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ANISOTROPIC DISTRIBUTION OF INTERNAL BREMSSTRAHLUNG IN K CAPTURE BY POLARIZED NUCLEI

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ANISOTROPY in the angular distribution of internal bremsstrahlung in K capture by polarized nuclei occurs if parity is not conserved in weak interactions. Experimental investigation of this phenomenon yields in principle the same information on the constants of the β-decay interaction as do experiments on the angular distribution of electrons in the β decay of polarized nuclei. From the experimental point of view the measurement of anisotropy of internal bremsstrahlung in K capture by polarized nuclei can be more convenient since in this case the observed effect is less dependent on the thickness of sources in which scattering of the radiation involved can take place. We also note that the anisotropy coefficient of internal bremsstrahlung does not depend on the energy of the γ quanta.

We calculated this effect for allowed transitions according to the usual method of the Born approximation in the Coulomb field of the nucleus. The angular distribution has the form

$$W = 1 + P\alpha\cos\theta, \tag{1}$$

where $P = \langle J_z \rangle / J$ is the polarization of the nucleus, J and J_z are respectively the spin and the projection of the spin of the nucleus in the ground state, and θ is the angle between the direction of polarization of the nucleus and the momentum of the bremsstrahlung. For interactions of the general type $S+T+V+A$ the anisotropy coefficient is given by the formulas:

$J \to J$ (no) transition

$$\alpha = \frac{\frac{1}{J+1}\left[(g_T g_T'^* + g_T' g_T^*) - (g_A g_A'^* + g_A' g_A^*)\right]\langle\|\sigma\|\rangle^2 + \frac{2J}{\sqrt{J(J+1)}}\,\mathrm{Re}\,\{\left[(g_S g_T'^* + g_S' g_T^*) - (g_V g_A'^* + g_V' g_A^*)\right]\langle\|1\|\rangle\langle\|\sigma\|\rangle\}}{\left[(|g_S|^2 + |g_S'|^2) + (|g_V|^2 + |g_V'|^2)\right]\langle\|1\|\rangle^2 + \left[(|g_T|^2 + |g_T'|^2) + (|g_A|^2 + |g_A'|^2)\right]\langle\|\sigma\|\rangle^2}, \tag{2}$$

$J \to J-1$ (no) transition

$$\alpha = \frac{(g_l g_l'^* + g_l' g_T) - (g_A g_A'^* + g_A' g_A^*)}{(|g_T|^2 + |g_T'|^2) + (|g_A|^2 + |g_A'|^2)}, \tag{3}$$

$J \to J+1$ (no) transition

$$\alpha = \frac{J}{J+1}\,\frac{-(g_T g_T'^* + g_T' g_T) + (g_A g_A'^* + g_A' g_A^*)}{(|g_T|^2 + |g_T'|^2) + (|g_A|^2 + |g_A'|^2)}. \tag{4}$$

Here $\langle\|1\|\rangle$ and $\langle\|\sigma\|\rangle$ are the nuclear matrix elements for the Fermi and Gamow-Teller parts of the interactions.

For the (V-A) interaction, with strict invariance under time reversal and with two-component neutrinos (polarized with spin opposite to the momentum direction in K capture) we have

$$J \to J-1 \quad (\text{no}) \quad \alpha = +1, \tag{5}$$

$$J \to J+1 \quad (\text{no}) \quad \alpha = -J/(J+1), \tag{6}$$

$J \to J$ (no)

$$\alpha = \left[\frac{1}{J+1}R^2B^2 - \frac{2J}{\sqrt{J(J+1)}}RB\right] \Big/ (1 + B^2R^2), \tag{7}$$

where[1] $R = |g_A/g_V| = 1.19 \pm 0.02$; $B = \langle\|\sigma\|\rangle / \langle\|1\|\rangle$.

Since experiments on K-capture radiation are best done with nuclei which decay directly to the ground state so that the background of nuclear γ rays does not interfere with the investigation of the bremsstrahlung, we list below values of the anisotropy coefficient α_{VA} for several such nuclei:[2]

V^{49}	$^7/_2^- \to {}^7/_2^-$	$J \to J$ (no)	$\alpha_{VA} = (0.32B^2 - 2.1B)/(1 + 1.42B^2)$
Fe^{55}	$^3/_2^- \to {}^5/_2^-$	$J \to J + 1$ (no)	$\alpha_{VA} = -0.6$
Ge^{71}	$^1/_2^- \to {}^3/_2^-$	$J \to J + 1$ (no)	$\alpha_{VA} = -0.33$
Mo^{93}	$^7/_2^+ \to {}^9/_2^+$	$J \to J + 1$ (no)	$\alpha_{VA} = -0.78$
Cs^{131}	$^5/_2^+ \to {}^3/_2^+$	$J \to J - 1$ (no)	$\alpha_{VA} = +1$

In conclusion we wish to express our gratitude to V. S. Shpinel' who drew our attention to this effect, and to I. S. Shapiro for his valuable advice and leadership.

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ELASTIC SCATTERING OF PROTONS BY CHROMIUM ISOTOPES AT 5.40 Mev

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We have investigated the angular distribution of protons scattered elastically by the chromium isotopes Cr^{52} and Cr^{53}. Protons accelerated in a linear accelerator were energy-analyzed by a magnetic field giving a deflection of 24° and sent through a collimation system with a diaphragm opening 2.3 mm in diameter onto a target located in the scattering chamber. The target consisted of thin metallic foils 4 μ thick in the case of Cr^{52} and 0.7 μ thick in the case of Cr^{53}. The protons scattered by the target were recorded in photo-emulsion pellicles 100 μ thick at angles of 20 – 160° every 10°. In the angular region 20 – 70° the plates were placed at distances $r = \text{const}/\sin^2(\theta/2)$, which made it possible to protect the emulsion from the intense "illumination" by protons scattered at small angles by the Coulomb field of the nucleus.

Figure 1 shows the energy spectrum of protons scattered by the nuclei under investigation at an angle of 130°. It is readily seen that the inelastic group of protons is easily distinguishable and that the number of elastically-scattered protons can be counted readily at any angle. We note that the inelastically scattered protons corresponding to the 540-kev level of Cr^{53} are relatively few, which is evidence that this level is weakly excited, while the number of protons corresponding to the 970-kev level is considerable.

The angular distribution of the elastically-scattered protons is shown in Fig. 2. The difference in the scattering is seen to be not only quantitative, but also qualitative. The intensity of the protons scattered by Cr^{52} is 2.5 times as large

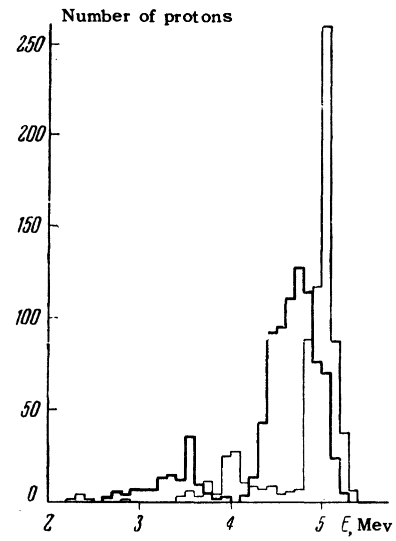

FIG. 1. Proton energy spectrum: heavy line – Cr^{52}, 893 tracks; thin line – Cr^{53}, 729 tracks.

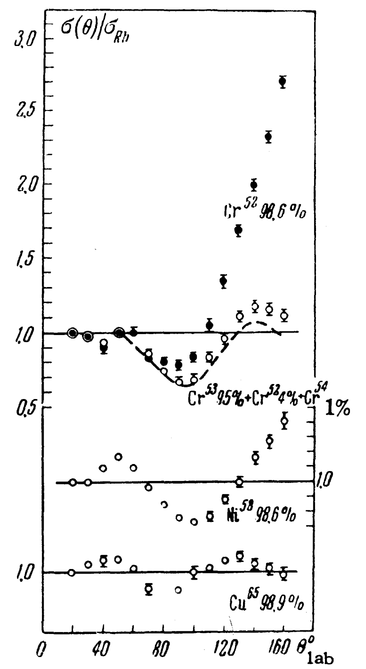

FIG. 2. Ratio of the measured cross section to the Rutherford cross section as a function of the angle of observation in the laboratory system; the dashed curve was obtained from a recalculation of the measured ratio for pure Cr^{53}.