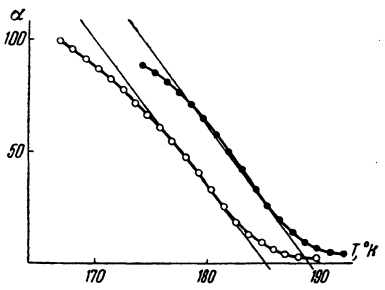
mining the Curie temperature in a ferromagnet with sufficient accuracy. In the present investigation, aiming to obtain preliminary data on the shifts of the Curie points, we investigated the temperature variation of the residual magnetism of samples of uranium hydride and deuteride. It is known that as the Curie point (close to 180° for the compounds of interest to us) is approached from the low-temperature side, the residual magnetism experiences a rapid decrease, linear over a sufficiently wide temperature interval. The intercept of the magnetization vs. temperature curve with the temperature axis can be assumed to be the Curie temperature of the specimen only in the first approximation. However, the difference in the so obtained "extrapolated" temperatures of the two specimens is apparently equal, with sufficient accuracy, to the true difference of the Curie temperatures of these specimens.

The residual magnetism of the specimens was measured with an astatic magnetometer. The temperatures of the specimens were determined in the various experiments either with a copper-constantan thermocouple, or with a platinum resistance thermometer. Approximately 20 specimens of uranium hydride and deuteride were prepared. The impurities in the initial uranium fluctuated from 0.4 to 0.12 percent. All the hydride and deuteride specimens were obtained through a direct reaction between the uranium and hydrogen or deuterium at approximately 250°C. The hydrogen and deuterium were produced by decomposition of a suitable amount of uranium hydride or deuteride at a temperature near 400°C.

In all the specimens investigated, an isotopic shift of the Curie temperature was observed in going from the hydride to the deuteride. This shift is practically independent of the purity of the initial uranium and consequently is not due to chemical impurities. Typical curves of the temperature dependence of the residual magnetism J_R of the hydride and deuteride samples are shown in the figure. It is seen from these curves that the difference in the Curie temperatures of uranium hydride and deuteride is 4°. The average error, obtained in the measurement of 10 pairs of specimens, is 0.5°. The Curie-temperature shift $\Delta\Theta$ in going from the hydride to the deuteride of uranium is thus

$$\Theta_{UH_3} - \Theta_{UD_3} = \Delta\Theta = +(4.0 \pm 0.5)^\circ K.$$

The method described is not suitable for the determination of the absolute Curie temperature. The Curie temperature obtained by the extrapolation method depends on the magnetic "prior history" of the specimen. In our experiments, residual



● – UH_3, ○ – UD_3; α – magnetometer deflection, proportional to the residual magnetism of the specimen, J_R.

magnetism was produced by slowly cooling (for one hour) the specimens, placed in a magnetic field of approximately 200 oersteds, from room temperature to that of liquid nitrogen, after which the magnetic field was turned off and the specimen remained magnetized. The value of the residual magnetism depends, naturally, on the intensity of the magnetic field in which the specimen is cooled and on the lowest cooling temperature.

The extrapolated Curie point, obtained from the residual magnetism vs. temperature curve for the given specimen, remained constant within 0.1 or 0.2° under considerable variations of the external conditions (magnetizing field and temperature).

We are planning an investigation of the absolute value of the Curie temperature of uranium hydride and deuteride.

In conclusion, we thank Academician I. K. Kikoin for suggesting the problem and for great help in the investigation.

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MAGNETOCALORIC EFFECT IN URANIUM HYDRIDE AND DEUTERIDE

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THE investigation of the magnetic properties of the ferromagnets uranium hydride and uranium deuteride is of great interest, because it discloses

how replacement of one element by its isotope affects the properties of the ferromagnet. It was shown, in particular,[1] that uranium hydride had a Curie temperature noticeably different from that of the deuteride (by approximately 4°).

Henry[2] has shown that even the saturation magnetizations of uranium hydride and deuteride are different. His value of the Curie temperature of uranium hydride (168°K) differs substantially from the value given by Lin and Kaufman (181°K).[3]

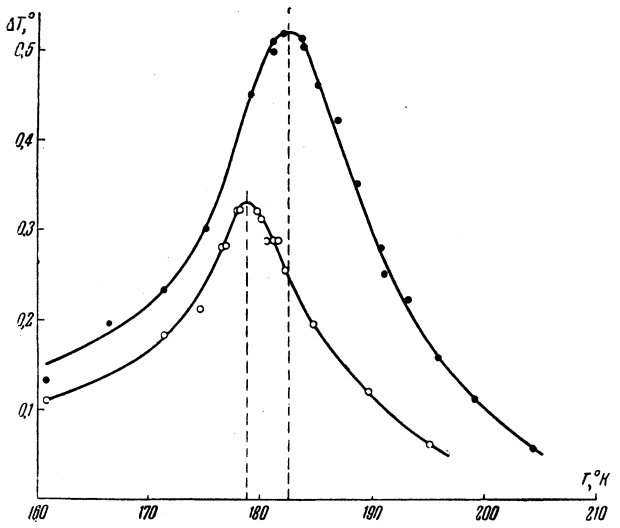
The procedure used in reference 1 made it possible to observe only the shift in the Curie temperature in going from the hydride to the deuteride of uranium; the absolute values of the Curie temperatures were determined in these experiments quite roughly.

One of the most reliable methods of determining the Curie temperature is to investigate the temperature dependence of the magnetocaloric effect, in which the temperature of a body is changed by adiabatic magnetization. This temperature change is equal to where J is the magnetization of the specimen, T the temperature, C_H the heat capacity, and H the intensity of the magnetic field. Since $(dJ/dT)_H$ of ferromagnetic bodies has its maximum at the Curie point, the temperature variation at this point has a clearly pronounced maximum, which permits an accurate determination of the Curie temperature.

$$dT = -\frac{T}{C_H}\left(\frac{dJ}{dT}\right)_H dH,$$

An investigation of the magnetocaloric effect has additional interest in that its value, together with the temperature dependence of the magnetization, permits a determination of the constant of the molecular field of the investigated ferromagnet.

Uranium hydride, like uranium deuteride, is obtainable only in finely-powdered form. A method was therefore developed of measuring the magnetocaloric effect in powdered specimens. To check this method, we measured the magnetocaloric effect in ferromagnetic chromium-tellurium (CrTe) and manganese-antimony (MnSb) alloys. The data obtained were found to agree well with measurements made by others on monolithic samples of these substances. We compared our results with the data of Weiss and Forrer[4] for nickel, with the data of A. K. Kikoin[5] for CrTe, and with the data of O. A. Shakalis (private communication) for MnSb. The method of obtaining specimens of uranium hydride and deuteride was analogous to that described in references 1, 3, and 6. The amount of impurities in the initial uranium did not exceed 0.12%. The magnetocaloric effect was measured



●–UH_3, ○–UD_3

at various values of magnetic field intensity, up to 17,000 oersteds.

The diagram shows curves for the dependence of the magnetocaloric effect on the temperature, plotted in a magnetic field of 17,000 oersteds. The maxima of the curves correspond to the ferromagnetic Curie temperatures $\Theta_{UH_3} = 182.0°K$ and $\Theta_{UD_3} = 178.4°K$. The difference in the Curie temperatures, $\Delta\Theta = 3.6 \pm 0.4°$, is in good agreement with the results of reference 1. The absolute Curie temperature for uranium hydride is nearly the same as obtained by Lin and Kaufman,[3] but differs considerably from the value of 168°K given by Henry for uranium hydride,[2] a value that must be considered erroneous.

It follows from the curves that uranium hydride and deuteride have not only different Curie temperatures, but also different magnetocaloric effects. In particular, the maximum temperature change ΔT_m in adiabatic magnetization (at the Curie point) is 1.6 times greater in uranium hydride than in deuteride.

Whether this difference in the magnetocaloric effects is due only to the difference in the saturation magnetisms of these compounds[2] or partly to the difference in the molecular-field constants can be ascertained only by detailed magnetic investigations, which are now in progress. In any case, the measurements of the magnetocaloric effect make it possible to determine the magnitude of the spontaneous magnetization for these new ferromagnetic substances.

A. G. Orlov, a student at the Moscow Engineering-Physics Institute, participated in the preliminary experiments on the magnetocaloric effect.

In conclusion, I thank the supervisor of this project, Academician I. K. Kikoin, for continuous inter-

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POLARIZATION OF THE μ^+ MESON CURRENT AT SEA LEVEL

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THE violation of the law of parity conservation in weak interactions is known to lead to the longitudinal polarization of the μ meson in the $\pi \to \mu$ decay in the center-of-mass system. The μ mesons observed at sea level are produced in the decay of π mesons in flight. A current of μ mesons with energy E_μ is generated by π mesons in a certain energy interval ΔE_π. Since the energy spectrum of the π mesons in the atmosphere decreases fast with the energy ($\sim E^{1-\gamma_\pi}$), there will be an excess of μ mesons flying, in the center-of-mass system, into the forward hemisphere relative to the direction of motion of the π mesons, i.e., the μ-meson current will be polarized. The degree of polarization of the the μ mesons was theoretically determined by Gol'dman (reference 1).* It is given by the expression

$$\eta = \frac{1}{v} - \frac{\gamma}{\gamma - 1}\frac{1-v}{v}\left[1 - \left(\frac{1-v}{1+v}\right)^{\cdot}\right] \Big/ \left[1 - \left(\frac{1-v}{1+v}\right)^{\gamma}\right], \quad (1)$$

where v is the velocity of the μ meson in the center-of-mass system, measured in units of c; γ is a parameter characterizing the energy spectrum of the particles which generate the μ mesons. It was further shown[1,2] that the depolarization due to scattering of the μ meson before it comes to rest is negligibly small. The polarization of the μ mesons can be determined by studying the asymmetry in the electron emission in the $\mu \to e$ decay.

In the two-component theory of the neutrino, this asymmetry is determined by the formula of Lee, Yang, and Landau:

$$W(\varepsilon, \theta)\, d\varepsilon\, d\Omega = \frac{\varepsilon^2}{2\pi}[(3 - 2\varepsilon) + \xi\eta(2\varepsilon - 1)\cos\theta]\, d\varepsilon\, d\Omega, \quad (2)$$

where ϵ is the energy of the positron in units of the maximal energy, ξ is a theoretical parameter which is close to unity and depends on the coupling constants, η is the degree of polarization, and θ is the angle between the polarization vector of the μ meson and the direction of emission of the electron.

The present note is devoted to the experimental determination of the degree of polarization of the cosmic μ^+ mesons at sea level. The measured quantity is the relative yield of decay positrons emitted into the upper hemisphere in the decay of the μ^+ meson as it comes to rest. The $\mu \to e$ decays were observed in a large rectangular Wilson chamber containing 9 copper plates each 4 mm thick. The presence of 550 g/cm^2 of material on top of the chamber determined the momentum of the μ mesons decaying in the chamber as $p_\mu \gtrsim 1.2$ Bev/c. In total, 202 meson decays were observed. In 122 events the positron was emitted into the upper hemisphere and in 80 events, into the lower hemisphere. The relative number of decays in which the positron was emitted into the upper hemisphere is thus $\beta_{Cu} = 0.604 \pm 0.034$,† which corresponds to a degree of polarization $\eta = 0.98^{+0.02}_{-0.32}$. To ascertain that no coarse systematic errors were incurred which might lead to an asymmetry, a control experiment was run in which the copper plates in the chamber were replaced by iron plates, which were so magnetized in the horizontal direction as to depolarize the μ mesons completely. In this experiment the relative number of decays with the positron emitted into the upper hemisphere was $\beta_{Fe} = 0.516 \pm 0.052$, which is in good agreement with an isotropic distribution $\beta = 0.5$.

Theoretical calculations[1] of the degree of polarization of the μ mesons produced by π mesons give the value $\eta = 0.3$. The experimental result is therefore not in agreement with the theoretical value. It also contradicts the experimental value $\eta = 0.19 \pm 0.06$ of Clark and Hersil.[4]