Evidence of New Isotopes: $^{169,170}\text{Ir}$, $^{166,167,168}\text{Re}$

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Received May 2, 1978

At the Darmstadt UNILAC new $\alpha$-emitting nuclei were produced in the bombardment of $^{89}\text{Y}$ and $^{93}\text{Nb}$ targets using $^{84}\text{Kr}$ ions with energies in the range of 5.1 to 5.5 MeV/u, and 5.8 to 6.4 MeV/u, and using $^{86}\text{Kr}$ ions with energies in the range of 5.6 to 6.0 MeV/u. Reaction recoils emitted from the targets were stopped and transported with argon to a collection site. Using three alpha detectors and spectrum multiscaling, energies and half-lives were measured. Ir and Re isotopes were identified by cross bombardments, excitation function data and $\alpha$-systematics. The decay characteristics of the new species are as follows:

<table>
<thead>
<tr>
<th>Isotope</th>
<th>$E_\alpha$ (MeV)</th>
<th>$T_{1/2}$ (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$^{170}\text{Ir}$</td>
<td>$6.03 \pm 0.01$</td>
<td>$1.05 \pm 0.15$</td>
</tr>
<tr>
<td>$^{169}\text{Ir}$</td>
<td>$6.07 \pm 0.01$</td>
<td>$0.4 \pm 0.2$</td>
</tr>
<tr>
<td>$^{168}\text{Re}$</td>
<td>$5.14 \pm 0.01$</td>
<td>$2.9 \pm 0.3$</td>
</tr>
<tr>
<td>$^{167}\text{Re}$</td>
<td>$5.33 \pm 0.01$</td>
<td>$2.0 \pm 0.3$</td>
</tr>
<tr>
<td>$^{166}\text{Re}$</td>
<td>$5.495 \pm 0.010$</td>
<td>$2.2 \pm 0.4$</td>
</tr>
</tbody>
</table>

Estimates on $\alpha$-branching ratios have been obtained for $^{169,170}\text{Os}$ and $^{166,167,168}\text{Re}$.

I. Introduction

Until recently, scarce information on very neutron deficient Ir isotopes was available. The light Ir isotopes down to mass number 171 have been produced by bombardment of enriched Er isotopes using $^{19}\text{F}$, and of Tm using $^{16}\text{O}$ ions, respectively [1]. During the course of the present measurement, the existence of $^{170}\text{Ir}$ having $E_\alpha = 6.01$ MeV and $T_{1/2} = 1.1$s was published [2] which data can be compared with our earlier preliminary results, namely $E_\alpha = 6.045$ MeV and $T_{1/2} = 0.8$s [3]. In the preliminary measurement [3] we have also found indication for two $\alpha$-emitting Re isotopes with half-lives in the range of seconds and $E_\alpha = 5.46$ MeV, and 5.34 MeV.

The production rate for the Re isotopes, however, was small. Still more $n$-deficient Re isotopes have been reported recently [4].

The present investigation was done in addition to our earlier work on $n$-deficient Ir and Re isotopes. It was also intended to remeasure decay properties of several light Os isotopes.

II. Experimental

At the Darmstadt UNILAC 1.2 to 2.0 mg/cm$^2$ Nb and Y targets were bombarded with $^{84}\text{Kr}$ with primary energy of 5.6 MeV/u, and of 6.8 MeV/u, and with $^{86}\text{Kr}$, of 7.03 MeV/u. By use of Ti degrader foils...
the beam energy was stepwise reduced. Reaction recoils emitted from the targets were entered into a gas-filled chamber, stopped and transported with argon as well as helium through 6 m of capillary. A target set-up inside the stopping chamber gave approximately twice the detection efficiency at a reduced energy resolution of the Kr ion beam. Collection was done onto a wheel, the wheel rotated to bring the activity in front of the detectors. Collection and detection was done automatically [5]. Three Si-surface barrier detectors were used, detector no. 1 in multiscale mode. After the subsequent measurements with the three detectors, the residual α-activity of a collection spot on the wheel was largely removed by use of a wiper. The efficiency of the detectors was measured using a calibrated $^{244}\text{Cm}$ source.

III. Alpha-Ray Energy and Half-Life

Typical results of α-ray spectra measured with detector no. 1 are given in Figure 1. As 2 mg/cm$^2$ target foils were used, the Kr ion energy was reduced in the targets giving a spread in Kr ion energy of about 30 MeV.

In Figures 1a–c, the α-ray spectra measured from 0.2 to 2.6 s are shown for three settings of $^{84}\text{Kr}$ ion energy and using $^{93}\text{Nb}$ target foils. In Figure 1d and 1e, α-spectra observed in the bombardment of $^{89}\text{Y}$ with $^{84}\text{Kr}$, and $^{90}\text{Kr}$, respectively, are shown. According to α-ray energy and half-life several of the observed α-rays in Figure 1 were identified to belong to the decay of already reported Ir and Os isotopes [1, 6–8]. The present decay data were entered into Table 1. At the high energy side of the known α-rays in Figure 1a–c two α-rays are indicated at 6.03 MeV, having $T_{1/2}=1.05$ s, and with small intensity at 6.07 MeV, having $T_{1/2}=0.4$ s. These two α-rays were exclusively seen in the spectra observed in the Kr bombardment of Nb targets. Further yet unreported α-rays were observed at 5.14 MeV having $T_{1/2}=2.9$ s, at 5.33 MeV having $T_{1/2}=2.0$ s, and at 5.495 MeV having $T_{1/2}=2.2$ s. Though with reduced intensity these α-rays were also indicated in the Kr-ion bombardments of the Y targets (Fig. 1d, e).

IV. Excitation Functions

The earlier excitation function data [3] were reanalysed using the present α-ray spectra of Figure 1 and are given in Figure 2. They were also compared with the calculations of the statistical model code ALICE [9]. The used ALICE version includes fission competition in the deexcitation process. The experimental α-ray intensities were corrected for differences in half-life, and integrated beam current. The excitation function data of 5.91 MeV $^{171}\text{Ir}$ α-ray measured for three settings of Kr ion energy were normalized to the calculated cross sections for the ($^{84}\text{Kr}, 6\alpha$) reaction values. The intensities of the experimental 6.03 MeV and 6.07 MeV α-rays, however, were allowed to vary with energy of the Kr beam in respect to the normalized $^{171}\text{Ir}$ α-ray intensities. The intensity of measured 6.03 MeV and 6.07 MeV α-rays are then in accordance with calculated excitation functions for the reaction $^{93}\text{Nb}(^{84}\text{Kr}, 7\alpha)^{170}\text{Ir}$, and $^{93}\text{Nb}(^{84}\text{Kr}, 8\alpha)^{169}\text{Ir}$, respectively. This agreement suggested that the new observed α-rays belong to the