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TWO NEW SHORT-LIVED ISOMERS Ir^{187m} *AND* Ir^{189m}

V. V. REMAEV, V. T. GRITSYNA, and Yu. S. KORDA

Physico-technical Institute, Academy of Sciences, Ukrainian S.S.R.

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Results of investigation of the millisecond isomeric γ activity previously observed [1] when osmium is bombarded by fast protons are presented. It is found that proton bombardment of an osmium sample with a natural isotopic composition results in the formation of two isomers, Ir^{187m} ($T_{1/2}$ = 29 msec, E_γ = 115 keV) and Ir^{189m} ($T_{1/2}$ = 14 msec, $E_{\gamma 1}$ = 120 keV, $E_{\gamma 2}$ = 180 keV and $E_{\gamma 3}$ = 300 keV). It is shown that isomeric states of these nuclei are produced in the reactions Os^{188}(p, 2n)Ir^{187m} and Os^{190}(p, 2n)Ir^{189m}.

MOROZOV, Yampol'skiĭ, and one of the authors [1] reported that the bombardment of osmium of natural isotopic composition by 20-MeV protons leads to an intensive emission of γ rays with a half-life $T_{1/2} = 10^{-2}$ sec and γ-ray energy E_γ = 0.320 MeV. Using enriched samples of osmium isotopes, the authors of the present paper were able to identify the observed isomeric radiation.

For the experiment, we used 20-MeV protons from a linear accelerator. The experimental arrangement and technique were similar to that described earlier.[2]

We had at our disposal samples of osmium enriched in the isotopes Os^{188}, Os^{189}, Os^{190}, and Os^{192}. The abundance of the various isotopes in these samples is given in the table.

Figure 1 shows three spectra of isomeric γ radiation. One of them corresponds to radiation produced as a result of the bombardment of an osmium sample of natural isotopic composition by protons, the other two represent samples enriched in Os^{188} and Os^{190}. Comparison of the γ-ray yields of different energies arising from the proton bombardment of targets enriched in different osmium isotopes showed that two new isomers are produced. An isomer with a γ-transition energy of 115 keV is produced from Os^{188} isotopes and an isomer with γ-transition energies of 120, 180, and 300 keV is produced from Os^{190}. The radiation spectrum of both isomers has an intense peak of 650-keV x rays. The half-lives of these isomers proved to be 29 ± 2 msec for the first and 14 ± 1 msec for the second. The decay curves of the isomeric activity are shown in Fig. 2.

To identify the reactions leading to the production of the observed isomers we determined the excitation functions of the corresponding isomeric activities (Fig. 3). The excitation function of the 14-msec activity was determined from the photopeak of the 300-keV γ transition with a target of natural osmium (~20 mg/cm^2 thick); the excitation function of the 29-msec activity was determined from the x-ray peak with a target enriched in Os^{188} (~60 mg/cm^2 thick). The obtained value of the threshold and the shape of the excitation function support the conclusion that the isomeric states in both cases are produced in a (p, 2n) reaction. Hence the observed γ activities correspond to the decay of two new millisecond isomers Ir^{187m} and Ir^{189m}, which are products of the nuclear reactions

Sample	Isotope abundance, %						
	Os^{184}	Os^{186}	Os^{187}	Os^{188}	Os^{189}	Os^{190}	Os^{19}
Natural Os	0,018	1,582	1,64	13,27	16,14	26,38	40,97
Os^{188}	—	—	—	75.4	11,7	8,7	3,9
Os^{189}	—	—	2,4	6,4	71.9	19,3	
Os^{190}	<0.1	<0,1	0,3	1,8	4.4	76,1	17,4
Os^{192}	—	—	—	—	—	1.9	98,1

$Os^{188}(p, 2n)Ir^{187m}$, $Os^{190}(p, 2n)Ir^{189m}$.

The Ir^{187m} isomer decays with a half-life of 29 ± 2 msec. Its γ spectrum consists of a peak corresponding to a (115 ± 5)-keV transition and an intense peak of iridium x rays. From the ratio of the areas of these two peaks we estimated the conversion coefficient α_K of the 115-keV transition. The obtained value $\alpha_K = 7 \pm 2$ was compared with the calculated values:[3] $\alpha_K(E1) = 0.23$; $\alpha_K(E2) = 0.59$; $\alpha_K(E3) = 1.17$; $\alpha_K(E4) = 2.5$; $\alpha_K(E5) = 5.5$; $\alpha_K(M1) = 3.5$; and $\alpha_K(M2) = 22.4$. It is seen that the 115-keV radiation most probably should be attributed to a mixture of transitions E1 + M2 or M2 + E3. The first conclusion on the multipolarity of the 115-keV transition is in poor agreement with the lifetime of the Ir^{187m} isomeric state. It is also quite possible that the decay scheme includes a transition preceding this one. Such a transition may not have been noticed if its energy is less than 30 keV or if it is strongly converted.

Fettweis and Campbell[4] recently reported that they obtained a new isomer Ir^{194m} from the $Ir^{193}(n, \gamma)Ir^{194m}$ reaction. The decay characteristics of this isomer ($T_{1/2} = 32$ msec, $E_\gamma = 115$ keV, $\alpha_K \approx 6$) agree, within the limits of experimental accuracy, with the values obtained by us for Ir^{187m}. Despite the good agreement of the characteristics of the isomeric radiation, we can rule out the possibility that the same isomer was observed in both experiments, since in [4] the isomer Ir^{187m} could not, in principle, have been obtained, while in our case we could not have obtained the isomer Ir^{194m}.

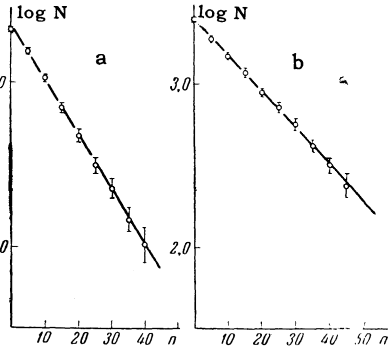

FIG. 2. Decay of isomeric activities for Os^{190} (a) and Os^{188} (b) (N is the number of recorded pulses, n is the channel number of the time analyzer). The channel widths are: a) 1.5 msec, (b) 2.1 msec. The measurements were made from the γ-ray photopeak at 0.3 MeV (a) and from the x-ray peak (b); the constant background has been subtracted in both cases.

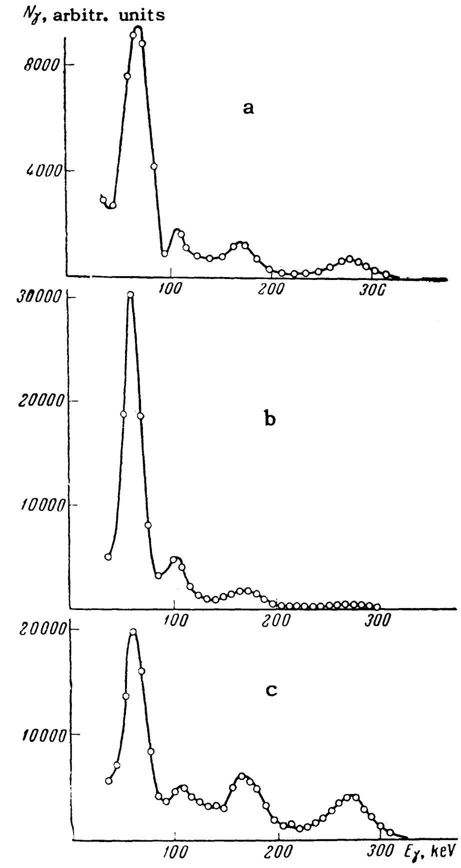

FIG. 1. Spectra of isomeric γ radiation produced in the bombardment of osmium samples by protons; a) natural isotopic composition, b) enriched in Os^{188}, c) enriched in Os^{190}.

The Ir^{189m} isomer decays with a half-life of 14 ± 1 msec. Its radiation spectrum contains an x-ray and three peaks corresponding to γ transitions of 120 ± 5, 180 ± 10, and 300 ± 10 keV. The existence of excited states of energy 113 and 305 keV in Ir^{189} has been established by Kryukova et al.[5]

According to the data of [5], the Ir^{189} state with an excitation energy of 305 keV is not isomeric. It can therefore be assumed that the isomeric level is higher and has an excitation energy ~350 keV. The transition from the isomeric level may not have been detected in our experiment if it is strongly converted or located close to the energy of the x-ray peak. At present, the isotopes Ir^{191} and Ir^{193} are known to have isomeric states with spin and parity $11/2^-$.[6] If it is assumed that the shift in this level in the case of Ir^{189} follows the same pattern as in the case of Ir^{191} and Ir^{193} (see Fig. 4), then the obtained decay scheme for the isomeric state of Ir^{189} is in good agreement with the experimental results.[1)] We then obtain an explanation of the sharp decrease in the lifetimes of isomeric states of these nuclei with decreasing

1)See note added in proof.

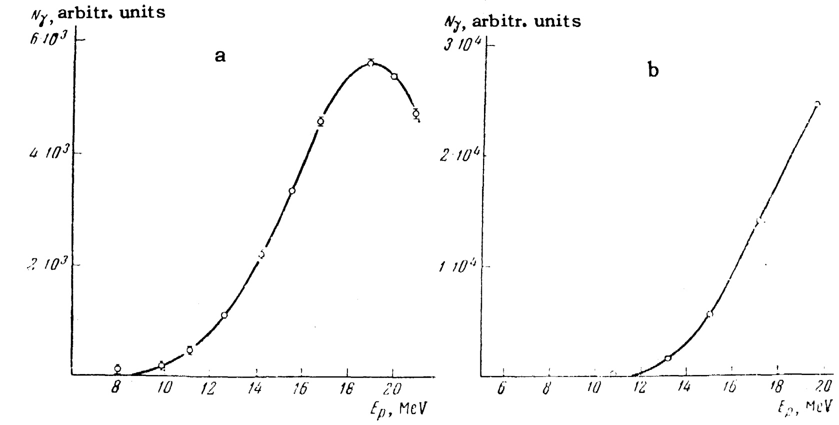

FIG. 3. Excitation functions for isomeric activities in the $Os^{190}(p, 2n)Ir^{189m}$ and $Os^{188}(p, 2n)Ir^{187m}$ reactions (a and b, respectively).

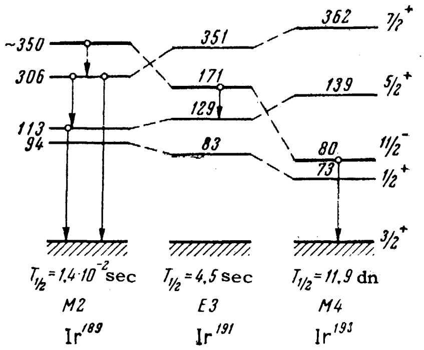

FIG. 4. Succession of levels of Ir^{189}, Ir^{191}, Ir^{193} and the suggested decay scheme for Ir^{189m}. The numbers denote the energy of the levels (in keV); the half-life of the isomeric state $11/2^-$ and the multipolarity of the transition from this level are shown for the respective schemes.

number of neutrons, so that the multipolarity of the isomeric transitions decreases.

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Note added in proof (March 4, 1963): The authors have made a more accurate determination of the energies of the γ transitions in Ir^{189m}: 114 ± 5, 184 ± 5, and 297 ± 5 keV. The following levels for Ir^{189} have recently been established:[7] 113.75 (5.2^+), 300.5 ($7/2^+$), and 372.1 ($11/2^-$). The energies of the corresponding transitions – 113.75, 186.75, and 300.5 keV – are in good agreement with our values. The transition from the 372.1-keV level is practically fully converted. Hence the decay scheme of Ir^{189m} in Fig. 4 should be regarded as confirmed; the state with an energy 372.1 keV ($11/2^-$) is isomeric.

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