# THE MAGNETIC PROPERTIES OF URANIUM TELLURIDES

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The magnetic properties of the tellurides UTe, $U_3Te_4$, $U_2Te_3$, $UTe_2$, and $uTe_3$ are investigated at temperatures between 77 and 600°K and at various magnetic field strengths. The magnetic transformation temperatures are determined for the compounds UTe, $U_3Te_4$, and $U_2Te_3$, and are respectively 103, 105, and 122°K. It is also found that in $UTe_2$ and $UTe_3$ the paramagnetic Curie point is negative.

At the present time there is extremely little research being done on the magnetic properties of the alloys and compounds of the metals of the actinide group.[1-3] Meanwhile, by studying the magnetic properties of these substances, it is possible to obtain new information on the participation of f electrons and conduction electrons in the exchange interaction mechanism and on the role of the conduction electrons in building the magnetic properties. In this connection, it is of particular interest to study the compounds of uranium, which has variable valence. According to[1], it is possible to have ferro- and antiferromagnetism in these compounds.

This paper concerns the study of the magnetic properties of uranium tellurides, namely the compounds UTe, $U_3Te_4$, $U_2Te_3$, $UTe_2$, and $UTe_3$, in the temperature interval 77—600°K at various values of the magnetic field intensity (up to 14 kOe).

These compounds were synthesized from the powdered metals uranium and tellurium of 99.9% purity. Before the synthesis, we studied the magnetic properties of the uranium and tellurium powders themselves. The atomic magnetic susceptibility of Te was found to be $\chi_A = -41 \times 10^{-6}$. The measurements on uranium showed that its susceptibility depended weakly on temperature in the range from 80 to 293°K. These results agree well with the data of other authors.[4,5] Before synthesis, the uranium powder was treated with dilute nitric acid, then washed with distilled water, methyl alcohol, and ether. The synthesis was effected in a corundum crucible, which was placed in a quartz ampule evacuated to $10^{-5}$ mm Hg, at 800°C for 48 hr. After this the powder was carefully ground, remixed, and again maintained in the oven under the same conditions. The magnetic susceptibility was measured with a pendulum balance.

Figure 1 shows the dependence of the specific magnetization $\sigma$ on temperature at various values of the magnetic field for the compound $U_3Te_4$. As can be seen from the figure, the specific magnetization in curves 5, 6, 7, and 8 has a maximum near 100°K. Below this temperature the magnetization at first falls sharply and then begins to rise again. At temperatures above 100°K, the magnetization monotonically decreases with increasing temperature. In the small-field region (500 to 1000 Oe) a maximum is not observed in $\sigma(T)$. As the magnetic field is increased, the maximum

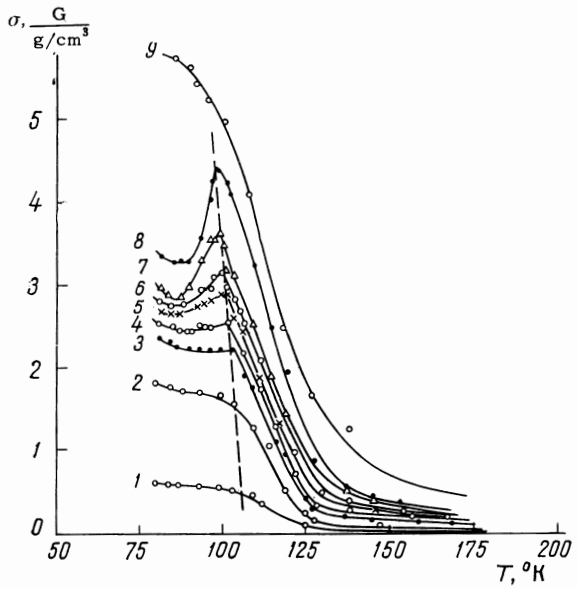


FIG. 1. Temperature dependence of the specific magnetization of $U_3Te_4$ at different fields: curve 1—500 Oe, 2—1000 Oe, 3—2000 Oe, 4—3000 Oe, 5—4000 Oe, 6—5000 Oe, 7—5900 Oe, 8—7000 Oe, 9— 14,000 Oe.

grows markedly and is sharpest at 7 kOe. At higher fields (14 kOe) it disappears (curve 9). As the magnetic field is increased, the maximum in $\sigma(T)$ characteristically shifts toward lower temperatures, just as in rare-earth ferromagnets. For $U_3Te_4$ at H = 2000 Oe, $\sigma_{max}$ is at 103°K, and for H = 7000 Oe it is at 97°K. A similar dependence of $\sigma$ on T is also observed in UTe. However, in the latter case the disappearance of the maximum in $\sigma(T)$ is not observed even at 14 kOe.

As is known, similar features are present in many rare-earth metals, which have a complex magnetic structure. It may be assumed that complex magnetic structures likewise exist in the compounds UTe and $U_3Te_4$. However, one cannot overlook the possibility that in these compounds the observed maxima are evoked by other sources, e.g., by a change in magnetic and magnetoelastic anisotropy energy.

Figures 2 and 3 give the data obtained in a study of the magnetic properties of $U_2Te_3$. It can be seen that this compound shows strongly expressed ferromagnetic properties. The magnetization curves (Fig. 2) measured up to 120°K have a nonlinear shape in magnetic fields up to 1 kOe, reaching saturation after that. At higher temperatures the dependence is linear. From these curves of $\sigma(H)$ was determined the magnitude of the

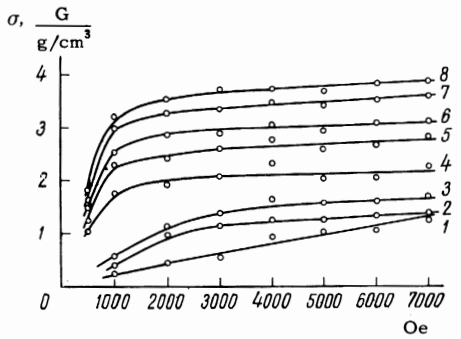


FIG. 2. Isotherms of the specific magnetization of $U_2Te_3$: curve 1–123°K, 2–121°K, 3–119°K, 4–114°K, 5–109°K, 6–103°K, 7–93°K, 8–84°K.

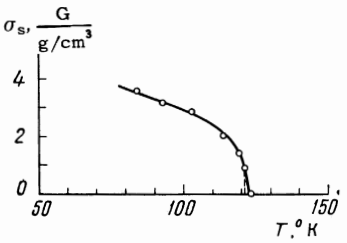


FIG. 3. Temperature dependence of the spontaneous specific magnetization of $U_2Te_3$.

magnetization $\sigma_S$, the temperature dependence of which is shown in Fig. 3. The temperature dependence of $\sigma_S$ determined at H = 0 has the same form as in the ordinary ferromagnetic substances of the iron group. The magnitude of $\sigma_S$ goes to zero at 122°K, the ferromagnetic Curie point of $U_2Te_3$.

The compounds considered above, as well as the compounds $UTe_2$ and $UTe_3$, were studied in the paramagnetic region. The magnetic susceptibility of all of them follows the Curie-Weiss law. The effective atomic magnetic moment calculated from the experimental data decreases from 3.16 $\mu_B$ for $UTe_3$ to 2.36 $\mu_B$ for UTe. This decrease, obviously, may arise from the fact that the valence of uranium in these compounds varies with the number of f electrons. It should be remembered that the electrical resistance of the uranium tellurides also depends strongly on composition, increasing from UTe, which has a conductivity of $1.3 \times 10^{-3}$ ohm-cm, to $UTe_2$, which has a conductivity of $1.2 \times 10^{-2}$ ohm-cm. The paramagnetic Curie temperature $\Theta_p$ is negative for $UTe_3$ and $UTe_2$ and is respectively −56 and −78°K. It is possible that these compounds are antiferromagnetic below nitrogen temperatures. The ferromagnetic compound $U_2Te_3$ has $\Theta_p$ = 123°K and $\Theta_f$ = 122°K, i.e., this compound has practically no transition region in its ferromagnetic transformation.

Thus, the results of this investigation show that the uranium tellurides display both ferro- and antiferromagnetic properties, depending sharply on the stoichiometric composition of the compound. Evidently, not only the f electrons but also the conduction electrons play a role in the formation of the magnetic structures.

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