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β-DELAYED γ-RAY SPECTROSCOPY OF HEAVY NEUTRON RICH NUCLEI "SOUTH" OF LEAD* **

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Relativistic projectile fragmentation of a ^{208}Pb primary beam has been used to produce neutron-rich nuclei with proton-holes relative to the $Z = 82$ shell closure, *i.e.*, "south" of Pb. β-delayed γ-ray spectroscopy allows to investigate the structural properties of such nuclei with $A \sim 195 \rightarrow 205$. The current work presents transitions de-exciting excited states in ^{204}Au, which are the first spectroscopic information on this $N = 125$ isotone.

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1. Introduction

The structural properties of proton-hole nuclei "south" of lead are important, not only because they provide valuable information about nuclear models far from stability, but also because they determine the observed abundances of r-process nuclei. The use of projectile fragmentation at relativistic energies has opened up the possibility to produce these nuclei via the "cold-fragmentation" reaction channels [1]. Isomer spectroscopy using passive stoppers with a germanium array [2,3] and time correlations for β-decays with an active stopper [4] have provided the first structural information on some of them. In the present work we take advantage of both of these developments to use β-delayed γ-ray spectroscopy to study the structure of such nuclei at the current limits of experimental synthesis.

2. Experimental details and results

The SIS-18 synchrotron at GSI delivered a ^{208}Pb primary beam at an energy of 1 GeV/u to a Be target of thickness 2.5 g/cm^2. Once the charge state distribution of the exotic nuclei produced by the "cold fragmentation" channels had been determined (Fig. 1(a)) [1] and the ions with $\Delta Q = 0$ selected, they were unambiguously identified from the mass-over-charge ratio A/Q by measuring their magnetic rigidity and time-of-flight with the FRagment Separator (FRS) and from the effective charge Q by determining their rate of energy loss with two MUlti Sampling Ionization Chambers (MUSIC) placed at the final focal point of the FRS (Fig.1(b)). Even though the ions with $\Delta Q = 0$ along the FRS were selected for identification, the rate of energy loss measured with the MUSICs chambers is related to their effective charge Q since the nuclei exchange electrons with the gas contained in

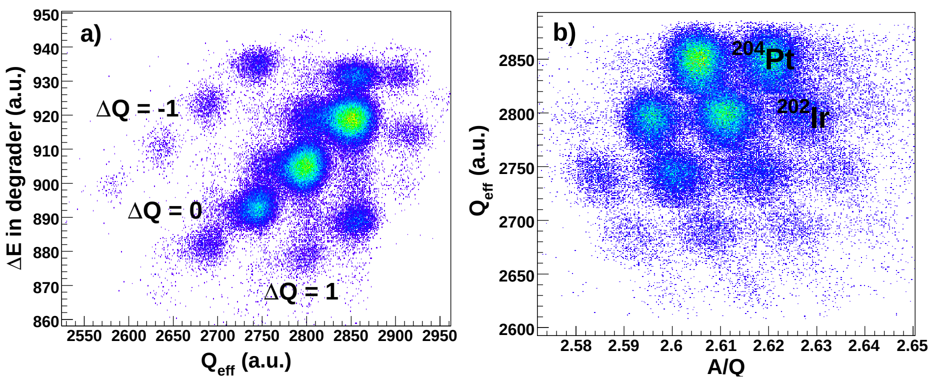

Fig. 1. Charge states selection (a) and mass identification of fully stripped nuclei (b) for an FRS setting centered in ^{202}Ir.

the detectors. The particle identification was confirmed by the observation of the previously reported isomeric decays in the exotic nucleus ^{204}Pt [5]. Fragments transmitted through the FRS were implanted in an Active Stopper [6], consisting of three Double Sided Silicon Strip Detectors (DSSSDs, $5 \times 5 \times 0.1$ cm^3) each with 16 vertical and horizontal strips. The aim of this device [7] was to perform event by event position and time correlations between the implanted ions and the electrons emitted in their decay. The Si Active Stopper was surrounded by the advanced RISING γ-ray spectrometer in its Stopped Beam configuration [8], which has an efficiency of $\sim 15\%$ at 661 keV and allows for β-prompt γ-ray time correlations. As an illustration, the upper panel of Fig. 2 shows the γ-ray spectrum in coincidence with the β-particles following the implantation of the exotic nucleus ^{204}Pt. Two γ-ray transitions at energies of 165 and 305 keV have been identified in the daughter nucleus ^{204}Au. The $\gamma\gamma$ coincidence analysis presented in middle and bottom panels of Fig. 2 shows that both are in mutual coincidence and form a cascade. Moreover, γ-ray decay curves following the detection of the β-particle show that they belong to the same β-decay.

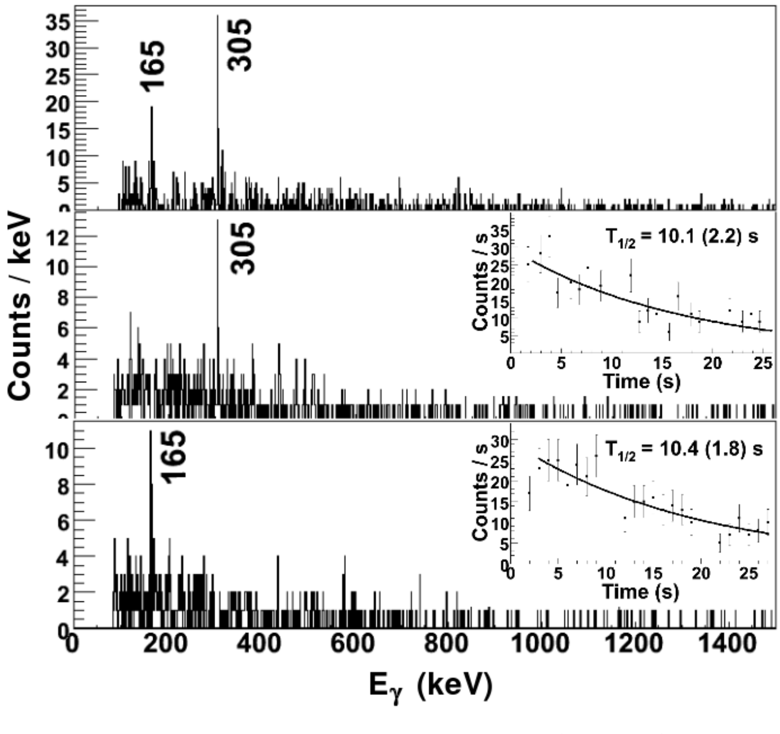

Fig. 2. Upper panel: β-delayed γ-ray spectrum for the ^{204}Pt $\rightarrow$ ^{204}Au decay. Middle and bottom panels: $\gamma\gamma$ coincidences and lifetime curves for the γ-ray transitions of ^{204}Au.

The β-decay half life of ^{204}Pt has been determined using the γ-ray transitions of ^{204}Au. Table I shows the result from the current work, together with the experimental half life of ^{198}Ir presented in reference [4]. Perusal of this table shows that the theoretical model used for r-process simulations (QRPA + FRDM [9]), overestimates the measured half lives close to the $N = 126$ shell. Recent investigations [10] suggest that the inclusion of first forbidden transitions provides shorter half lives for nuclei close to this region. This would indicate that the r-process matter flows to heavier fissioning nuclei faster than currently expected.

TABLE I

Measured and theoretical β-decay half lives.

Nucleus	$T_{1/2}$ [s]	QRPA+FRDM [s]
^{204}Pt	10 (2)	≥ 100
^{198}Ir	8 (2)	377.1

In conclusion, β-delayed γ-rays emitted in the decay of heavy neutron-rich nuclei provide information on structural properties in the region around $N = 126$. Moreover, ion-beta time correlations in coincidence with β-delayed γ-ray decays provide the β half lives of their mother nuclei.

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