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INVESTIGATION OF Kx-γ DIRECTION CORRELATION IN THE DECAY OF Mn^{54}

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Electron capture by an excited level in nuclear decay can be used to study the relative angular distribution of the emitted x-rays and γ quanta. In practice this differs little from the γ-γ correlation investigations, but the nature of the phenomenon is different. Theory [1] denies the existence of Kx-γ correlation of the directions. On the other hand, the theory predicts Lx-γ correlation. There are no published papers on this question. A special setup was constructed to investigate Lx-γ correlation, and also correlations with Auger or conversion electrons, but it was found the measurement of Lx-γ correlation is hindered by the background from the Kx rays, which has an anisotropic angular distribution relative to the γ-quantum direction. This was followed by investigations of the coincidence between the Kx and γ rays. It was assumed initially that the apparatus gives rise to errors, and much time was lost in ascertaining their cause. Various experiments, however, not only failed to disclose an error but, conversely, gave compatible results, thus demonstrating the existence of Kx-γ correlations.

The apparatus consists of a proportional counter, a movable scintillation counter, and analyzing and recording equipment. The construction of the proportional counter is somewhat similar to that described earlier [2], except that the fiducial volume absorbs quanta in the required solid angle. The body of the fiducial volume is made of thin aluminum foil, so that the counting rate from the movable γ detector is the same for all angles, even $\nu = 0$, when the γ rays pass through the Kx-ray detector. Only pulses from the peak of the Kx rays of the proportional counter and from the photopeak of the γ rays of the scintillation counter are selected for the coincidences, so that corrections for distance are small.

We measured the number of coincidences simultaneously with the counting rate in the channels at four angles: 0, $\pi/2$, $2\pi/3$, and π. From the experimental data we calculated the expansion coefficients of the correlation function

$$W(\nu) = \sum_g A_g P_g(\cos \nu).$$

The experimental data reduction and the calculations of the coefficients A_g were by the same procedure as described by Rose [3].

The isotope Mn^{54} has a "convenient" decay scheme: one 0.835-MeV line, sufficiently short intermediate-state lifetime 1.2×10^{-11} sec, and allowed transition. We obtained

$A_g = 0$ for $g > 2$. However, $A_1 \neq 0$, since the number of coincidences at 0 and 180° was nevertheless somewhat different for Mn^{54}.

Table

A_1	$\sigma(A_1)$	A_2	$\sigma(A_2)$	ϵ^2
-0.0022	0.0060	+0.0172	0.0075	0.504
-0.0035	0.0098	+0.0179	0.0132	0.716
+0.0014	0.0132	+0.0356	0.0161	0.532
+0.0007	0.0145	+0.0183	0.0165	1.41
-0.0073	0.0109	+0.0068	0.0126	3.29
+0.0004	0.0061	+0.0095	0.0072	1.21
-0.0012	0.0088	+0.0251	0.0114	0.830
-0.0091	0.0145	-0.0029	0.0228	2.83
+0.0013	0.0099	+0.0111	0.0110	1.04

The table lists the calculated coefficients A_g and their rms errors $\sigma(A_g)$ obtained in different series of measurements, each under different experimental conditions. We varied the arrangement of the counters, their types, the rotation of the source plane, the activity and state of the emitter (metal on a conducting layer, salt on a nonconducting film), the resolving time of the coincidence circuit, and the discriminator gaps.

Each coefficient was corrected for the angular resolution and the source dimensions; for scattering, and for background. We used the "ϵ^2 criterion" in accord with [3]. When ϵ^2 differs little from unity, this means that there is no systematic error.

The weighted mean of different measurement series gives a correlation function in the form

$$W(\nu) = 1 - (0{,}0016 \pm 0{,}0010) P_1(\cos\nu) + (0{,}0150 \pm 0{,}0027) P_2(\cos\nu).$$

It is strange that $A_1 \neq 0$. This holds only for the isotope Mn^{54}, since other investigated isotopes show no differences in the number of coincidences at 0 and 180°. Whereas this effect ($A_1 \neq 0$) can be attributed to a systematic error, in view of its smallness, the main effect ($A_2 \neq 0$) is quite noticeable and is confirmed by measurements with other isotopes. The coefficient A_2 can be either positive or negative, depending on the isotope, and $A_2 = 0$ in control experiments where isotropy should be observed.

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