Correlation between the angular momentum of the residual nucleus and the neutron multiplicity in the reaction (π^-, xn)

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The dependence of the isomer ratio on the number of emitted neutrons in the reaction Sn(π^-, xn)^{108,109}In is established. This dependence has a maximum at $x = 6$–7, corresponding to an exciton energy on the order of $m\pi/2$.

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It is known that when stopped negative pions are absorbed by complex nuclei, a large number of neutrons is emitted and high-spin states are excited in the residual nuclei.[1]

The purpose of the present study was to investigate the connection between these two phenomena. This reduced to a determination of the relative probabilities of the formation of high-spin isomers at fixed values of the spins of the initial and final nuclei, and at different numbers of emitted neutrons.

We measured in the experiment the isomer ratios in the isotopes ^{108}In and ^{110}In produced as a result of bombarding even tin isotopes with pions (Table I).

The bombardment, cooling, and measurement times for all the targets were the same, namely 30, 4, and 30 minutes respectively, accurate to 10 seconds.

The measurements were performed in the same geometry and for the same regime of the germanium-lithium spectrometer. The shape and dimensions of the targets (disk 30 mm in diameter, $h \leq 1$ mm) made it possible to neglect the self-absorption of the γ rays with energies higher than 600 keV. Figures 1a and 1b show the sections of the γ-ray spectra containing the most intense lines of the isotopes ^{108}In and ^{110}In, from which we determined their isomer ratios. Table II yields information on these isotopes. In both indium isotopes, they are no isomeric transitions between the high-spin and low-spin isomers, and they undergo β decay independently of each other. Therefore the sought isomer ratios are directly proportional to the ratio of the γ-ray yields produced in the decay of the metastable and ground states, and were calculated from the areas of the photopeaks of the corresponding lines in the spectra.

TABLE I. Characteristics of targets.

Target	^{112}Sn	^{114}Sn	^{116}Sn	^{118}Sn	^{120}Sn	^{122}Sn	^{124}Sn
Enrichment, %	80.0	70.0	98.0	98.3	99.2	92.1	97.9
Weight in grams	5.0	9.2	10.4	9.0	9.0	10.0	9.0

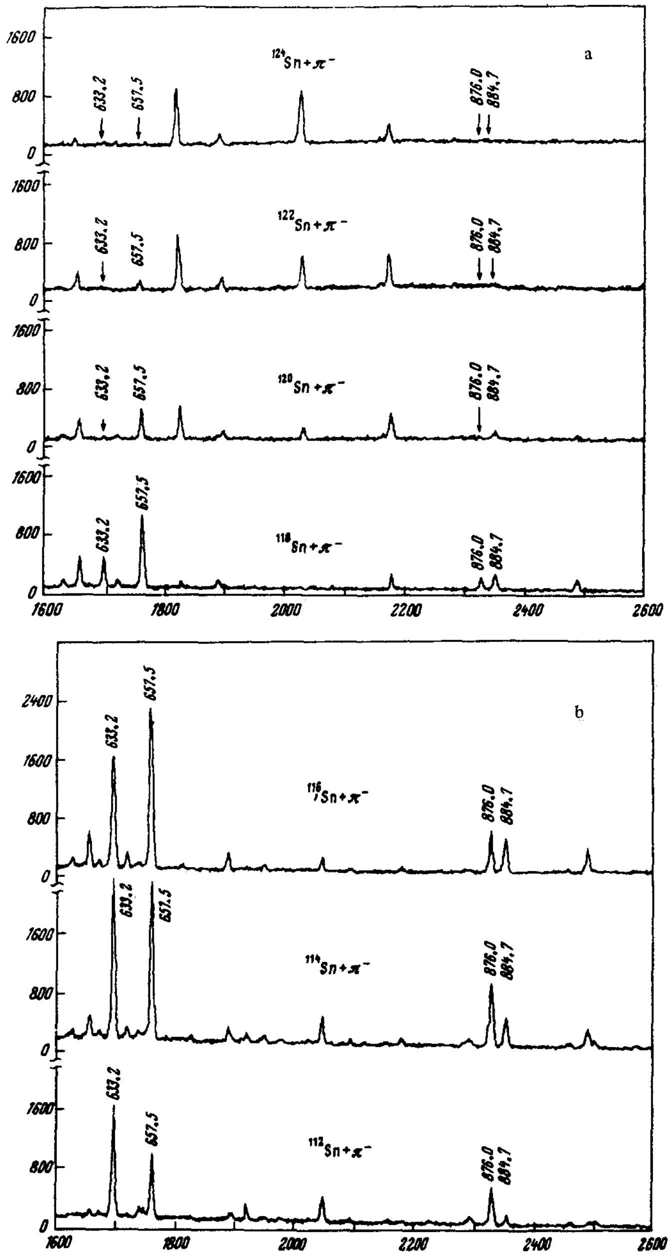

FIG. 1. Gamma-ray spectrum sections containing the most intense lines of the isotopes ^{108}In and ^{110}In. For the target ^{120}Sn and ^{122}Sn, the arrows show the positions of the very weak lines, which can be noted only by statistical reduction.

TABLE II. Characteristics of the isotopres ^{108}In and ^{110}In.

	$T_{1/2}$		E_{γ}, keV	$I_{\gamma}^{rel.}$
^{108M}In	56 min	6^+	633.2 876.0	100 85
^{108O}In	39 min	3^+	633.2	100
^{110M}In	4.9 min	7^+	657.5 884.7	100 96
^{110O}In	69 min	2^+	657.5	100

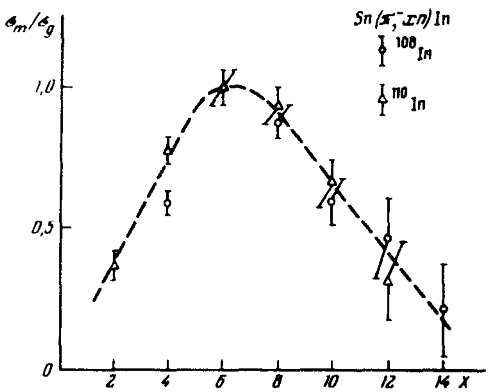

FIG. 2. Dependence of the isomer ratio on the multiplicity of the neutrons. All the values are normalized to $X = 6$.

Figure 2 shows the obtained values of the isomer ratios in relative units as functions of the number of emitted neutrons. It is seen that the isomer ratio in the isotopes ^{108}In and ^{110}In increases as the neutron multiplicity increases from 2 to 6, and then decreases with further increase of X. In the case of the ^{124}Sn target, the yield of ^{108}In and ^{110}In is so small that we were unable to determine σ_m/σ_g.

The experimental results are in qualitative agreement with statistical-model calculations [2] and point to an important role of the intranuclear cascade in the formation of the angular momentum of the residual nuclei.

[1]V. S. Buttsev, Yu. K. Gavrilov, Zh. Ganzorig, S. M. Polikanov, and D. Chultém, Pis'ma Zh. Eksp. Teor. Fiz. **21**, 400 (1975) (JETP Lett. **21**, 182 (1975)].

[2]A. S. Il'inov, V. I. Nazaruk, and S. E. Chigrinov, Preprint IYaI Akad. Nauk SSSR (Inst. Nuc. Phys. USSR Acad. Sci.), p-0022, Moscow, 1975.