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DETECTION AND STUDY OF THE α-DECAY OF THE COMPOUND STATES ^{188}Os

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The paper reports on the results of the study of the α-decay of highly excited states of ^{188}Os. The experiment was performed by the time-of-flight method and utilized neutrons from the IBR-30 booster of the Laboratory of Neutron Physics, JINR. For the first time one has succeeded in measuring, with the help of a two-section ionization chamber with a grid, α-widths of $(6.8 \pm 1.0) \cdot 10^{-9}$ eV and $(2.0 \pm 0.3) \cdot 10^{-9}$ eV for two resonances at $E_0 = 9.47$ eV and $E_0 = 12.7$ eV, respectively. Average α-widths were found to be $(17 \pm 10) \cdot 10^{-9}$ eV and $(6.3 \pm \pm 4.7) \cdot 10^{-9}$ eV over two neutron energy intervals from 38 to 53 eV, and from 53 to 150 eV, respectively. Experimental alpha-particle strength functions are compared to those calculated within the model of "the black nucleus".

The investigation has been performed at the Laboratory of Neutron Physics, JINR.

Обнаружение и исследование альфа-распада компаунд-состояний ^{188}Os

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Приводятся результаты исследований альфа-распада высоковозбужденных состояний ^{188}Os. Измерения проводились с использованием метода времени пролета на пучке нейтронов импульсного бустера ИБР-30 ЛНФ ОИЯИ. Впервые удалось с помощью двухсекционной ионизационной камеры с сеткой получить альфа-ширины двух резонансов с $E_0 = 9.47$ эВ и $E_0 = 12.7$ эВ, которые равняются $(6.8 \pm 1.0) \cdot 10^{-9}$ эВ и $(2.0 \pm 0.3) \cdot 10^{-9}$ эВ. Для интервалов энергии нейтронов $38 \div 53$, $53 \div 150$ эВ получены средние значения альфа-ширин: $(17 \pm 10) \cdot 10^{-9}$ эВ и $(6.3 \pm 4.7) \cdot 10^{-9}$ эВ соответственно. Экспериментальные величины альфа-частичной силовой функции сравниваются с рассчитанной по модели "черного" ядра.

Работа выполнена в Лаборатории нейтронной физики ОИЯИ.

The study of α-decay of neutron resonances, being carried out for many years, has provided us with vast information on average α-widths for a wide range of nuclei $60 \le A \le 180$ /1/. The experimental data are well reproduced by the cluster model of α-decay /2/. However measurements of the thermal neutron induced (n, α) reaction cross section of ^{238}U have yielded /3,4/ α-widths six orders of magnitude different from those calculated in the cluster model. What is the reason for that? Is it a new mechanism of the α-decay of heavy nuclei? In this connection the measurement of the $^{187}Os(n, \alpha)$ reaction is of interest, since it is a further step towards heavy nuclei region.

Two earlier attempts /5,6/ have only allowed the determination of the upper limit for the average α-width: $\langle\Gamma_\alpha^{J^\pi}\rangle \leq 6 \cdot 10^{-6}$ eV and $\langle\Gamma_\alpha^{J^\pi}\rangle \leq 0.43 \cdot 10^{-6}$ eV. The experiments have however failed to measure the Γ_α for individual resonances.

The present measurement was carried out with a two-section ionization chamber with a grid. The isotope of ^{187}Os enriched to 99 % was used as a target and had a thickness of 2 mg/cm². It was irradiated by neutrons from the IBR-30 booster. The reduction of the background of electrons and γ-quanta, produced in the (n, γ) reaction having an 8 orders of magnitude larger cross section, required the pressure in the chamber to be 30 % lower than that at which α-particles from the target have flight paths equal to the distance to the grid. This circumstance and also the large thickness of the target did not allow the identification of transitions to separate levels. The obtained data are thus a result of averaging over the lowest levels of the final nucleus. Values of

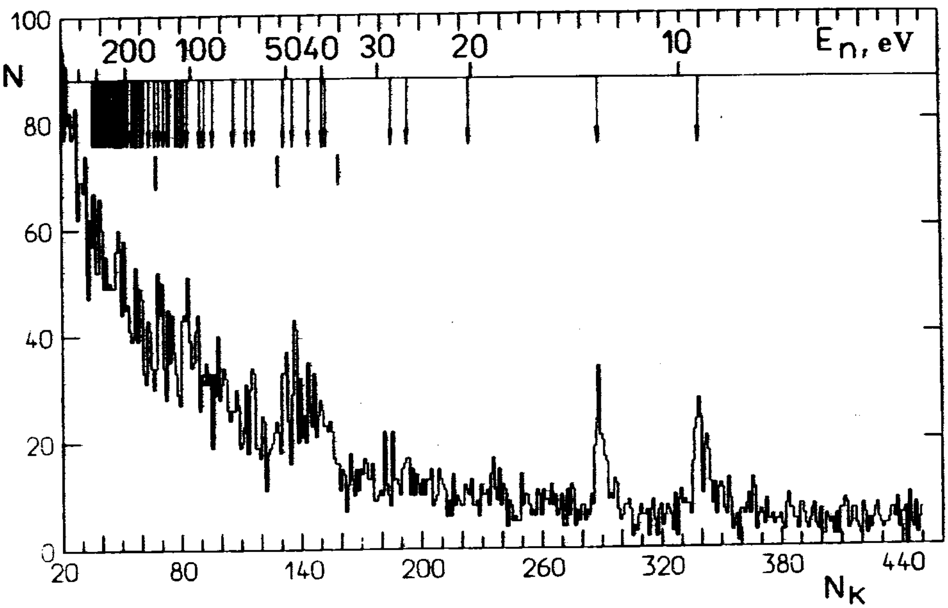
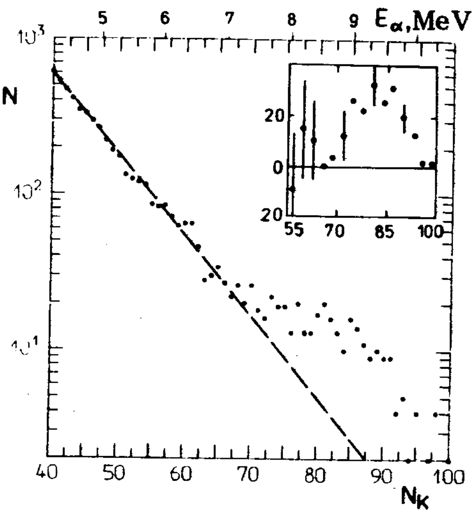


Fig. 1. The time of flight spectrum of the $^{187}Os(n, \alpha)^{184}W$ reaction. Arrows show positions of resonances from /8/ . Also there are shown energy intervals for which averaged parameters of the reaction were calculated.

Fig. 2. The amplitude spectrum in the time window of the resonance $E_0 = 9.47$ eV. The dashed line shows extrapolated background, the insertion illustrates the spectrum after background subtraction.



averaged α-widths were determined by a relative method using the normalization to ^{143}Nd α-width at $E_0 = 127.4$ eV and $E_0 = 135.5$ eV from Refs. /7, 8/. A collimated beam of neutrons simultaneously passed through two targets (^{187}Os and ^{143}Nd) at an angle of 4° with respect to their surface. Signals from two electronic circuits were fed to a mini-computer.

Figure 1 shows the time of flight spectrum of the ^{187}Os(n, α)^{184}W reaction measured in the amplitude window corresponding to the energies of α-particles from a compound nucleus ^{188}Os. Two resonances at $E_0 = 9.47$ eV and $E_0 = 12.7$ eV and a bump in the interval from 38 to 53 eV corresponding to a group of 5 resonances /8/ are observed.

The (n, α) reactions were identified for individual resonances and given energy intervals by the method reported in Ref. /9/. Figure 2 illustrates the amplitude spectrum in the time window of a resonance at $E_0 = 9.47$ eV. The dashed line shows the extrapolated background.

Table 1 summarizes the data on the number of α-counts and calculated α-widths for two resonances. The data acquired for two energy intervals are shown in Table 2. The values for Γ_α, $\langle\Gamma_\alpha\rangle$, $\langle\sigma_{(n,\alpha)}\rangle$ are obtained in the same way as described in Ref. /10/ and the α-particle strength function is determined by a formula /11/:

$$S_\alpha = \frac{\langle\Gamma_\alpha\rangle}{\sum_f \Gamma^{sp}_{\alpha,f} \cdot D},$$

where $\langle\Gamma_\alpha\rangle$ is the averaged over a given interval α-width; $\Gamma^{sp}_{\alpha,f}$, the single particle α-width for the transition to a given state of a final nucleus; D, the mean level spacing of the neutron resonances with spin-parity J^π at the compound nucleus.

The largest contribution to the errors of α-widths is connected with the resolving of the background and with the errors due to a finite number of resonances in an interval ΔE. The obtained values of the

Table 1.

E, eV	N_α	Γ_α, eV $\cdot 10^{-9}$
9.47	177 ± 22	6.8 ± 1.0
12.7	155 ± 21	2.0 ± 0.3

Table 2.

E, eV	N_α	$<\sigma_{(n,\alpha)}>$, μb.	$<\Gamma_\alpha>$, eV $\cdot 10^{-9}$	S_α, MeV^{-1} $\cdot 10^{-2}$
38—53	312 ± 85	22 ± 6	17 ± 10	23 ± 14
53—150	259 ± 180	5.4 ± 3.8	6.3 ± 4.7	8.6 ± 6.4
over resonances 9.47 and 12.7			4.4 ± 2.6	6.0 ± 3.5

α-particle strength function may be compared with S_α^{bn} = $= 4.8 \cdot 10^{-2}$ MeV^{-1}, the α-particle strength function for the nucleus ^{187}Os, calculated in the frame of a "black nucleus" model as Kadmensky et al. did in their work /11/. The strength function exceeds a little the S_α^{bn} in the first energy interval, while in the second and in the interval of averaging over two resonances it coincides with the S_α^{bn}, i.e. the $<\Gamma_\alpha>_{exp}$ does not show a considerable rise over the cluster model value for A = 188.

It would be of interest to compare the obtained results to the values calculated with account for the deformation of the nucleus and correlations among channels, since these calculations have shown a decrease of the value of S_α^{bn} for several nuclei.

The obtained values of average α-widths have confirmed the fact that the α-decay channel is very narrow as compared to the channel of radiation capture by the ^{187}Os nucleus and, therefore, can be neglected in making estimates for the decrease in number of ^{187}Os nuclei in the process of nucleosynthesis.

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