E. I. Golovenchits, V. A. Sanina, and G. A. Smolenskiĭ. *Electric-dipolar glass in crystals with Jahn-Teller ions.* Rare-earth ions in crystals have, as a rule, low-lying excited states, whose population can change substantially when the temperature of the crystal is changed. In the case of crystals containing Jahn-Teller rare-earth ions, whose local environment in the lattice becomes distorted as the electronic state of the ions changes, it may be expected that the dielectric properties of the crystal will change when the excited states of the ions are populated as the temperature is increased. In this respect, compounds with Eu^{3+} ions are especially interesting. The ground state of Eu^{3+} ions is nondegenerate ($^7F_0$) and the lowest excited state ($^7F_1$) is degenerate (Jahn-Teller). The magnitude of the splitting of the single-ion $^7F_0$–$^7F_1$ states is ~ 300 cm^{-1}, so that the changes in the dielectric properties owing to the change in the population of the $^7F_1$

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level can be observed in a convenient temperature range. The marked difference between the properties of an ion in the $^7F_0$ and $^7F_1$ states suggests that the expected changes in the dielectric properties will be large.

The dielectric properties—the real (ε') and imaginary (ε'') parts of the dielectric constant for frequencies in the range 30 Hz–20 kHz and temperatures in the range 100–500 K were studied experimentally in this work. A sharp increase in ε' together with a maximum in ε'' were observed at temperatures close to room temperature in $EuCrO_3$. Low-frequency dispersion of the dielectric properties was observed: the higher the frequency, the higher the temperature at which the anomalies in ε were observed. The logarithmic dependences $\ln\varepsilon'(T^{-1})$ indicate that the anomalies in ε have a thermal activation character. In the temperature range from 100 K to a temperature T_1 whose value depends on the frequency ε' is proportional to the concentration of thermally excited Eu^{3+} ions in the $^7F_1$ state, which is indicated by the linear dependence of $\ln\varepsilon'(T^{-1})$ with an activation barrier of 300 cm^{-1}, which agrees with the value of the energy gap up to the $^7F_1$ level of Eu^{3+} ions. At $T \approx T_1$ a sharp change occurs in the slope of the dependence $\ln\varepsilon' T^{-1}$. The energy barrier in this case turns out to be of the order of 10^4 K. This rapid growth in ε' continues up to a temperature of $T \approx T_2$, whose value also depends on the frequency. The temperature interval T_1–$T_2 \sim 40$ K. The rapid growth in ε' stops when $T > T_2$. At the same temperature a maximum is observed in ε''. The state of the crystal for $T > T_2$ is characterized by a wide collection of relaxation times, which is characteristic for a state of the spin-glass type.

We assume that the experimentally observed anomalies are caused by the thermal population of excited $^7F_1$ states of Eu^{3+} ions. When the Eu^{3+} ion is excited into the Jahn-Teller state $^7F_1$, the local environment of the ion in the lattice is distorted, which with a noncentral position of the Eu^{3+} (Cs) ion leads to the formation of an electric dipole. At $T \approx T_1$, when the concentration of thermally excited Eu^{3+} ions—electric dipoles—reaches 20–25%, the interaction between the electric dipoles causes the formation of clusters within which the electric dipoles are ordered. At the same time the polarizability of the crystal changes markedly and low-frequency dielectric losses appear. In the temperature interval T_1–T_2 the number of thermally excited clusters increases. At $T \approx T_2$ correlations appear between clusters and a state of the dipolar-glass type is established in the entire crystal as a whole.

A photoinduced magnetic phase transition was observed previously at low temperatures in the same crystal. The $^7F_1$ state of the Eu^{3+} ions was populated with the help of intense optical pumping. At the same time, the nonmagnetic (prior to pumping) subsystem of Eu^{3+} ($^7F_1$) ions became magnetic and acquired an antiferromagnetic ordering. Magnetic ordering was observed after pumping during an experimental investigation of the antiferromagnetic resonance and of the magnetization of the crystal before and after pumping.

Subsequent dielectric and optical studies at low temperatures after the photoinduced phase transition showed that antiferromagnetic and antiferroelectric ordering coexist in the crystal after pumping, i.e., the photoinduced transition proceeds into the ferroelectric-magnetic state.

In $EuCrO_3$ the exchange interaction between the Eu^{3+} ($^7F_1$) ions is stronger after pumping than the electric-dipole interaction (the corresponding ordering temperatures are 140 and 80 K) because of the polarization f-d-f exchange, so that the initial small metastable clusters—nuclei of the new phase accompanying optical pumping—are apparently formed as a result of the exchange interaction. The electric-dipole interaction, however, is significant in quite large clusters and leads ultimately to the electric-dipolar orderings of the entire crystal. The articles in which the basic results of the work were published are cited in the list of references.

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