decreased by unity occur in this case in the 1.1-μ region, since the vibrational quantum in the lower state is equal to 725 cm^{-1} [1]. Recognizing that the vibrational quantum in the upper state should be somewhat smaller, the appearance in the emission spectrum of several lines belonging to the series $v + 1 \rightarrow v$ becomes understandable.

It should be noted in conclusion that in spite of the fact that the photodissociation of COS (1) results mainly in sulfur atoms in the excited $^1D_2$ states, no inversion via the most probable transition $^1D_2 \rightarrow {}^3P_2$ ($\lambda = 1.08$ μ) takes place. This is seen from the reaction rate constants given above. The $S(^1D_2)$ state is annihilated at a rate higher than the annihilation rate of $S(^3P_2)$, but the rates of population of these states differ insignificantly.

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NATURE OF MAGNETOSTRICTION OF DYSPROSIUM AND OF ITS ALLOYS WITH GADOLINIUM

R.Z. Levitin, Yu.F. Popov, O.D. Chistyakov, and V.L. Yakovenko
Moscow State University

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Recent investigations have shown that the magnetostriction of heavy rare-earth metals (HREM) (with the exception of gadolinium) are quite high, on the order of $10^{-3} - 10^{-2}$ (cf., e.g., the review [1]). The nature of so large of a magnetostriction of the HREM, however, has not yet been explained. The most detailed studies were those of the magnetostriction deformations due to rotation of the magnetization vector in the basal plane of a hexagonal crystal [2 - 4], and it was shown that the temperature dependence of these magnetostriction deformations are in satisfactory agreement with the value calculated theoretically for the model of one-ion anisotropy. Such an agreement, however, can not serve as proof of the one-ion nature of the magnetostriction. As shown in [5], the exchange interaction of the 4f electrons of HREM via the conduction electrons leads to the appearance of anisotropic interactions that depend on the state of only one ion, and therefore the magnetic anisotropy due to such an interaction should have a temperature dependence analogous to the dependence of the one-ion anisotropy. This conclusion can apparently be extended also to magnetostriction, since the anisotropic magnetoelastic interaction can be regarded as the deformation-dependent part of the magnetic-anisotropy energy.

To explain the nature of the magnetostriction of HREM, we measured the magnetostriction of dysprosium-gadolinium alloys. If the magnetoelastic interaction in HREM is of the one-ion type, then its value in the alloy can be regarded as the additive sum of the magnetoelastic interactions of the individual atoms, and the magnetostriction constants should depend in this case linearly on the concentrations of the alloy components. On the other hand, if the magnetoelastic interaction is of the exchange type, then it depends on the number of pairs of interacting atoms, and consequently the magnetostriction constants should

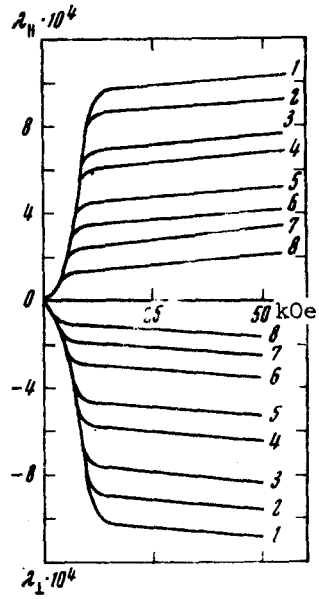

Fig. 1

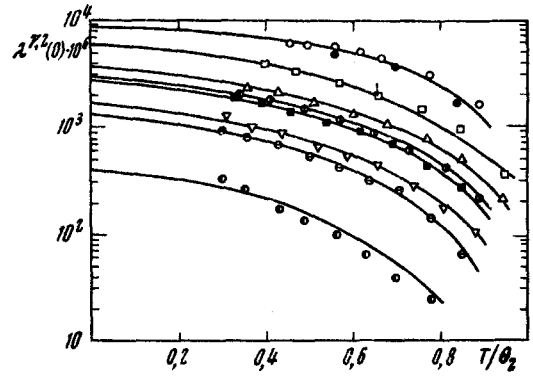

Fig. 2

Fig. 1. Isotherms of longitudinal and transverse magnetostriction in the basal plane of the alloy $Dy_{0.296}Gd_{0.704}$ at 85°K (1), 100°K (2), 120°K (3), 140°K (4), 160°K (5), 180°K (6), 200°K (7), and 220°K (8).

Fig. 2. Temperature dependence of the magnetostriction constants $\lambda^{\gamma,2}$ of Dy_xGd_{1-x} alloys. Experimental points: ◐) x = 0.046, ⊖) x = 0.103, ▽) x = 0.183, ■) x = 0.296, ●) x = 0.378, △) x = 0.49, □) x = 0.7, ○) x = 1.0, ●) x = 1.0 from [2]. Continuous curves - theoretical results for the one-ion magnetostriction model (formula (3)).

vary quadratically with changing component concentration[1].

The interpretation of the results obtained for the alloys with gadolinium is much easier, since their magnetostriction is much lower than that of other HREM, and the influence of the gadolinium on the magnetostriction of the alloy can be neglected.

The magnetostriction of the alloys Dy_xGd_{1-x} ($0.046 \leq x \leq 1.0$) was measured in single-crystal samples in the form of spheres of 2.5 - 3 mm diameter in the temperature interval 78 - 300°K using an external piezoelectric pickup [6] in pulsed magnetic fields. We measured the longitudinal magnetostriction in the basal plane, and also the transverse magnetostriction in the basal plane, and in the measurement of the latter the field was also oriented in the basal plane.

Figure 1 shows the isotherms of the longitudinal and transverse magnetostrictions of an alloy with x = 0.296 at different temperatures. Similar $\lambda(H)$ plots are observed also for the other alloys. We have observed that the saturation magnetostriction λ_s (which was determined by linearly extrapolating the $\lambda(H)$ curve from the strong-field to the zero-field region) is affected by the prior history of the sample. This is connected with the dependence of the magnetostriction on the domain structure in the demagnetized state. To obtain

[1] The nature of the magnetostriction in rare-earth iron garnets was determined in a similar manner [9].

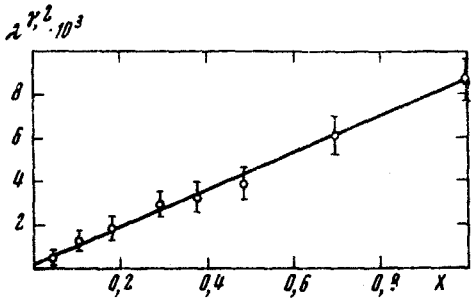

Fig. 3. The magnetostriction constant $\lambda^{\gamma,2}(0)$ vs. the composition of the dysprosium-gadolinium alloys: 0) our data; o) data of [2].

comparable results, the sample was demagnetized prior to each measurement by heating it above the magnetic-ordering temperature θ_2.

Our measurements of the magnetostriction make it possible to determine the magnetostriction constant $\lambda^{\gamma,2}$, which characterizes the deformation of the basal plane of a hexagonal crystal upon rotation of the magnetization vector in this plane. It follows from the general formula for the magnetostriction of a hexagonal crystal [7] that

$$\lambda^{\gamma,2} = (\lambda^{\parallel}_{bp})_s - (\lambda^{\perp}_{bp})_s, \qquad (1)$$

where $(\lambda^{\parallel}_{bp})_s$ and $(\lambda^{\perp}_{bp})_s$ are the longitudinal and transverse saturation magnetostrictions in the basal plane.

Figure 2 shows plots of the magnetostriction constants $\lambda^{\gamma,2}$ of dysprosium-gadolinium alloys against the relative temperature T/θ_2. The same figure shows plots of $\lambda^{\gamma,2}(T)$ based on the formula

$$\lambda^{\gamma,2} = \lambda^{\gamma,2}(0)\hat{I}_{5/2}\left\{L^{-1}[m(T)]\right\}. \qquad (2)$$

for the one-ion magnetostriction model [7]. $\lambda^{\gamma,2}(0)$ in (2) is the magnetostriction constant at 0°K, $I_{5/2}$ is the reduced hyperbolic Bessel function, L^{-1} is the reciprocal Langevin function, and m(T) is the relative magnetization of the dysprosium in the alloy. The value of m(T) was determined by us in the molecular-field approximation by the method described in [8]. It is seen from Fig. 2 that the experimental temperature dependences of the magnetostriction of dysprosium-gadolinium alloy are satisfactorily described by the theoretical formula for the one-ion anisotropy model. The agreement between the theoretical and experimental temperature dependences of the magnetostriction of the alloy with $x = 0.046$ is somewhat worse, because at low dysprosium contents the magnetostriction of the alloy begins to be affected by the gadolinium, whose magnetostriction has an anomalous temperature dependence [1].

Figure 3 shows the dependence of the magnetostriction constant $\lambda^{\gamma,2}(0)$ on the composition of the dysprosium-gadolinium alloy. We see that this constant increases linearly, within the limits of error, with increasing dysprosium content in the alloy. As indicated above, this is evidence in favor of the one-ion magnetostriction model. It follows thus from our measurements that the magnetostriction of gadolinium-dysprosium alloys is mainly of the one-ion type and is due to the interaction of the anisotropic charge cloud of the 4f-electrons of the dysprosium with the crystal lattice field.

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OBSERVATION OF THE FREE-EXCITON SPECTRUM AT SUBMILLIMETER WAVELENGTHS

E.M. Gershenzon, G.N. Gol'tsman, and N.G. Ptitsina
Moscow Pedagogical Institute
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Excitons are usually investigated at optical wavelengths. Nonetheless, special interest attaches to their investigation at submillimeter wavelengths corresponding to the characteristic frequencies of the exciton transitions from the ground to excited states [1]. A detailed analysis of such transitions reveals, besides the energy spectrum of the free exciton, entirely new possibilities of investigating their interaction with one another or with phonons or free carriers, etc. Such experiments, however, have just barely begun. A wide absorption band in the 2 - 6 meV range was observed for germanium in [2] by methods of long-wave infrared spectroscopy. This band is probably attributable to unresolved exciton-transition lines at a sufficiently high temperature (~7°K) under conditions when the excitons interact strongly. To detect the transitions from the ground to the excited states of free excitons at low exciton concentrations and at low temperatures it is necessary to have more sensitive spectroscopic apparatus.

We have observed in germanium narrow lines of exciton transitions from the ground to the excited state, using a backward-wave-tube submillimeter spectrometer of much higher sensitivity and resolution [2, 3]. We used Ge samples with total impurity concentration $N_d + N_a \lesssim 10^{12}$ cm^{-3}, since experiments [3, 5] have shown that otherwise the effects due to impurities make an appreciable contribution to the absorption and the photoconductivity; the energy interval in which exciton lines should be observed corresponds to transitions between the excited states of the impurity and photoionization of the donor and acceptor centers. The experiments were performed in the wave bands 2000 - 500, 400 - 345, and 310 - 250 μ (the gaps on the spectrum are the results of our not having the corresponding radiation generators). The temperature ranged from 4.2 to 1.6°K, and the level of the optical generation of the electron-hole pairs was $10^{15} - 10^{17}$ cm^{-2}sec^{-1}. The exciton concentration n_e averaged over the sample did not exceed 10^{13} cm^{-3} (the sample thickness was ~1 mm), and the spectra could be recorded to $n_e \approx 10^{10}$ cm^{-3}.

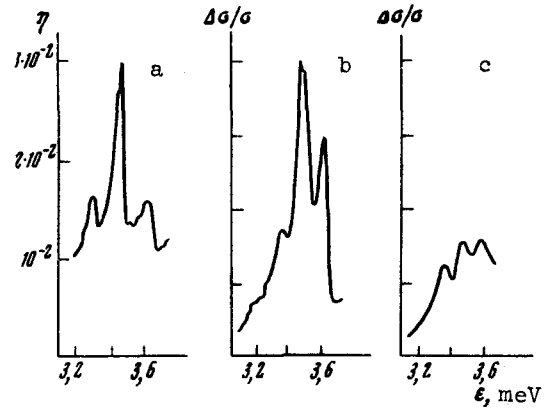

Fig. 1

Absorption and photoconductivity lines were observed in the energy interval 3.2 -