Average Effective Thicknesses for Na^{24} Recoil Nuclei at $E\gamma_{max} = 260$ Mev.

Reaction	t_f (micrograms/cm²)		t_b (micrograms/cm²)			t_r (micrograms/cm²)	
	Experimental	Compound nucleus	Experimental	Compound nucleus	"Quasi-deuteron" model	Experimental	Compound nucleus
Al^{27} (γ, $2pn$)	125 ± 3	515 ± 50	102 ± 3	271 ± 30	180 ± 30	72 ± 3	122 ± 15
Si^{28} (γ, $3pn$)	80 ± 8	530 ± 50	80 ± 16	200 ± 20	160 ± 30	40 ± 8	48 ± 5
P^{31} (γ, $4p3n$)	80 ± 8	680 ± 70	50 ± 16	250 ± 30	160 ± 30	20 ± 8	44 ± 5
S^{32} (γ, $5p3n$)	40 ± 8	660 ± 70	20 ± 8	240 ± 30	—	0 ± 8	40 ± 5

a_0 is the total number of recoil nuclei produced per unit mass of the specimen. To determine N, the investigated specimens were coated with triacetate films 20 microns thick. These films served to gather the Na^{24} recoil nuclei from the specimen. Stacks made up of the specimens and films were placed in the bremsstrahlung beam of the 260-Mev synchroton of the Physics Institute of the Academy of Sciences, both parallel and perpendicular to the beam (Fig. 1), and exposed for 10 to 15 hours. Ten to 15 hours after the end of the exposure, only the characteristic activity of Na^{24} was observed on the films and specimens. The ratio N/a_0 was calculated from the measured activities of Na^{24} by introducing corrections for the decay and for the self absorption. The experiments with aluminum were carried out at maximum bremsstrahlung energies ($E\gamma_{max}$) of 80, 100, 150, 200, and 260 Mev. The experiments with silicon, phosphorus, and sulphur were carried out at $E\gamma_{max} = 260$ Mev.

The experimental results are shown in Fig. 2 and in the table, which lists also the values of t_f, t_b and t_r (see Fig. 1), calculated with the compound-nucleus model, and tentative values of t_b calculated with the "quasi-deuteron" model. As can be seen from Fig. 2 and from the table, the values of t calculated with the compound-nucleus model are several times greater than the experimental ones. This shows that a model that assumes the formation of a compound nucleus with subsequent evaporation of the nucleons cannot be used to explain the reactions investigated. The values t_b calculated by the "quasi-deuteron" model are also considerably greater than the experimental ones. Further experiments and refinement of the calculations should show whether these discrepancies can be eliminated by a suitable modification of the "quasi-deuteron" model or whether deep photofissions of this kind must be explained by introducing a substantially different mechanism of interaction, for example a mechanism that takes into account the interaction between the gamma quanta and the alpha particles or the more complicated fragments of the nuclei.

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ISOTOPIC INVARIANCE IN ANTI-HYPERON PROCESSES

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In this note we consider formation and interaction processes of anti-hyperons with nucleons and light nuclei on the basis of isotopic invariance.

As was shown by Amati and Vitale,[1] the most convenient process for the identification and study of the anti-hyperons is not the nucleon-nucleon collision, but the reaction involving a beam of K particles:

$$K + N \rightarrow \tilde{Y} + N + N. \qquad (1)$$

Using K^+ particles and protons in reaction (1), we get two channels for the charge states (with formation of $\tilde{\Sigma}$ anti-hyperons):

$$\begin{aligned} K^+ + p &\rightarrow \tilde{\Sigma}^0 + p + p, && \text{(a)} \\ &\rightarrow \tilde{\Sigma}^- + p + n. && \text{(b)} \end{aligned} \qquad (1')$$

Applying, in the usual way,[2] the hypothesis of isotopic invariance, we obtain for the cross sections of processes (a) and (b) the following expressions:

$$\sigma_a = {}^1/_2 \, |A_1^1|^2, \quad \sigma_b = |A_0^1|^2 + {}^1/_2 \, |A_1^1|^2, \tag{2}$$

where A_t^T is the amplitude for the transition into a final state with total isotopic spin T, while the isotopic spin of the two-nucleon system is equal to t (= 0, 1). From this we only get an unequality for the cross sections:

$$\sigma_b \geqslant \sigma_a. \tag{3}$$

In reference 1 the interaction of the $\tilde{\Sigma}^+$ anti-hyperon with deuterium was discussed. The $\tilde{\Sigma}^+$ anti-hyperon has negative charge, and is thus slowed down by ionization losses. After coming to rest, it is absorbed. The following reactions take place:

$$\begin{aligned} \tilde{\Sigma}^+ + d &\to n + \pi^- + K^+, && \text{(a)} \\ &\to n + \pi^0 + K^0, && \text{(b)} \\ &\to p + \pi^- + K^0. && \text{(c)} \end{aligned} \tag{4}$$

We investigate these reactions in somewhat more detail than was done in reference 1. The amplitudes for the processes (a), (b), and (c) in Eq. (4) have, under the hypothesis of isotopic invariance, the following form:

$$\begin{aligned} F_a &= \frac{1}{\sqrt{2}}\left(-A_0^1 + \frac{1}{\sqrt{2}} A_1^1\right) = -\frac{\sqrt{3}}{2} B_{3/2}^1, \\ F_b &= -\frac{1}{\sqrt{2}} A_1^1 = \frac{1}{\sqrt{3}}\left(B_{1/2}^1 + \frac{1}{\sqrt{2}} B_{3/2}^1\right), \\ F_c &= \frac{1}{\sqrt{2}}\left(A_0^1 + \frac{1}{\sqrt{2}} A_1^1\right) = \frac{1}{\sqrt{3}}\left(-\sqrt{2} B_{1/2}^1 + \frac{1}{2} B_{3/2}^1\right), \end{aligned} \tag{5}$$

where A_t^1 is the amplitude for the transition into a final state, with the isotopic spin of the system K meson — nucleon equal to t (= 0, 1); $B_{t'}^1$ has the same meaning for the system π meson — nucleon ($t' = 1/2, 3/2$).

If we express the amplitudes for the processes by the amplitudes A_t^1, characterizing the system K meson – nucleon in the final state, we obtain the inequality

$$\sigma_a + \sigma_c \geqslant \sigma_b. \tag{6}$$

The equality sign holds for the case when the interaction amplitude for the system K meson — nucleon in the state with isotopic spin t = 1 predominates over the amplitude for the same system with t = 0. We note that the experimental data point to a strong interaction in the system N – K for t = 1. In this limiting case $\sigma(a):\sigma(b):\sigma(c) = 1:2:1$, and the ratio $K^+/K^0 = 1/3$, i.e., we get the result of reference 1.

If we express the amplitudes F_i by the amplitudes $B_{t'}^1$, characterizing the system π meson – nucleon in the state with isotopic spin t′, we obtain the inequality

$$\sigma_b + \sigma_c \geqslant \sigma_a/3. \tag{7}$$

In the limiting case of a predomination of the interaction amplitude for the system π-N in the state with $t' = 3/2$ we get an equality, and $\sigma(a):\sigma(b):\sigma(c) = 9:2:1$, $K^+/K^0 = 3$ (cf. reference 1).

In the general case we must be content with the inequalities (6) and (7). Their violation would indicate the absence of isotopic invariance in anti-hyperon processes.

Specific inequalities between the cross sections can also be obtained from the obvious fact that $|F_a|$, $\sqrt{2}\,|F_b|$, and $|F_c|$ may be regarded as the lengths of the edges of a triangle. This leads to the following set of inequalities:

$$\begin{aligned} |\sqrt{\sigma_a} - \sqrt{\sigma_c}| &\leqslant \sqrt{2\sigma_b} \leqslant \sqrt{\sigma_a} + \sqrt{\sigma_c}, \\ |\sqrt{2\sigma_b} - \sqrt{\sigma_c}| &\leqslant \sqrt{\sigma_a} \leqslant \sqrt{2\sigma_b} + \sqrt{\sigma_c}, \\ |\sqrt{\sigma_a} - \sqrt{2\sigma_b}| &\leqslant \sqrt{\sigma_c} \leqslant \sqrt{\sigma_a} + \sqrt{2\sigma_b}, \end{aligned} \tag{8}$$

The experimental verification of these relations is also of interest for the applicability of the hypothesis of isotopic invariance for interactions involving strange particles, and in particular, anti-hyperons.

We note that these considerations are immediately generalized for the case of light nuclei with isotopic spin zero (He^4, C^{12}, etc.).

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LOWER EXCITED STATES OF Th^{231}

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A considerable fraction of the Th^{231} produced in the alpha decay of U^{235} is in excited states. Up to recently it was assumed that the gamma transitions