni induced compound reactions, an unusually long-lived high spin isomer has been found. After in- and off-beam $\gamma$ and conversion electron measurements, as $\gamma$ excitation functions, $\gamma\gamma$ and $e\gamma$ coincidences, pulsed beam techniques and multi spectrum analyses of the residual activities, this isomer has been tentatively assigned to be a 10+ state in $^{146}$Dy, which decays into two 7− states by E3 transitions. The half-life of the isomer has been measured to be 150±20 ms. The isomer has been found to follow the $\beta$ decay of the previously unknown 3.9 s isotope $^{146}$Ho. The mechanism of the appearance of such an isomer is discussed.

1. Introduction

$^{58}$Ni projectiles of about 250 MeV from the postaccelerator [1, 2] of the Munich tandem give an unique opportunity to study very proton rich nuclei with neutron numbers close to $N = 82$. One of the even-even nuclei, furthest from stability in this region, is $^{146}$Dy which has two protons more and two neutrons less than $^{146}$Gd which shows nuclear properties almost like double magic nuclei (see e.g. [3, 4]). Such nuclei could have yrast traps or high spin isomers. With this possibility in mind, we performed series of studies on the yrast structure of $^{146}$Dy and the $\beta$ decay of a possibly high spin isomer of $^{146}$Ho.

A high spin isomer with an unusually long half-life of 150 ms was identified. This isomer was also found to be populated in the $\beta$ decay of a high spin isomer of $^{146}$Ho. In the following the experimental procedure, as well as the spin assignment and the interpretation of this isomer, will be described.

In parallel works we have investigated yrast states of the neutron deficient isotopes $^{148}$Er, $^{150}$Er and of neighbouring nuclei [5] and $\beta$ decays of proton rich nuclei with $N \approx 82$ [6].

2. Experimental Set-Up

Enriched $^{90}$Zr (96.8%) and $^{91}$Zr (95.8%) targets were bombarded with $^{58}$Ni beams of 233 and 250 MeV from the Munich heavy-ion postaccelerator [1, 2] to study the nucleus $^{146}$Dy and neighbouring nuclei.

The final nuclei were studied with the following techniques:
- $\gamma$ ray excitation functions
- $\gamma\gamma$ coincidences
- $e\gamma$ coincidences
- pulsed beam
- multi spectrum analyses of $\gamma$ radiation and conversion electrons

The $\gamma$ spectra were taken with a 180 cm$^3$ coaxial Ge(Li) detector and a planar Ge(Li) detector (19 cm$^2$ active area and 1.6 cm thick). Absorbers were used in front of the detectors: typically, 0.5 mm Cd and 0.5 mm Cu for the coaxial and 0.2 ... 0.5 mm Cu for the planar detector.
Multi spectrum analyses of $\gamma$ radiation and conversion electrons were measured with a pulsed beam in the 100 ms and sec range. Deflection of the beam by magnetic steers was used to pulse the beam in the sec range.

3. Experimental Procedure and Results

3.1. $\gamma$ Singles Spectra

$\gamma$ singles spectra were taken during the irradiation of $^{90}$Zr and $^{91}$Zr targets with 233 and 250 MeV $^{58}$Ni ions. The 23 mg/cm$^2$ thick targets were mounted at 45° to the beam axis. The beam was stopped in the targets. The compound nucleus of the system $^{58}$Ni $\rightarrow$ $^{90}$Zr is $^{148}$Er, and is $^{149}$Er for $^{58}$Ni $\rightarrow$ $^{91}$Zr. Figure 2 shows the in-beam $\gamma$ singles spectrum taken with the coaxial Ge(Li) detector during the bombardment of $^{90}$Zr with 250 MeV $^{58}$Ni ions. The open reaction channels were identified with the help of the excitation functions, cross bombardments with $^{91}$Zr, $^{92}$Zr and $^{92}$Mo targets and the $\gamma\gamma$ coincidences. The relative yields of the open evaporation channels for the system $^{58}$Ni($250$MeV) $\rightarrow$ $^{90}$Zr are listed in Table 1. The yields were normalized to the yield of the $n2p$ channel being 100. Figure 3 shows the relevant part of the nuclear chart, where the yields of the residual nuclei are drawn. The strongest evaporation channels from the compound nucleus $^{148}$Er are $n2p(145$Dy), $2p(146$Dy), $3p(145$Tb) and $n3p(144$Tb).

3.2. $\gamma\gamma$ Coincidences

The $\gamma\gamma$ coincidences were measured in-beam during the irradiation of the $^{90}$Zr target. Four groups of coincident strong $\gamma$ lines were identified. The first group ($^{146}$Dy) contains the transitions at 682.9, 925.3, 1100, 673.7, 499, 237.2, 416.5, 289.7 and 127 keV. 7 spectra taken with the coaxial Ge(Li) detector in prompt coincidences to the transitions at 682.9, 237.2, 289.7 and 416.5 keV are seen in Fig. 4. All listed transitions except the 127 and 416.5 keV lines were weakly observed in prompt coincidence to the $\gamma$ coincidence to the Dy K x-rays. All listed transitions were in prompt coincidence to the $^{145}$Tb. The second and third group of $\gamma$ lines were tentatively assigned to the nuclei $^{145}$Dy and $^{145}$Tb. The level schemes for these nuclei are not yet accomplished.

The fourth group contains the $\gamma$ transitions following the $\beta$ decay of $^{145}$Tb. This decay scheme will be described in [6].