2.8 Hours Rhenium–190

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Summary The properties of the beta and gamma radiation emitted by the 2.8 hours ^{190}Re are studied. The possibility is discussed that this activity may be due to an excited state of the nuclide.

Zusammenfassung Wir untersuchten die β- und γ-Strahlung des 2,8 h ^{190}Re. Die Möglichkeit, daß diese Aktivität von einem angeregten Kern herrührt, wird diskutiert.

Résumé Les radiations β et γ du ^{190}Re à 2,8 h de demi-vie ont été étudiées. On discute que cette activité puisse être due à un état excité de la nuclide.

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In a previous paper [1] we reported the existence of a 2.8 hours rhenium nuclide with 190 as its probable mass number. This mass number has been confirmed and the decay properties of the nuclide studied further. The presence of the 2.8 hours half-life in the rhenium fraction of iridium bombarded with fast neutrons [1] and in that of 98,7% pure ^{192}Os with 28 MeV deuterons [2], in combination with its lower yield in fast neutron bombardments of natural osmium and enriched ^{189}Os (87,3% pure), as compared to ^{190}Os (95,5% pure), narrows down the possibilities for the mass number to only 190.

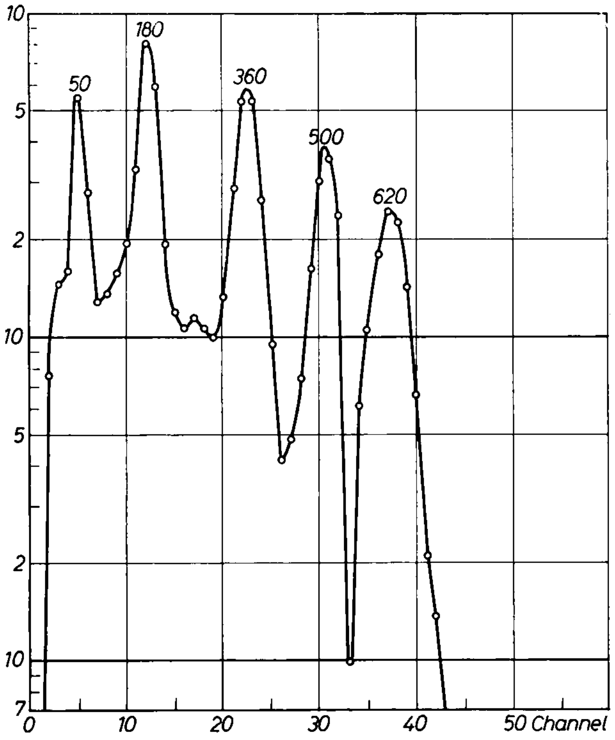

Fig. 1. Scintillation spectrum of ^{190}Os irradiated with fast neutrons (without chemical separation), measured after 35 minutes. The part of the spectrum above 150 KeV is essentially that of 10 minutes ^{190m}Os. The energy values obtained in this experiment are not very accurate, more precise figures are given in the text

Maximum beta-ray energy determinations were carried out with aluminium foils and a Geiger counter. A value of 1.7 MeV was found on a Ir (n, alfa) sample and of 1.6 MeV on a sample from deuteron bombardment on ^{192}Os. On this last sample corrections for the presence of ^{189}Re were made and a Feather plot could be taken. The value of 1.6 MeV should be correct to within $\pm$ 0.2 MeV. The absorption curve also shows a gamma background and from the calibration of the counting set-up with nuclides having well-known decay schemes, the total gamma energy per beta-decay amounts to about 1.5 MeV.

The presence of gamma lines corresponding to 2.8 hours ^{190}Re can be seen from the ^{190}Os sample bombarded with fast neutrons without chemical treatment (Fig. 1, 2 and 3). Shortly after the irradiation, the 4 line gamma cascade of 10 minutes ^{190m}Os (614, 500, 361 and 187 keV) is predominant. More than an hour later the spectrum begins to shift and 3 hours later new lines appear, some of which cannot be explained by other known bombardment products.

The gamma-lines of 2.8 hours ^{190}Re can be seen clearly from the rhenium sample chemically separated after a deuteron bombardment on ^{192}Os. This sample was thoroughly purified by a double rhenium distillation [2]. Figure 4 shows the lower energy part of the gamma-spectrum about 2 hours after the end of irradiation, in which the gamma-lines belonging to 23 hours ^{189}Re [2] have been substracted. A gamma peak of 820 keV, not shown in this figure, was also present. Spectra taken

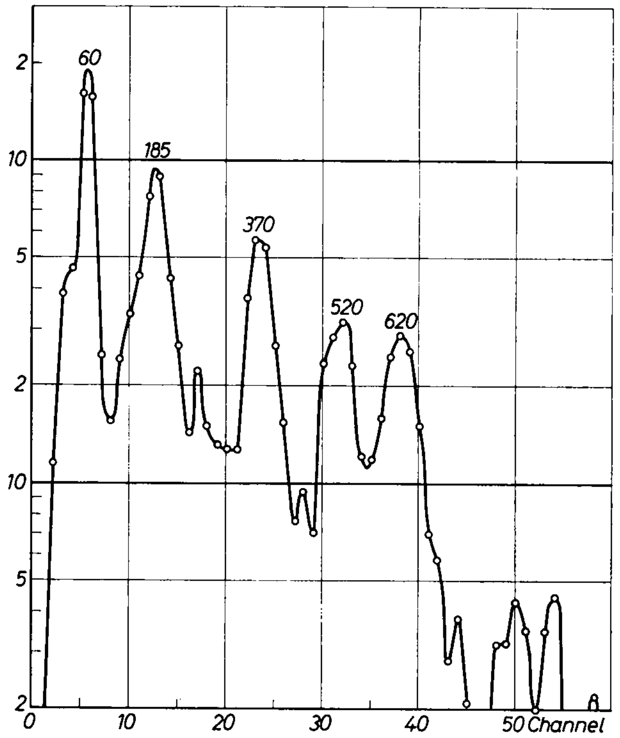

Fig. 2. Scintillation spectrum of ^{190}Os irradiated with fast neutrons (without chemical separation), measured after 1 hour and 20 minutes. The part of the spectrum above 150 KeV is still mainly due to 10 minutes ^{190m}Os. The energy values obtained in this experiment are not very accurate, more precise figures are given in the text

with intervals showed that these lines decay with a half-life of approximately 3 hours. The spectra were taken with a single channel spectrometer and a 2" × 2" NaI crystal. The sample was nearly in contact with the crystal.

Discussion

There exists a marked similarity in the decay properties of the 2.8 minutes ^{190}Re found by ATEN and DE FEYFER [3] and the 2.8 hours isomer. The maximum beta energy is roughly the same. The gamma lines of the 2.8 minutes isomer were compared with those of

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2. J. FLEGENHEIMER, G. B. BARÓ and M. VIIRSOO, Radiochim. Acta 2, 7 (1963).
3. A. H. W. ATEN jr. and G. D. DE FEYFER, Physica 21, 543 (1955).

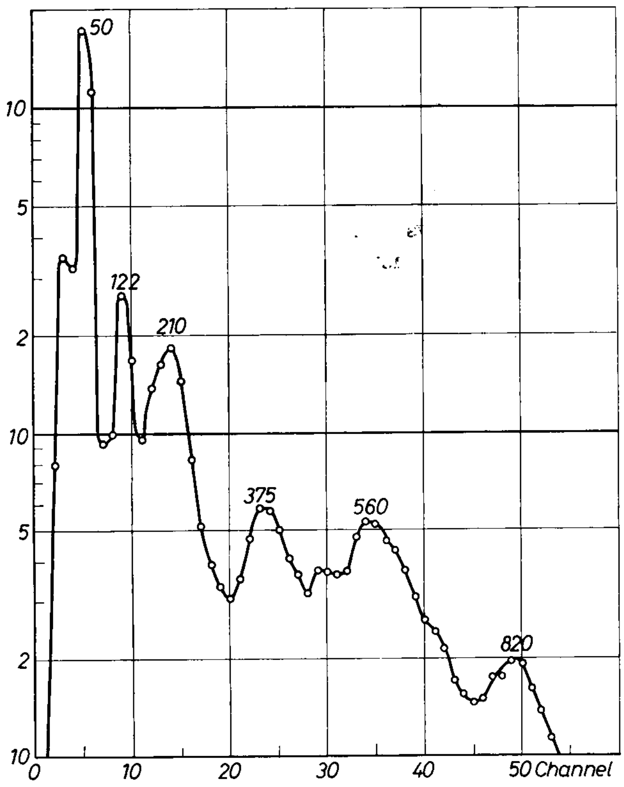

Fig. 3. Scintillation spectrum of ^{190}Os irradiated with fast neutrons (without chemical separation), measured after three hours. The part of the spectrum above 150 KeV is mainly, but not exclusively, due to 2.8 hours ^{190}Re. The energy resolution is poor in this case, more accurate values are found in Fig. 4.

both ^{190}Ir isomers [4]. A rather complete decay scheme of the 2.8 minutes ^{190}Re is presented in the Nuclear Data Sheets [5]. If this scheme is correct, the gamma-lines with their respective intensities as presented in Table 1 should be observed for this nuclide. Although Figure 4 is not sufficient for a detailed analysis of the 2.8 hours ^{190}Re decay scheme, it can be seen that in fact very strong agreement exists between the spectra of both ^{190}Re isomers. It is true that lines of 120 keV and 230 keV are not present in Table 1, but the way in which our spectrum was obtained does not warrant to stress this difference. The similarity of the spectra of both ^{190}Re isomers and the strong difference from the ^{190m}Os spectrum (Fig. 1) shows that the 2.8 hours ^{190}Re feeds the same osmium levels as the

Table 1. *Gamma-lines of 2.8 minutes* ^{190}Re *according to the decay scheme in [5]. The values of the intensities are on an arbitrary scale and are rounded of. Gamma-lines of intensities lower than 1 have been discarded*

keV	relative intensities	keV	relative intensities
187	94	569	5
197	2	604	12
361	76	724	2
371	20	825	30
407	7	1020	50
518	19	1330	25
557	24		

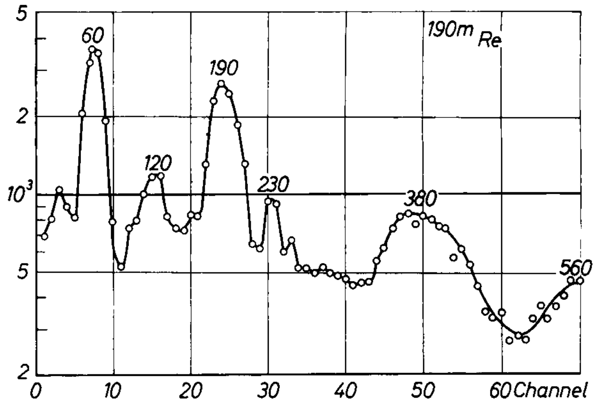

Fig. 4. Scintillation spectrum of 2.8 hours ^{190}Re.

2.8 minutes isomer, and not the 10^- level of 10 minutes ^{190m}Os.

The following possibilities have now to be considered:
a) Both isomers decay independently.
b) They are related. In this case either b') 2.8 min → 2.8 h. or b") 2.8 h. → 2.8 min.

If a) is correct, then the beta transitions of the 2.8 hours isomer would be first forbidden, which is in contradiction to the preferred filling of the odd parity levels in ^{190}Os. Case b') does not agree with the fact that the beta and gamma rays of the 2.8 minutes isomer decay with the correct half-life.

Case b") could be proved if the electron conversion spectrum shows a strong peak. A chemical equivalent of such a proof would be the existence of a Szilard Chalmers reaction between these rhenium isomers. This last approach was followed trying to milk the 2.8 minutes ^{190}Re in the +7 valence state from the 2.8 hours ^{190}Re in the +4 state. Such a process has been shown to be possible for the ^{188}Re isomers [6]. In our case, these tests have been unsuccessful up to now. In this connection it may be seen from Figure 4 that the Os K X-ray peak at ~60 keV can not be particularly pronounced.

A possible explanation of these facts is that indeed the 2.8 hours level decays to the 2.8 minutes level but that its transition-energy is lower than 70 keV. In this case an M3 radiation would seem likely for the transition but this would be hard to reconcile with the accepted levels in ^{190}Os in the single particle model.

It is interesting to note that all rhenium isotopes of even mass number from 180 to 190, with the possible exception of ^{186}Re, show isomerism while no isomer is known with certainty for the odd mass numbers. A long-lived rhenium nuclide has been observed repeatedly to which no mass number has been assigned [7, 8, 9].

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