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POLARIZATION OF COBALT AND IRON NUCLEI IN FERROMAGNETS

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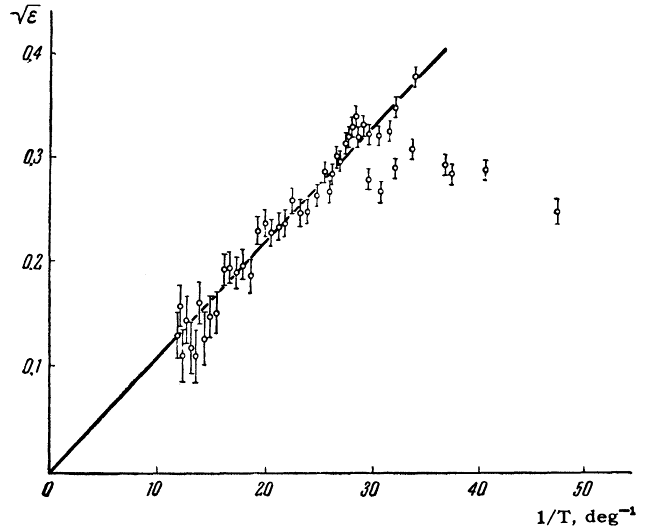
The anisotropy of gamma rays from Co^{60} in a magnetized cobalt-iron alloy (Permendur) was measured at temperatures from 0.03 to 0.1° K. The effective magnetic field strength $H = 2.5 \times 10^5$ gauss was obtained at the cobalt nucleus. No gamma-ray anisotropy was detected in similar experiments on Fe^{59} nuclei in Armco iron cooled down to 0.02° K.

A few years ago Khutsishvili suggested a procedure for polarizing nuclei in ferromagnets. In 1955 and 1956 he reported[1,2] the results of an experimental test of this procedure by Alekseevskiĭ, Shchegolev and Zavaritskiĭ,* who observed about 10 — 15% anisotropy of γ rays from Co^{60} at 0.05 — 0.08° K. Similar results were obtained at about the same time by the Kurti group at Oxford.[3] The present note concerns experiments on the polarization of Co^{60} and Fe^{59} nuclei in ferromagnetics.

A specimen of Permendur, a ferromagnetic polycrystalline alloy (50% Co and 50% Fe), of 3 mm diameter and 0.2 mm thickness, was irradiated by thermal neutrons in a reactor. After irradiation the specimen was vacuum annealed and soldered to the end of a copper "cold conductor;" it was then placed in a field of 1000 oersteds between the poles of a small permanent magnet in a cryostat. The specimen was then cooled to a temperature of a few hundredths of a degree by the adiabatic demagnetization of potassium chrome alum. The magnetic temperature was measured with an ac bridge at 60 cps.

γ rays from Co^{60} were registered by two scintillation counters with CsI crystals of 40 mm diameter and 40 mm thickness. The radioactivity of the specimens was 3 or 4 μcuries, which yielded more than 10,000 scintillation counts in 100 sec (at a single temperature). Several series of measurements were obtained with two specimens.

The most reliable experimental results are shown in the figure, where $\epsilon = 1 - N(0)/N(\pi/2)$ is the anisotropy, $N(0)$ is the count from the counter placed parallel to the magnetic field, $N(\pi/2)$ is the count perpendicular to the magnetic field and T is the absolute temperature of the salt. An insignificant correction for heating due to the absorption of beta particles was neglected. Values obtained for the anisotropy down to 0.04° K are well fitted by the straight line



$$\varepsilon = 1.2 \cdot 10^{-4} T^{-2}.$$

The deviation from this line at lower temperatures is associated, in our opinion, with the maximum of the nuclear specific heat of cobalt, which prevents cooling of the specimen to the temperature of the salt.

A comparison of our results with those in reference 4 shows that the field at a cobalt nucleus in the alloy lattice is close in value to the field at an ion in a pure cobalt crystal. In our case $H = 2.5 \times 10^5$ gauss, which corresponds to $A = 2.4 \times 10^{-2}$ °K for the hyperfine splitting factor. In reference 4 $H = 2.3 \times 10^5$ gauss and $A = 2.2 \times 10^{-2}$ °K.

The experiment on the polarization of Fe^{59} nuclei was similar to that performed with cobalt. The specimen of Armco iron was a disk 3 mm in diameter and 0.1 mm thick, which was annealed

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*The data obtained by N. V. Zavaritskiĭ are given in greater detail in reference 2.

after being irradiated in a reactor. The initial activity of the disk did not exceed 2 or 3 μcuries. The counters registered only gamma rays with 1290 kev (from the transition $3/2^- \xrightarrow{\gamma} 7/2^-$) emitted after $3/2^- \xrightarrow{\beta} 3/2^-$ beta decay.

In the temperature range from 0.02 or 0.03 to 1° K these experiments detected no difference between the gamma-ray counts parallel and perpendicular to the field, with better than 0.5% accuracy. This result disagrees with that given in reference 5. Assuming that the field of the electron shells at the Fe^{59} nucleus does not differ greatly from that at the cobalt nucleus, we can obtain an upper limit for the magnetic moment of the Fe^{59} nucleus. With $H = 2.5 \times 10^5$ gauss and $\epsilon \lesssim 0.5\%$ we obtain $\mu(Fe^{59}) \leq 1.5$ nuclear magnetons.

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