# β- AND γ-RADIATION FROM $U^{239}$ AND $Np^{239}$

By PROF. HILDING SLÄTIS

IN connexion with the discovery of the transuranic element ${}_{93}Np^{239}$, McMillan and Abelson[1] report 0·47 MeV. as the upper energy limit of the β-spectrum. The γ-radiation was found to be complex and the energy less than 0·3 MeV. Philipp, Riedhammer and Wiedemann[2,3] studied the β-spectrum of $Np^{239}$ photographically by means of the semicircular method. They found ten internal conversion lines. Eight of them were interpreted as the *K*-, *L*- and *M*-lines of three nuclear γ-radiations of the energies 208, 226 and 276 keV., two lines as the *L*- and *M*-lines of a *K*α-radiation. The results are reproduced in the accompanying table. Later, Philipp and Riedhammer[4] reported that the β-spectrum is a single one and that the β-decay is connected also with a 500 keV. γ-radiation. Recently, Feather and Krishnan[5] investigated the radiation from $U^{239}$ by absorption measurements. They found, in the main, a single β-spectrum and give the value 1·20 MeV. for the upper energy limit. A γ-radiation of 76 keV. energy and another of at least 300 keV. were also observed.

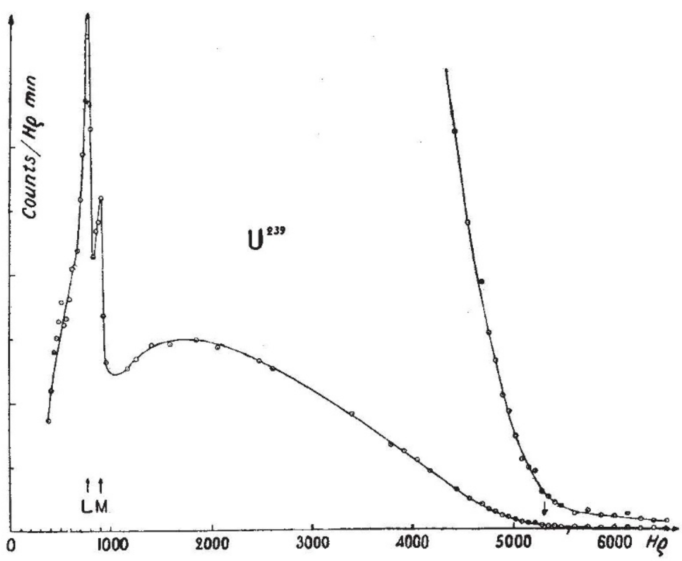


Fig. 1. β-SPECTRUM OF $U^{239}$

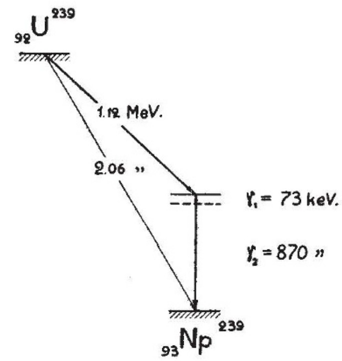


Fig. 2. NUCLEAR-LEVEL SCHEME FOR THE DISINTEGRATION OF $U^{239}$

In the spring of this year I investigated the radiations from $U^{239}$ and $Np^{239}$. Uranyl salicylaldehyde-*o*-phenylenediimine was irradiated with slow neutrons, and the $U^{239}$ and $Np^{239}$ formed were concentrated according to a technique developed by Melander[6]. Absorption measurements in lead showed that the γ-radiation from $U^{239}$ consists of two components of energies 920 and 80 keV. Similarly, the γ-radiation from $Np^{239}$ was found to consist of three components, 500, 200 and 51 keV.

The β-spectra were studied in a magnetic lens spectrograph constructed by K. Siegbahn[7]. The spectrum of $U^{239}$ (Fig. 1) showed two internal conversion lines at 50·7 and 67·8 keV. They constitute *L*- and *M*-lines of a nuclear γ-radiation. The former gives the value 73·0 keV., and the latter 73·5 keV. for the energy of this γ-radiation. A Fermi analysis showed that the β-spectrum is double, with the upper energy limits 2·06 and 1·12 MeV. The difference, 0·94 MeV., corresponds to the higher value found by the absorp-

β-RAY LINES OF $Np^{239}$

| | | Philipp, Riedhammer, Wiedemann | | | | Slätis | | |
|---|---|---|---|---|---|---|---|---|
| No. of line | Notation | $H\rho$ | $E\beta$ (keV.) | $E\gamma$ (keV.) | Remarks | $H\rho$ | $E\beta$ (keV.) | $E\gamma$ (keV.) |
| 1 | $L_1$ | | | | | 631 | 33·9 | 56·8 |
| 2 | $L_2$ | | | | | 671 | 38·2 | 61·1 |
| 3 | $L_3$ | | | | | 724 | 44·2 | 67·1 |
| 4 | $M_1$ | | | | | 766 | 49·2 | 55·1 |
| 5 | $M_2$ | | | | | 818 | 55·7 | 61·6 |
| 6 | $M_3$ | | | | | 861 | 61·4 | 67·3 |
| | | 970 | 74·6 | 97·3 | $L_{K\alpha}$ fairly weak | — | — | — |
| 7 | $K_4$ | 1050 | 86·2 | 206·2 | medium | 1022 | 84·8 | 206 |
| | | 1090 | 92·4 | 98·3 | $M_{K\alpha}$ weak | — | — | — |
| 8 | $K_5$ | 1164 | 105·0 | 225·0 | strong | 1152 | 105·8 | 227 |
| 9 | $K_6$ | 1445 | 153·0 | 273·0 | " | 1421 | 154·3 | 275 |
| 10 | $L_4$ | 1615 | 186·9 | 209·6 | fairly weak | 1578 | 185·4 | 208 |
| 11 | $L_5$ | 1696 | 203·5 | 226·2<br>209·4 | $= L_5$<br>$= M_4$ } medium | 1670 | 204·0 | 227<br>210 |
| 12 | $M_5$ | 1774 | 221·6 | 227·5 | weak | 1760 | 223·0 | 229 |
| 13 | $L_6$ | 1936 | 254·4 | 277·1 | medium | 1905 | 255·0 | 278 |
| | | 2010 | 271·0 | 276·9 | $= M_6$ weak | — | — | — |

| | Electrons | | | Electrons | | |
|---|---|---|---|---|---|---|
| | *K* | *L* | *M* | *K* | *L* | *M* |
| *W* = Ionization work in Pu = | 120 | 22·7 | 5·87 | 121 | 22·9 | 5·91 |

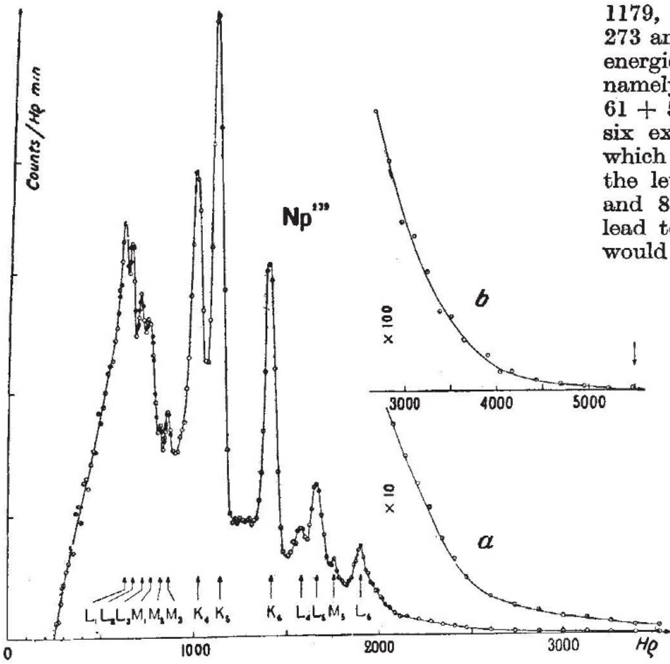


Fig. 3. β-SPECTRUM OF $Np^{239}$

(a) PART OF THE β-SPECTRUM, WHEN THE COUNTS ARE MULTIPLIED BY 10; (b) END OF THE β-SPECTRUM, WHEN THE COUNTS ARE MULTIPLIED BY 100

tion measurements, while the internal conversion line obviously answers to the lower one. These results lead to a disintegration scheme, in which the greatest part of the β-decay leads to an excited Np-nucleus, while a small part leads to the ground-state (Fig. 2).

In the β-spectrum of $Np^{239}$ (Fig. 3) thirteen internal conversion lines were found. Seven of these (see table) are connected with the three nuclear γ-radiations 206, 227 and 275 keV. found by Philipp, Riedhammer and Wiedemann[3]. The six other lines are $L$- and $M$-conversion lines of three new γ-radiations of the energies 57, 61 and 67 keV. The $L$- and $M$-lines of the $K\alpha$-radiation in $Pu^{239}$ were not found in the β-spectrum of $Np^{239}$, but appeared strongly in the spectrum of photo-electrons, released in a lead radiator. A Fermi analysis of the β-spectrum showed that it was fourfold with the upper energy limits 1179, 676, 403 and 288 keV. The differences, 503, 273 and 115 keV., correspond to the sum of pairs of energies computed from the internal conversion lines, namely, $503 \approx 275 + 227$, $273 = 206 + 67$, $115 \approx 61 + 57$. Therefore, the $Pu^{239}$ nucleus seems to have six excited levels (Fig. 4), the differences between which are 275, 227, 206, 67, 61 and 57 keV. Thus the levels have the energies 275, 502, 708, 775, 836 and 893 keV. The β-decay of $Np^{239}$ would chiefly lead to the 775 keV. level, while the other decays would lead to the levels 893, 502 keV. and the ground-state. Hence the γ-quanta would be emitted in cascade, 2, 4 and 6 in succession. An edge in the spectrum of the photo- and Compton-electrons released in lead gives evidence for a cross-over transition from the 775 keV. level to the ground-state in the Pu-nucleus.

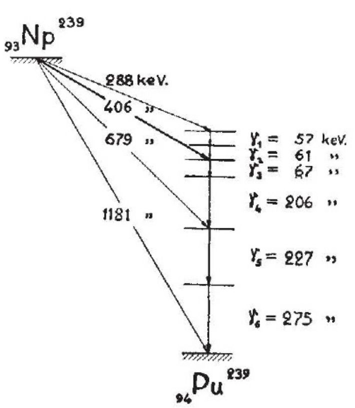


Fig. 4. NUCLEAR-LEVEL SCHEME FOR THE DISINTEGRATION OF $Np^{239}$

A detailed account of these investigations will be published in the near future[8].

I wish to express my thanks to the head of the Nobel Institute for Physics, Prof. Manne Siegbahn, by whose kind offices my stay in Stockholm was made possible. I am also indebted to the Nobel Foundation for fellowship grants made to me. My thanks are equally due to Dr. Lars Melander, who has carried out the chemical preparations, and to Dr. Kai Siegbahn for valuable discussions.

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# INFRA-RED SPECTRUM AND MOLECULAR STRUCTURE OF PHTHIOCERANE

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THE properties of phthiocerane, the hydrocarbon derived from the wax alcohol phthiocerol[1,2] of the tubercle bacillus, for a pure specimen of which we are indebted to Prof. R. J. Anderson, Yale University, indicate a branched-chain structure[3], probably a long chain with a methyl side-chain near one end[4]. For comparison with phthiocerane, a series of hydrocarbons having a total of 34, 35 and 36 carbon atoms*, with a methyl side-chain in position 2-, 3-, 4-, or 5- from one end, have been synthesized at Uppsala, partly by the use of new synthetic methods[5]. The melting points of the synthetic hydrocarbons are plotted in Fig. 1 (the data for the $n$-hydrocarbons

* The analytical data for phthiocerol do not allow a decision between the formulæ $C_{34}H_{67}(OH)_2OCH_3$ and $C_{35}H_{69}(OH)_2OCH_3$ (cf. ref. 2). For the hydrocarbon, Stodola and Anderson favour the formula $C_{34}H_{70}$.