NUCLEAR POLARIZATION OF WEAKLY-MAGNETIC ELEMENTS INTRODUCED INTO A FERROMAGNET

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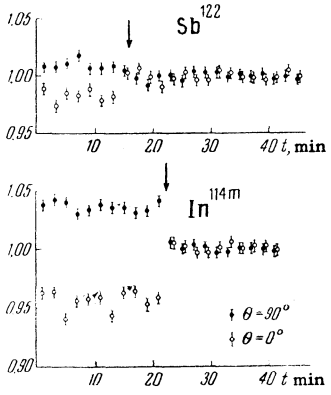
WE have already described[1] the polarization of Au^{198} nuclei in an Au-Fe alloy. In the present communication data are presented on the nuclear polarization of Sb^{122} and In^{114m} in weak solutions of antimony and indium in iron.

The apparatus for cooling the magnetized specimens differed from the previous one in that an electromagnet was used instead of a constant magnetic field. This magnet was placed inside the helium Dewar and enabled us to obtain in the specimen position a field of up to 2,000 oersteds which was 2 — 2.5 times larger than the field used in the experiments with Au^{198}. The error due to incomplete magnetization of the ferromagnetic specimen was thus reduced. Otherwise the method of cooling the specimen and measuring the γ-ray anisotropy were the same as in the experiments with Au^{198}.

A specimen of an Sb-Fe alloy (0.6% Sb by weight) was irradiated by thermal neutrons in a reactor. The activity of the Sb^{122} nuclei formed in the specimen amounted, at the time of the experiment, to about 4 μc. In the figure results are presented of one of the experiments to measure the anisotropy of the 566-kev γ rays ($2^+ \rightarrow 0^+$ transition) emitted after the β decay of Sb^{122} ($2^- \rightarrow 2^+$ transition). The experimental points show the variation with time after salt demagnetization, of the γ-ray counting rates at detectors disposed along ($\theta = 0°$) and across ($\theta = 90°$) the direction of the specimen magnetizing field. These rates were normalized to the counting rates after the specimen was heated up. In the interval from five minutes to fifteen minutes the temperature changed from 0.025 to 0.035° K. The specimen was heated by increasing the amplitude of the alternating magnetic field used to measure the magnetic temperature. The moment at which heat was applied is shown in the figure by an arrow. Assuming that ten minutes after demagnetization the specimen had taken up the temperature of the salt (0.03° K), we obtained for the value of γ-ray anisotropy at this temperature $\epsilon = 2.5\%$ ($\epsilon = 1 - N(0°)/N(90°)$), where $N(\theta)$ is the number of counts for the detector at angle θ. From this value of ϵ, using the formulae of Tolhoek and Cox,[2] we calculated the polarization f_1 of Sb^{122} nuclei and the effective magnetic field H_n at the antimony nucleus in the lattice of the alloy. It appeared that $f_1 \approx 25\%$ and $H_n \approx 1.9 \times 10^5$ oersted. For the calculations we took the magnetic moment of the Sb^{122} nucleus as equal to 1.9 nuclear magnetons.[3]



A specimen of In-Fe alloy (0.5% In by weight) was produced by alloying metallic indium — previously irradiated in a reactor — with iron. Shown in the figure are the results of one of the experiments to measure the anisotropy of the 192-kev γ rays from In^{114m} ($5^+ \rightarrow 1^+$ transition). Five minutes after demagnetization the temperature of the salt was ~ 0.035° K; heat was applied at a temperature of ~ 0.045° K. From the value of the anisotropy $\epsilon \approx 8\%$ at T = 0.04° K, it follows that the nuclear polarization f_1 at this temperature is ~ 30% and the effective magnetic field at the indium nuclei $H_n \approx 1.5 \times 10^5$ oersteds. For the calculations the magnetic moment of the In^{114m} nucleus was taken to be equal to 4.7 nuclear magnetons.[3]

We made an attempt to find the polarization of Cr^{51} nuclei in a Cr-Fe alloy. Measurements in the temperature range 0.03 — 1° K of the anisotropy of the 320-kev γ rays ($5/2^- \rightarrow 7/2^-$ transition) emitted by Cr^{51} after K capture ($7/2^- \rightarrow 5/2^-$ transition) gave a negative result with an accuracy of not less than 0.5%. This result could be simply due to the magnetic moment of the Cr^{51} nucleus — which, unfortunately, is unknown — being too small.

The error in the values obtained for the magnetic field at the Sb and In nuclei in alloys of these elements with iron amounts to $^{+50}_{-20}$ %.

These errors were determined by the statistics of quanta-counting, and by the inaccuracy of determining the specimen temperature* — also, for Sb^{122}, by the absence of data on the characteristics of β decay and, for In^{114m}, by incomplete separation of the 192-kev γ rays from harder scattered

γ rays. The latter strongly interfered with the counts at the detector disposed in the direction of the field, since in this case part of the detector was screened by the pole of the magnet. Apparently, one can thus explain the fact that the ratio of the change in counts along the field to the change in counts across the field was not equal to two (see figure). The accuracy of the results presented will be increased in further experiments.

In our previous communication[1] we thought that the presence of an intrinsic magnetic moment at the gold atoms was needed to form the strong magnetic field at the Au^{198} nuclei in the Au-Fe alloy. However, it now appears highly probable that a large (or basic) contribution to this field arises in the conduction electrons. This possibility was first pointed out to us by E. K. Zavoĭskiĭ. Recently Marshall[4] proposed a mechanism for the creation of a "contact" field at the nucleus of a ferromagnetic atom. Apparently this mechanism also applies in our case, with the difference that the conduction electrons are polarized close to the neighboring atoms of iron and pass to the impurity atoms without change of orientation. Unfortunately, existing calculations of the magnetic field created by the conduction electrons in a ferromagnet are still only estimates. We hope to obtain more definite data on the origin of this field in further experiments (in particular by the study of the magnetic field at In and Au nuclei in In-Ni and Au-Ni alloys).

From the results we have obtained it would seem that the method of polarizing nuclei of weakly-magnetic atoms by introducing them into ferromagnets is of general applicability and allows a relatively high degree of polarization to be obtained.

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*The errors in temperature determination are associated both with the inaccuracy of measuring the thermodynamic temperature of the salt itself and with the difference in the temperatures of salt and specimen (due to the short time elapsing after the demagnetization of the salt).

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395

LIFETIMES OF THE FIRST EXCITED STATES OF Rb^{85} *AND* Pr^{141}

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We have measured the lifetimes of the 150-kev level of Rb^{85} and of the 142-kev level of Pr^{141} by the method of delayed β-γ coincidences. The apparatus consisted of two scintillation counters with diphenyl acetylene crystals and FEU-33 photomultipliers and of a coincidence circuit with a resolving time of $2\tau_0 = 4.5 \times 10^{-9}$ sec. It was possible to insert calibrated sections of 200-ohm coaxial cable as delay lines into either channel.

As sources we used Kr^{85} and Ce^{141}, produced by exposure of natural krypton and cerium in a reactor. The gaseous radioactive krypton was contained at an absolute pressure of 3 atmos in a brass cylinder, 15 mm in length and diameter. The faces of the cylinder, through which the electrons and γ rays escaped, were covered with a 1 mg/cm^2 nylon film. The cerium source was a thin layer of cerium oxide powder mounted on aluminum foil.

The number $N_{\beta\gamma}$ of β-γ coincidences is related to the delay t in the channel of the β