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# SOME RESULTS OF THE INVESTIGATION OF α-SPECTRA FROM (n, α) REACTIONS[1]

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Some results of the investigation of α-spectra from the (n, α) reaction with odd neodymium and samarium isotopes used as targets are considered. Under discussion are also the ways of obtaining information about neutron resonances and the possible deviation from the statistical theory of the ratio of α-decay probabilities to the ground and the first excidet states. In conclusion data on the $^{143}$Nd(n, γα) reaction are analysed in order to study γ-transitions between the compound states.

Such measurements are carried out on the fast pulse reactor IBR-30 (JINR) by the time-of-flight method. The α-particle spectrometer is a double ionization chamber with a grid. The large flux of the background γ-rays and the scattered neutrons influence the resolution power of the spectrometer. In order to reduce their influence the spectrometer is placed behind the collimators with a narrow slit so that the neutrons reach the target at sliding angles of about 4°. Targets with a large area (~1200 cm$^2$) have to be used, as the cross-section of (n, α) reaction is small. We used electronic α-particle collimation to suppress the tail in the α-spectra extended to low energies. Under these conditions the strong α-peaks do not hinder the observation of the adjacent weak ones [1]. Energy, time-of-flight and angle information about α-particles in the measured α-spectra is recorded on a magnetic tape. By means of the selection device connected with the system for the advanced procession of the manydimensional information of the BESM-4 computer one may obtain the amplitude spectra in a given time-of-flight and angle interval.

We have measured the α-spectra from the (n, α) reaction for $^{147,149}$Sm [2, 3] and $^{143,145}$Nd [4, 5, 6]. The time-of-flight spectra provide data for the determination of spins of neutron resonances. In the case of the $^{147,149}$Sm and $^{143,145}$Nd nuclei the excited states with spin $3^-$ or $4^-$ are formed by the capture of slow s-neutrons. The ground and the first excited state of the product nuclei have spin and parity $0^+$ and $2^+$, respectively. As the transition $4^- \to 0^+$ is forbidden, the presence of the resonance peak in the time spectrum observed in the amplitude interval $\alpha_0$ points unambiguously to the fact that spin and parity are equal to $3^-$ (Fig. 1). Thus, for example, the right value $J^\pi = 3^-$ was obtained for the resonance at $E_0 = 8.9$ eV of $^{149}$Sm [3].

From the analysis of α-spectra 11 resonances $^{147}$Sm [2], the ratio may be obtained from the averaged reduced probabilities of α-transitions from the compound level to the first excited state with $I^\pi = 2^+(\langle \gamma^2_{\alpha 2^+} \rangle)$ and the ground state with $I^\pi = 0^+(\langle \gamma^2_{\alpha 0} \rangle)$ of the $^{144}$Nd daughter nucleus. The experiment gives for the ratio $\langle \gamma^2_{\alpha 2^+} \rangle / \langle \gamma^2_{\alpha 0^+} \rangle$ the

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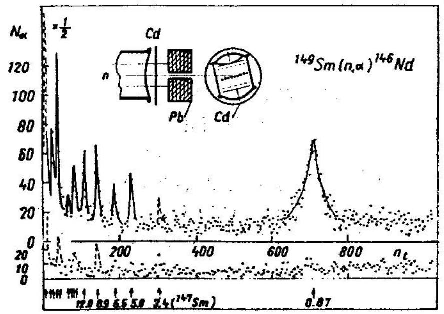


Fig. 1

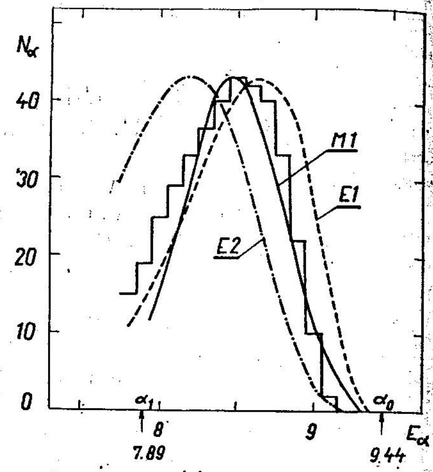


Fig. 2.

value $0.9 \pm 0.4$, or $2.2 \pm 1.0$, when the resonance at $E_0 = 183.7$ eV having an extremely large total width is not taken into account.

For the ratio $R = \langle\Gamma_\alpha^{3-}\rangle/\langle\Gamma_\alpha^{4-}\rangle$ the value $R_{exp} = 3.9 \pm 1.3$ may be obtained on the basis of the experimental data on total α-widths and spins of the compound states of the $^{148}$Sm [2, 7] nucleus. The optical model gives the value $R_{OM} = 9.1 \pm 1.9$. The comparison of $R_{OM}$ with $R_{exp}$ shows that the probability of α-transition to the first excited state with $J^\pi = 2^+$ of the daughter nucleus $^{144}$Nd may possibly become stronger. It is consistent with the qualitative predictions made by V. G. Soloviev [8].

For the $^{149}$Sm$(n, \alpha)$ $^{146}$Nd [3] reaction, the experimental value $R_{exp}$ is $4.5 \pm 3.5$, while $R_{OM} = 7 \pm 1$. A large error in determination of $R_{exp}$ caused by a limited number of resonances does not allow to draw a definite conclusion about the increase (or not) of the α-transition probability to the $2^+$ excited state of the nucleus $^{146}$Nd.

The investigation of the $(n, \gamma\alpha)$ reaction gives a unique possibility to obtain information about γ-transitions between the compound states close to the binding energy of the neutron. We have measured the α-particle spectrum in the $E_0 = 55.3$ eV resonance $(J^\pi = 4^-)$ of $^{143}$Nd. The experimental arrangement and the detailed analysis of the data are given in JINR communications [4]. The results are presented in Table 1. The fact that the thermal neutron cross-section of the $^{143}$Nd$(n, \gamma\alpha)$ reaction obtained by different experiments differ greatly has influenced us to perform the measurements wit hour own experimental arrangement using the angle selection for the registration of α-particles. Table 1 gives $\Gamma_{\gamma\alpha}$ values calculated using the results of Kvitek [10] and Macfarlane [9] together with the estimation of the $\Gamma_{\gamma\alpha}$ value for the $E_0 = 2.33$ eV resonance of $^{123}$Te made on the basis of our results.

Table 1

| Nucleus | $(E_0$ (eV)) | $J^\pi$ | $\sigma_{\gamma\alpha}$ (mb) | $\Gamma_{\gamma\alpha} \times 10^7$ (eV) | $HF(M1)$ | $HF(E1)$ |
|---|---|---|---|---|---|---|
| $^{143}$Nd | 55.3 | $4^-$ | | $1.1 \pm 0.8$ | $1 \times 10^4$ | $0.4 \times 10^6$ |
| | $-6$ | $3^-$ | 0.3 [9] | 0.8 | $2 \times 10^4$ | $2 \times 10^6$ |
| | | | 0.9 [10] | 2.4 | | |
| | | | $0.6 \pm 0.3$ | $1.6 \pm 0.8$ | $1 \times 10^4$ | $1 \times 10^6$ |
| $^{123}$Te | 2.33 | $1^+$ | | $\leqslant 0.02$ | | |



However the comparison of the experimental spectrum from [9] obtained with a rather good resolution with the theoretical spectra $W_{\gamma\alpha}(E_\alpha)$ for various γ-transitions gives evidence of the predominance of $E1$ and $M1$ transitions (Fig. 2).

Comparing the experimental value of the ratio $\omega = \Gamma_{\gamma\alpha}^{3-}/\Gamma_{\gamma\alpha}^{4-}$ for $^{143}$Nd obtained using the results given in Table 1 $(\omega_{exp} = 1.5 \pm 1.3)$ with the theoretical one calculated under the assumption that only the $E1$ transitions $(\omega_{th}^{E1} \simeq 5)$ or the $M1$ transitions $(\omega_{th}^{M1} \simeq 0.8)$ contribute to the $(n, \gamma\alpha)$ reaction, one may make the conclusion about the predominant role of the $M1$ transitions in soft γ-transitions between the states close to the neutron binding energy.

The Table gives the lower limits of the hindrance factors obtained under the assumption of only the $E1$ or the $M1$ γ-transitions. The uncertainties due to the above assumptions together with the unambiguity of the optical models parameters used in the calculations may cause the variation of the $HF$ value within an order of magnitude.

Comparing our data with those on the γ-transitions between the low-lying levels $(HF(E1)_L = 10^2 - 10^5)$ given in [12] one may arrive at the conclusion that in the region of the high level density the hindrance factors are larger than in the region of the low excitation energy at least for the $E1$ γ-transitions. The obtained $HF$ values still seem to be quite reasonable from the point of wiev of the new semi-microscopic approach to the description of the neutron resonance structure developed by V. G. Soloviev [13].

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