MAGNETOSTRICTION OF THULIUM ORTHOFERRITE SINGLE CRYSTALS IN THE REGION OF THE TEMPERATURE OF REORIENTATION OF THE "WEAK" FERROMAGNETIC MOMENT

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The weak ferromagnetism of thulium orthoferrite is due to the non-collinear arrangement of the iron-sublattice spins. When the temperature is raised to 92°K, a reorientation of the weak ferromagnetic moment of this compound, from the c to the a axis of the rhombic crystal, is observed [1,2]. Reorientation of the magnetic moment and accordingly of the antiferromagnetism vector should be accompanied, in connection with the change of the magnetic symmetry of the crystal, by a spontaneous deformation of the lattice. Since an external magnetic field directed along the antiferromagnetism axis is capable of shifting the reorientation temperature, causing "flipping" of the iron sublattices of the orthoferrites [3], it is obvious that the occurrence of magnetostriction deformations in the crystal can be observed following superposition of a sufficiently strong field.

Measurements of the magnetostriction of single-crystal thulium orthoferrite by means of strain gauges near the reorientation temperature, in fields up to ~13 kOe, have shown that when the field is applied along the c axis, which is the antiferromagnetism axis below the transition temperature, positive magnetostriction of appreciable magnitude occurs in the interval from 93 to 67°K (Fig. 1). In fields up to 13 kOe the magnetostriction first increases with increasing departure from the reorientation temperature, reaching a maximum at 78°K

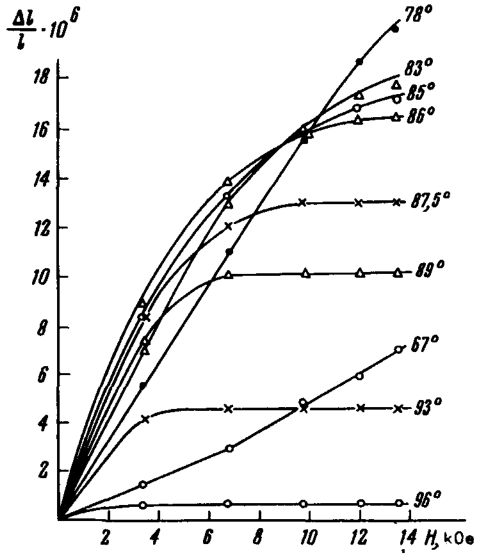

Fig. 1. Longitudinal magnetostriction vs. the field applied along the c axis of single-crystal thulium orthoferrite at various temperatures.

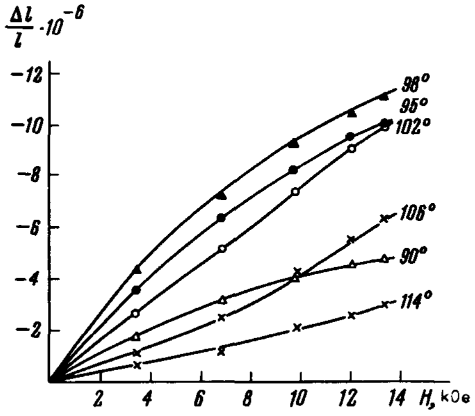

Fig. 2. Magnetostriction stresses along the c axis vs. the field applied along the a axis of the thulium-orthoferrite single crystal above the reorientation temperature.

($\Delta l/l \sim 20 \times 10^{-6}$), and then decreases. This, obviously, is connected with the fact that the threshold fields increase rapidly with increasing departure from the reorientation temperature [3], and the threshold field exceeds 13 kOe below 78°K. Above the transition temperature, magnetostriction is observed only when the field is directed along the a axis, which is the antiferromagnetism axis at these temperatures. We have measured the magnetostriction deformation produced along the c axis when a field is applied along the a axis of the crystal in the temperature interval from 90 to 114°K (Fig. 2). The sign of the magnetostriction is different for fields applied along the c and a axes of the crystal, for in the former case the field lowers the magnetic-moment reorientation temperature, and in the latter it raises it. As seen from Fig. 2, the magnetostriction decreases at temperatures above 100°K. This, obviously, is connected with the already mentioned fact that the threshold fields increase noticeably with increasing departure from the reorientation temperature, and exceed the fields in which our measurements were made.

The relatively low threshold fields (~10 kOe) in the temperature interval ~70 - 100°K are connected with the fact that the spontaneous magnetic moment can be readily rotated by the field from the c axis to the a axis of the crystal, owing to the low values of the anisotropy constant, as was demonstrated by us in measurements of the rotating moments, in accord with the work of Kuroda et al. [2]

When a magnetic field is applied along the b axis of the crystal, no magnetostriction is observed in the entire investigated temperature range, since the b axis is perpendicular to the plane containing the antiferromagnetism vector, and consequently the field cannot cause "flipping" of the iron sublattices and lead to magnetostriction deformation in the crystal.

It must be noted that it is easy to determine the threshold field from the magnetostriction vs. field curves. This is particularly important in those cases when it is impossible to determine the threshold field from the "jump" in the magnetization curves during the instant of "flipping" of the antiferromagnetic sublattices. For thulium orthoferrite, a difficulty of this kind arises as a result of the large paramagnetic susceptibility of the thulium ions, against the background of which the "jump" in the magnetization is practically unnoticeable.

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