International Journal of Modern Physics E
Vol. 18, No. 4 (2009) 1002–1007
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ISOMERIC DECAY STUDIES IN NEUTRON-RICH N≈126 NUCLEI

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Received October 31, 2008
Revised November 25, 2008

Heavy neutron-rich nuclei were populated via relativistic energy fragmentation of a E/A=1 GeV ^{208}Pb beam. The nuclei of interest were selected and identified by a fragment separator and then implanted in a passive plastic stopper. Delayed γ rays following internal isomeric decays were detected by the RISING array. Experimental information was obtained on a number of nuclei with Z=73-80 (Ta-Hg), providing new information both on the prolate-oblate transitional region as well as on the N=126 closed shell nuclei.

1. Introduction

The evolution of the properties of atomic nuclei with respect to neutron and proton numbers is a key question of nuclear physics. The study of unstable, neutron-rich nuclei represents one of the foremost pursuits of modern nuclear physics. Over the coming decade new radioactive ion beam facilities are being constructed with one of the main objectives being to probe the structure of neutron-rich nuclei. The part of the nuclear chart with the least information on neutron-rich nuclei is the $_{76}$Os to $_{82}$Pb region. This mass region is however an ideal testing ground of nuclear theories. With the removal of just a few nucleons the landscape evolves from spherical[1–3] to elongated prolate through disk shaped oblate and triaxial formss.[4–6]

2. Experimental Details

The SIS-18 accelerator at GSI provided a ^{208}Pb beam at $E/A = 1$ GeV. The ^{208}Pb ions impinged on a target of ^{9}Be of thickness 2.5 g/cm^2. The nuclei of interest

Table 1. Approximate number, in thousands, of nuclei implanted in the plastic stopper at the end of the GSI fragment separator. All six settings as well as all charge states are considered.

Nucleus	No. (in 10^3)	Nucleus	No. (in 10^3)	Nucleus	No. (in 10^3)
^{206}Tl	86	^{202}Hg	12	^{203}Hg	142
^{204}Hg	52	^{205}Hg	417	^{206}Hg	1718
^{200}Au	2.1	^{201}Au	2.7	^{202}Au	61
^{203}Au	402	^{204}Au	133	^{205}Au	337
^{206}Au	12	^{197}Pt	7.4	^{198}Pt	24
^{199}Pt	8.8	^{200}Pt	65	^{201}Pt	68
^{202}Pt	388	^{203}Pt	319	^{204}Pt	92
^{205}Pt	1.4	^{194}Ir	1.7	^{195}Ir	8.0
^{196}Ir	3.1	^{198}Ir	51	^{199}Ir	358
^{200}Ir	354	^{201}Ir	165	^{202}Ir	36
^{203}Ir	8.0	^{191}Os	0.43	^{192}Os	2.3
^{193}Os	2.1	^{194}Os	1.1	^{195}Os	22
^{196}Os	121	^{197}Os	159	^{198}Os	78
^{199}Os	29	^{200}Os	6.3	^{201}Os	1.4
^{202}Os	0.02	^{191}Re	2.4	^{192}Re	23
^{193}Re	90	^{194}Re	101	^{195}Re	61
^{196}Re	14	^{197}Re	5.5	^{198}Re	0.71
^{188}W	3.7	^{189}W	11	^{190}W	30
^{191}W	37	^{192}W	21	^{193}W	9.4
^{194}W	2.9	^{185}Ta	1.1	^{186}Ta	3.6
^{187}Ta	11	^{188}Ta	14	^{189}Ta	9.1
^{190}Ta	3.9	^{191}Ta	0.26	^{182}Hf	0.49
^{183}Hf	3.0	^{184}Hf	5.4	^{185}Hf	7.1
^{186}Hf	5.2	^{187}Hf	2.9	^{188}Hf	1.2
^{181}Lu	0.43	^{182}Lu	1.3	^{183}Lu	1.2
^{184}Lu	0.66	^{185}Lu	0.29	^{179}Yb	0.58
^{180}Yb	0.66	^{181}Yb	0.33	^{176}Tm	0.10
^{177}Tm	0.17	^{178}Tm	0.14		

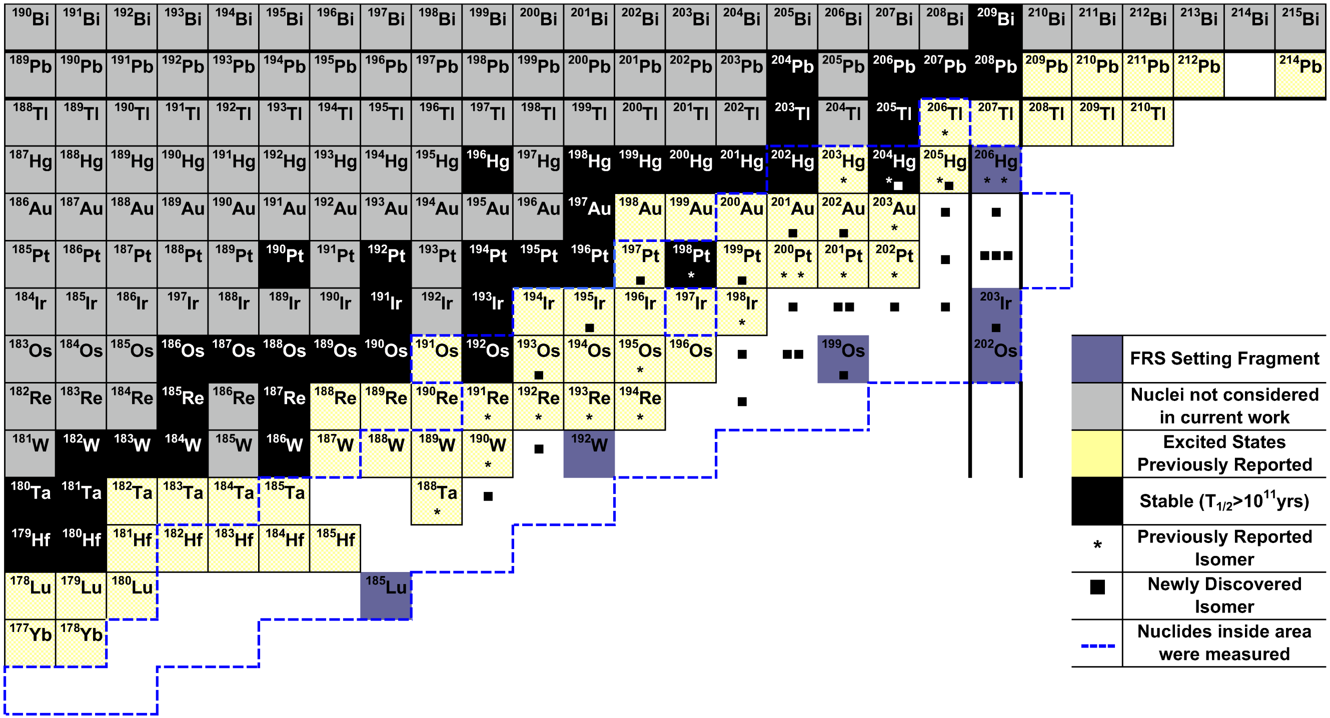

Fig. 1. Section of the nuclear chart indicating the nuclei studied in the present experiment.

were selected and identified in flight by the FRagment Separator (FRS)[7] used in achromatic mode. The identified ions were stopped in a passive stopper, positioned at the final focal plane of the FRS. The stopper was surrounded by the RISING array in the "Stopped Beam" configuration.[9,10] These detectors recorded the delayed γ-ray transitions associated with the implanted nuclei. For details on the experimental setup, identification procedure and analysis see.[2,8]

3. Results

Six different fragment separator settings were used: the magnetic rigidities were set to transmit fully stripped ions of ^{206}Hg, ^{203}Ir, ^{202}Os, ^{199}Os, ^{192}W and ^{185}Lu. An average of 20 hours of beam time was dedicated to each setting, with a primary beam intensity of $\sim 10^9$ ions/22 s spill. The number of the implanted nuclei for individual nuclides are given in Table 1.

The nuclei on which spectroscopic information was obtained in the current experiment are summarised in Fig. 1. The experiment had as its main aim the study of neutron-rich N=126 isotones. New experimental information was obtained on three of these, namely ^{205}Au, ^{204}Pt[2] and ^{203}Ir. The delayed gamma-ray spectra are shown in Fig. 2. In addition, previously unobserved isomeric decays have been identified for a wide range of nuclei with N<126 (see Fig. 3).

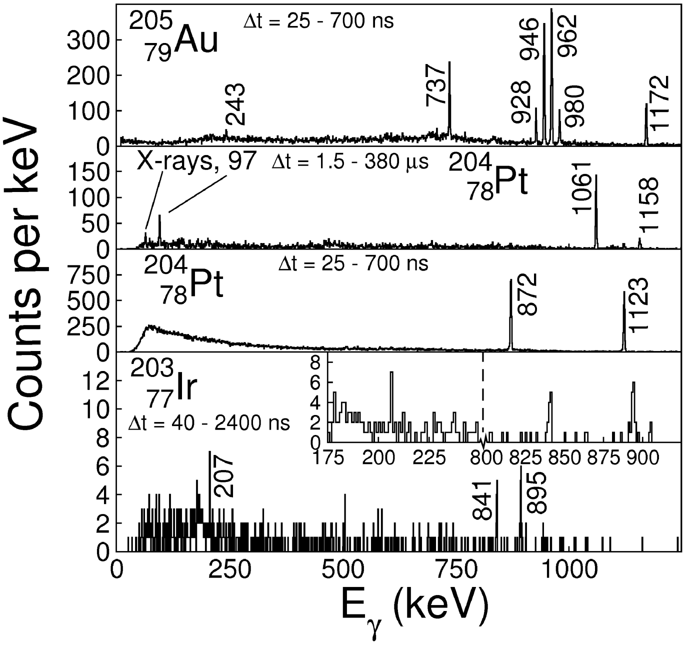

Fig. 2. Delayed γ-ray spectra obtained for the N=126 isotones ^{205}Au, ^{204}Pt[2] and ^{203}Ir.

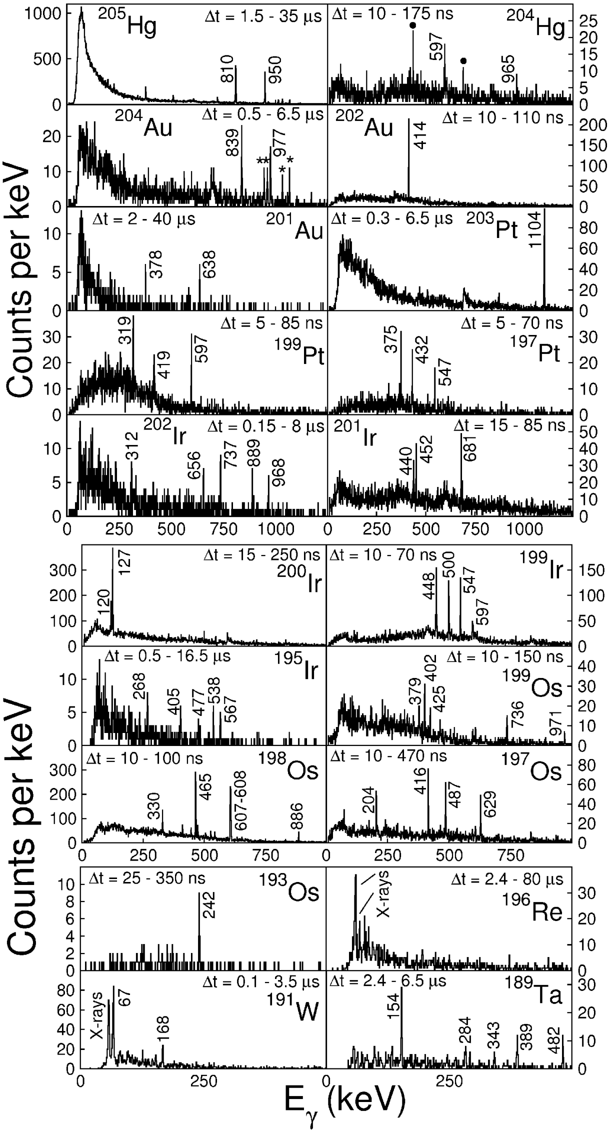

Fig. 3. Examples of delayed γ-ray spectra. The labelled transitions originate from previously unobserved isomeric decays. γ-ray transitions from previously observed isomers are labelled with •, contaminations from other nuclei with *.

4. Conclusions and Outlook

Projectile fragmentation when combined with decay spectroscopy is a powerful tool in the study of the structure of exotic nuclei. Experimental results on the heavy neutron-rich nuclei have been presented. The interpretation of the data is in progress.

More recently, further experiments have been performed aimed at the study of neutron-rich N≈126 nuclei. Measurements using the same technique as presented here, but employing an active Si stopper,[11] were performed and information on the β decay of several nuclei has been obtained.[12,13] Furthermore, nuclei with N>126 and Z< 82 were populated in the fragmentation of a ^{238}U beam.[14] By combining all the experimental information to be obtained from these studies, a much better understanding of this mass region will be achieved.

Acknowledgments

The excellent work of the GSI accelerator staff is acknowledged. This work is supported by the STFC/EPSRC(UK) and AWE plc.(UK), the EU Access to Large Scale Facilities Programme (EURONS, EU contract 506065), The Swedish Research Council, The Polish Ministry of Science and Higher Education, The Bulgarian Science Fund, The US Dept. of Energy, The Spanish Ministeriode Educacion y Ciencia, The German BMBF, The Hungarian Science Foundation and the Italian INFN.

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