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Introduction

In the region of even-even osmium isotopes the life-times of 2^+ first excited states have so far been measured in $^{184-192}Os$ isotopes /1,2/. Recently the ^{182}Os new isotope was identified in the ^{182}Au decay chain (3).

In the present work the life-time of the 2^+ excited state of the ^{182}Os isotope was measured and the life-time of the 2^+ excited state of ^{184}Os remeasured.

The level scheme of ^{204}Bi was recently investigated by Kusch et al./4/. The suggestion of the existence of excited states with measureable life-times in the nanosecond region was supported in the present work by the measurement of the life-time of the 1020 keV state in ^{204}Bi .

Measurements and Results

The radioactive sources of ^{182}Ir and ^{184}Ir were obtained in reactions $^{175}Lu(^{12}C,3n)^{184}Ir$ and $^{175}Lu(^{12}C,5n)^{182}Ir$ on the heavy ion beam of the U-300 cyclotron of the Nuclear Reactions Laboratory of the Joint Institute for Nuclear Research.

Thin metallic targets (ca 5 mg/cm^2 permitted the use of well-defined carbon energies and it was therefore possible to obtain nearly pure sources of different irridium isotopes. For energies of bombarding ions $E_{^{12}C}$ = 81 MeV and $E_{^{12}C}$ = 62.4 MeV sources of ^{182}Ir and ^{184}Ir were obtained respectively. The single gamma spectra of ^{182}Ir and ^{184}Ir decay taken with the 14 cc Ge (Li) detector (Fig. 1) prove the purity of the obtained sources.

The life-time measurements were performed using a conventional fast-slow coincidence circuit with time-to-amplitude converter.

The life-time of the 127 keV level in ^{182}Os was measured by means of the delayed $\gamma-\gamma$ and $e_L-\gamma$ coincidence method. The $\gamma-\gamma$ coincidence measurements were performed with two plastic scintillators (NE 102, 20 mm 5 mm) and XP1020 photomultipliers.

The gamma channels were set on the 127 keV and 273 keV compton edge. In the $e_L-\gamma$ measurements a 0.3 mm thin PILOT B scintillator was used as a detector of L conversion electrons of the 127 keV transition and the gamma channel was set on the 273 keV compton edge.

The time resolution and the prompt slope were determined using ^{60}Co source in the prompt coincidence measurements for both cases.

In the $\gamma-\gamma$ measurements $2\tau_0$ = 900 psec $T_{½\,prompt}$ = 220psec and in the $e_L-\gamma$ measurements $2\tau_0$ = 320 psec $T_{0\,prompt}$ = 65 psec.

The $e_L-\gamma$ and $\gamma-\gamma$ measurements were repeated several times and the mean value of the life-time of the 2^+ 127 keV state in ^{182}Os was calculated as

$$T_{1/2} = 0.813 \pm 0.011 \text{ ns} \quad .$$

Examples of $\gamma-\gamma$ and $e_L-\gamma$ delayed coincidence curves are shown in Fig. 2.

The life-time of the 120 keV level in ^{184}Os was measured by means of the $e_L-\gamma$ delayed coincidence method and the value

$$T_{1/2} = 1.06 \pm 0.03 \text{ ns}$$

(see Fig. 3) was obtained, which is in good agreement with the value reported by T. Bedike et al. (2).

In the case of ^{204}Bi, the life-time was measured by means of $\gamma-\gamma$ delayed coincidences. For γ-rays detection two NaJ(Tl) scintillators with RCA photomultipliers were used. The gamma channels were set on 270 keV and 1016 keV + 1040 keV photopeaks. The time resolution of the prompt curve was $2\tau_0 = 1{,}4$ ns and the slope 0.25 ns. By using a different selection of the gamma channels it was checked that the observed life-time is connected with the 1020 keV level. An example of the delayed coincidence curve is presented in Fig. 4. From several measurements the mean value of the life-time of the 1020 keV level

$$T_{1/2} = 3.96 \pm 0.08 \text{ ns}$$

was calculated.

Discussion

A. ^{182}Os and ^{184}Os

The obtained experimental results for the life-times of the first 2^+ excited states in ^{182}Os and ^{184}Os, and also the recently measured life-times of the first 2^+ states in $^{186-192}Os$ can be compared with the theoretical predictions of Kumar and Baranger/5,6/. Using the theoretical values of the conversion coefficients for pure E2 transitions (7), the reduced transition probability $B(E2, 2\to 0)_{exp}$ can be calculated from the experimental life-time. From the well-known formulas

$$Q_0^2 = 16\pi \cdot B(E2 \quad 2 \to 0)$$

$$Q_0 = 3/(5\pi)^{1/2} \; Z R_0^2 \beta \, (1 + 0.16\,\beta)$$

the intrinsic quadrupole moment Q_0 and the deformation parameter can be calculated.

In Table I the comparison between the experimental values of $B(E2, 2\to 0)$ and the theoretical predictions of Kumar and Baranger is presented. The experimental values for $^{186-192}Os$ listed in Table I are taken from ref. 2. In Fig. 5a and 5b the A dependence of the experimental and theoretical values of Q_0 and β is shown. Triangles denote the experimental values and circles the theoretical values taken from ref. 5. These theoretical values were obtained by a static calculation in which the determination of the parameters was performed by fitting the odd-even mass differences, intrinsic quadrupole moments, and moments of inertia of 50 even nuclei from the rare earth region. In a second paper of Kumar and Baranger /6/ a more detailed calculation for some rare earth nuclei (including the $^{186-192}Os$ isotopes) taking into account the complete dynamics of the quadrupole motion is presented. The values of Q_0 calculated from the $B(E2, 0 \rightarrow 2)$ given in ref. 6 are denoted in Fig. 5a and 5b by crosses.

B. ^{204}Bi

The 1021 keV level in ^{204}Bi is de-excited by the 204 keV, 884 keV, and 1016 keV gamma transitions. V. Kusch et al. /7/ performed conversion electron measurements for gamma transitions in ^{204}Bi. From the experimental values of the conversion coefficients and from the measured K/L and K/M ratios the multipolarities of some gamma transitions were determined. The 204 keV transitions are assigned as M1, the 884 keV transition as E2 (E3 cannot be excluded), and the 1016 keV transition as E2.

Using the life-time measured in this work and the experimental values of the conversion coefficients and the gamma transition intensities from ref. 7, the partial half-life for the 204 keV, 884 keV, and 1016 keV gamma transitions were calculated. It was assumed that these transitions have a pure character. In Table II the experimental results are compared with the single particle estimates for the M1, M2, E1, E2, and E3 multipolarities of each transition. The ratios $T^{\gamma}_{1/2\,exp} / T^{\gamma}_{1/2\,sp}$ are presented in the same table. It is difficult to make any decisive statement about the multipolarities of the 204 keV, 884 keV and 1016 keV transitions from the life-time measurements. A more precise determination of the conversion coefficients and angular correlation measurements is needed.

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R e f e r e n c e s

1. *J. Lindskog, T. Sundstrom, P. Sparrman. Tables of life-time measurements of excited nuclear states in Perturbed Angular Correlations ed. by E. Karlsson, North Holland Publ. Company, Amsterdam, 1964.*
2. *T. Bedike, N.G. Zaiceva, W.A. Morozov, T.M. Muminov and S. Seledjeanu, Communications of the Joint Institute for Nuclear Research, Dubna, 1969, No 6-4350.*
3. *Isolde collaboration, CERN, Geneva, presented by Dr. J. Jastrzebski at the Conference Spectroscopy and Nuclear Structure in Dubna, 1969.*
4. *W. Kusch, R. Broda, W. Walus and A. Hrynkiewicz, Communications of the Joint Institute for Nuclear Research, Dubna, 1969, No 6-4701.*
5. *K. Kumar, M. Baranger. Nuclear Phys., A110, 529 (1968).*
6. *K. Kumar, M. Baranger. Nuclear Phys., A122, 272 (1968).*
7. *W. Kusch, H. Droste, T. Morek, S. Chojnacki, I.I. Tschuburkova, Communications of the Joint Institute for Nuclear Research, Dubna, 1969, No P6-4585.*

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Table I

Nucleus A	E Level (keV)	$T_{1/2}$ (ns)	α_{tot}	$B(E2, 2 \to 0)_{exp}$ ($e^2 10^{-48}$ cm^4)	$B(E2, 2 \to 0)_{KB}$ ($e^2 10^{-48} cm^4$)	$Q_{o\ exp}$ ($10^{-24} cm^2$)	$Q_{o\ KB}$ ($10^{-24} cm^2$)	β_{exp}	β_{KB}
182	127.0	0.813 ± 0.011	1.90	0.723 ± 0.025	0.655	6.02 ± 0.07	5.763	0.219 ± 0.002	0.235
184	119.8	1.09 ± 0.02	2,14	0.665 ± 0.020	0.595	5.78 ± 0.10	5.474	0.207 ± 0.002	0.221
186	137.2	0.84 ± 0.05	1.26	0.610 ± 0.040	0.505	5.54 ± 0.15	5.037	0.200 ± 0.003	0.199
188	155.0	0.71 ± 0.03	0.80	0.493 ± 0.020	0.400	4.96 ± 0.08	4.497	0.176 ± 0.002	0.180
190	186.7	0.33 ± 0.02	0.42	0.529 ± 0.035	0.415	5.15 ± 0.15	4.576	0.182 ± 0.003	0.170
192	205.7	0.275 ± 0.018	0.26	0.441 ± 0.030	0.348	4.71 ± 0.15	4.193	0.167 ± 0.003	0.152

Table II

E (keV)	$T^{\gamma}_{1/2\ exp}$	$T^{\gamma}_{1/2}(M1)_{sp}$ (sec)	$T^{\gamma}_{1/2}(M2)_{sp}$ (sec)	$T^{\gamma}_{1/2}(E1)_{sp}$ (sec)	$T^{\gamma}_{1/2}(E2)_{sp}$ (sec)	$T^{\gamma}_{1/2}(E3)_{sp}$ (sec)	$T^{\gamma}_{1/2\ exp}/T^{\gamma}_{1/2}(\sigma L)_{sp}$				
							M1	M2	E1	E2	E3
205	5.10×10^{-8}	6.00×10^{-11}	2.40×10^{-7}	2.25×10^{-15}	2.10×10^{-8}	3.20×10^{-2}	8.5×10^{2}	2.1×10^{-1}	2.25×10^{7}	2.4	1.6×10^{-6}
884	7.2×10^{-9}	3.10×10^{-14}	1.60×10^{-10}	2.70×10^{-17}	1.40×10^{-11}	1.15×10^{-6}	2.3×10^{5}	4.5×10^{1}	2.6×10^{8}	5.1×10^{2}	6.3×10^{-3}
1016	1.10×10^{-8}	2.1×10^{-14}	8.00×10^{-11}	1.80×10^{-17}	7.20×10^{-12}	4.30×10^{-7}	5.2×10^{5}	1.4×10^{2}	6.1×10^{8}	1.5×10^{3}	2.5×10^{-2}

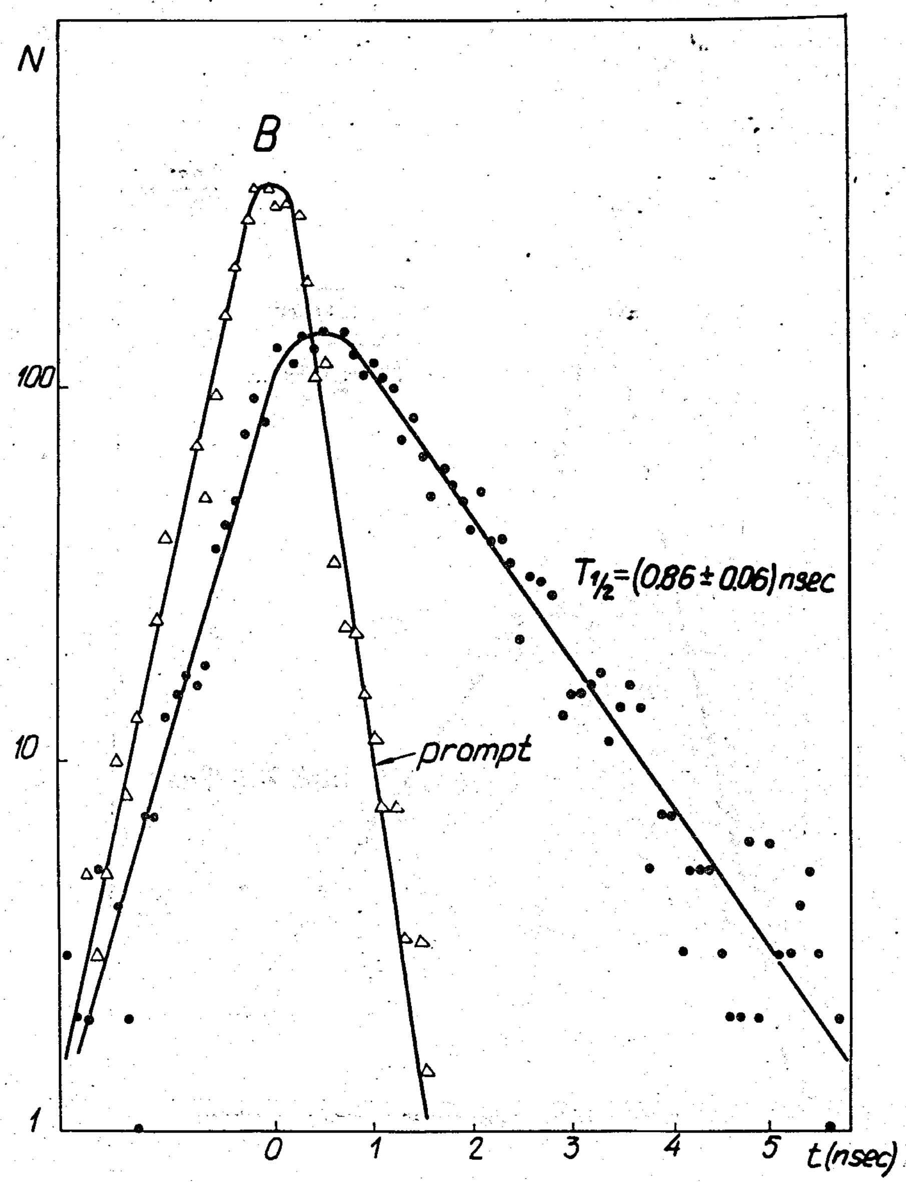

Fig. 2. Curves of the delayed coincidence measurements for the 273 keV – 127 keV $\gamma-\gamma$ cascade in ^{182}Os .

b) $\gamma - e_L$. coincidence measurement.

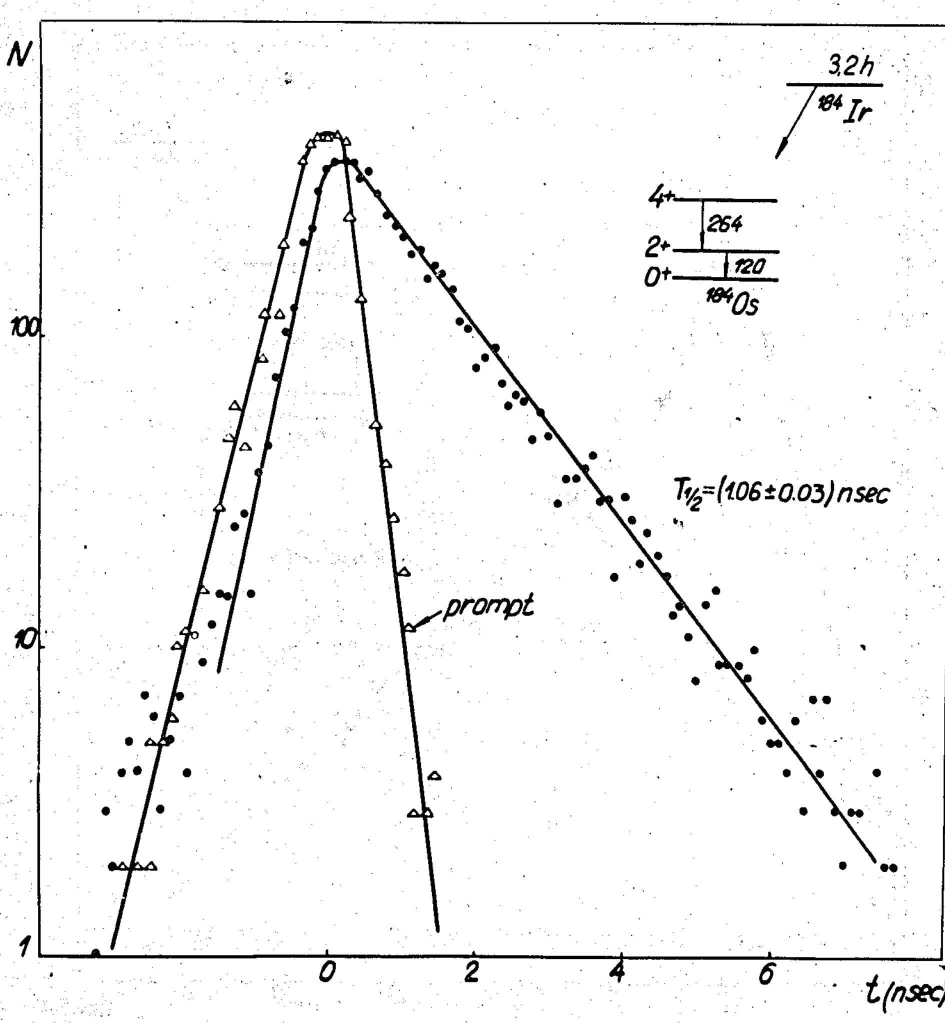

Fig. 3. Curve of the delayed $\gamma - e_L$ coincidence measurement for the 264 keV – 120 keV γ - γ cascade in ^{184}Os.

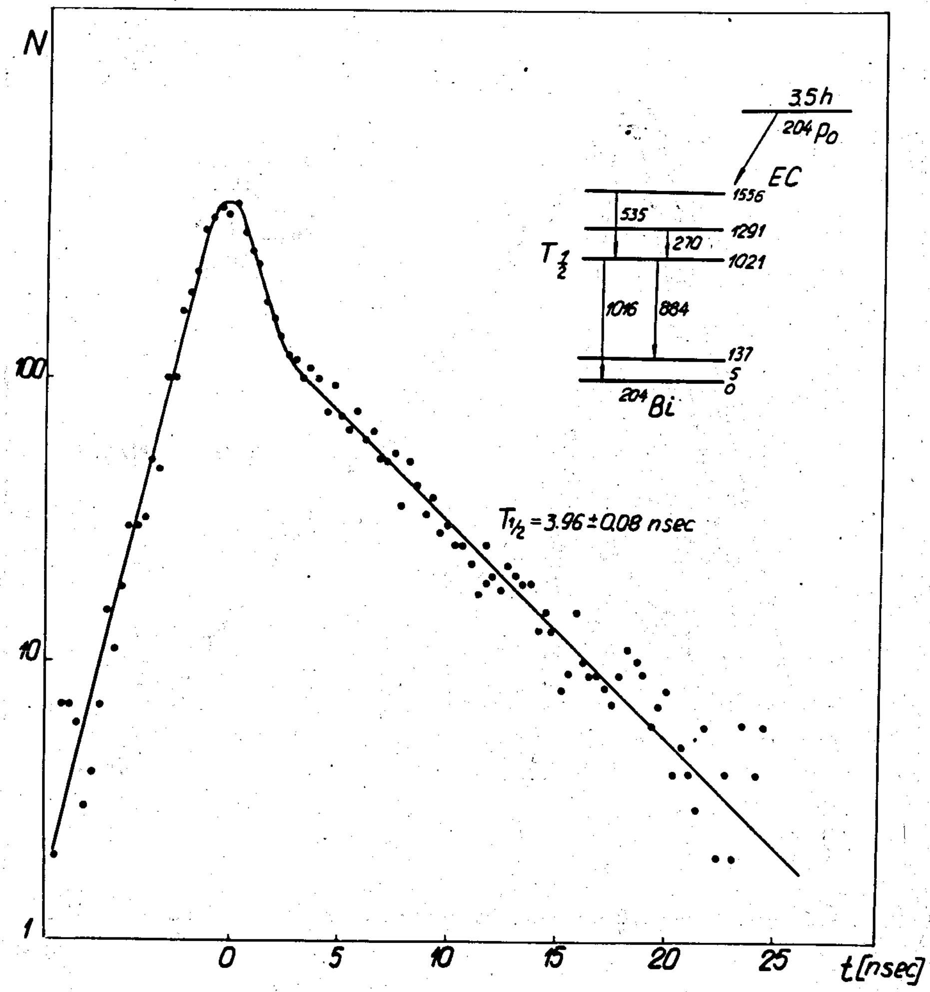

Fig. 4. Curve of the delayed coincidence measurement for the 270 keV (800-1100) keV γ-γ cascade in ^{204}Bi.

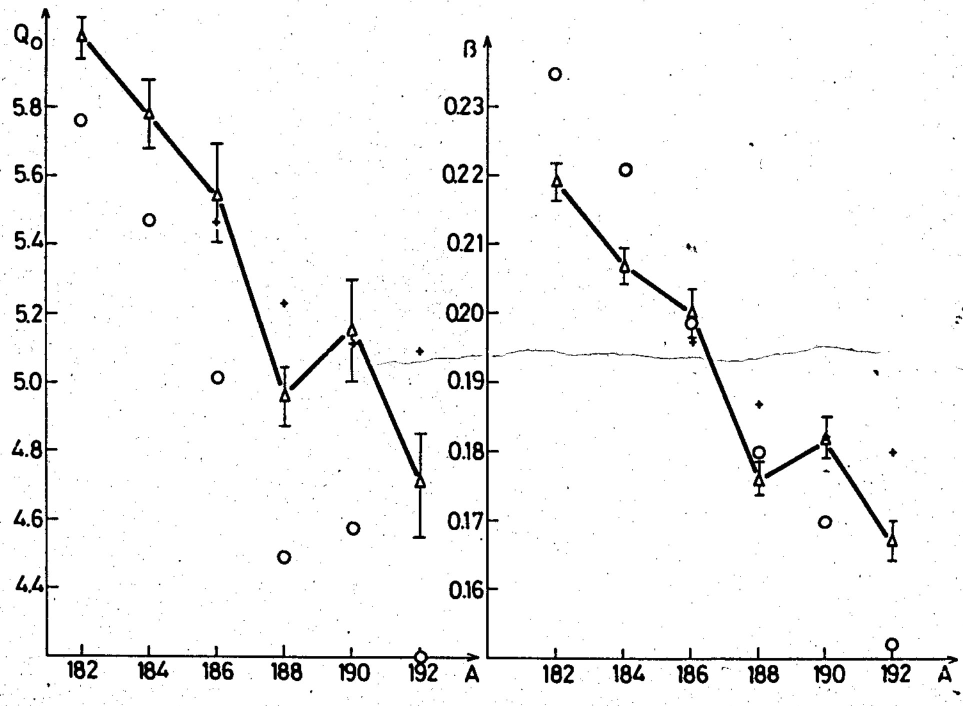

Fig. 5. Intrinsic quadrupole moments Q_0(a) and deformation parameters β(b) for even-even osmium isotopes calculated from the experimental B(E2) values in comparison with the theoretical predictions of Kumar and Baranger.