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Low field magnetic studies of some $Gd_{1-x}La_x$ alloys

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Abstract. Polycrystalline pure Gd and $Gd_{1-x}La_x$ ($x = 0.15$, 0.25, 0.27 and 0.50) alloys have been studied by low field magnetic susceptibility (χ_{AC}), magnetization and electrical resistivity measurements. Measurements were also performed on samples with low demagnetizing factor geometry in order to study the ground state properties of these systems. For hexagonal close-packed (hcp) samples the effect of spin reorientation is indicated by a broad peak in the susceptibility curve and it shifts rapidly to lower temperatures with increasing La content in Gd metal. The spin reorientation effect is not observed in the samples with La concentration higher than 15%. The χ_{AC} and resistivity measurements indicate a ferromagnetic transition at $T_C = 225$ K for 15% La concentration. For the Sm-type structure sample, with $x = 0.27$, two magnetic transition peaks are observed at 135 K and 113 K and helical antiferromagnetic order is suggested. Finally, the results for the $x = 0.50$ alloy with double hexagonal close-packed (dhcp) crystalline structure indicate a spin-glass magnetic phase type, below $T_g = 30$ K. Observed magnetization remanent effects, in this latter case, give additional support for the presence of the spin-glass phase.

1. Introduction

The rare earth metals (RE) and their alloys have been studied extensively for more than 30 years, revealing important characteristics associated with their magnetic and structural properties. To better understand the magnetic interaction among the localized moments of the magnetic rare earth elements in the solids, dilution of the magnetic species has often been made using the non-magnetic rare earth elements La and Lu and also Sc and Y (e.g. Legvold 1979, Taylor and Darby 1972, Foldeaki *et al* 1995 and references therein).

The Gd atomic ground state is $^8S_{7/2}$ and, therefore, it has a locally spherical charge distribution with low magnetic anisotropy compared to other rare earth elements. However, at normal pressure, Gd metal crystallizes in a compact hexagonal structure (hcp) and presents a complicated thermal dependence of its magneto-crystalline anisotropy (see Berger *et al* 1995 and references therein). As a result, the easy axis of magnetization below the Curie temperature (T_C) has temperature dependent direction, relative to the crystallographic axes, as shown from torque and neutron diffraction measurements, respectively reported by Corner and Tanner (1976) and Cable and Koehler (1982). The Gd metal orders ferromagnetically at $T_C = 293$ K and the easy direction of magnetization stays along the crystallographic c-axis of the hcp structure, in the temperature interval down to about 235 K. With further temperature reduction the easy axis moves sharply away from the crystallographic c-axis, reaching a maximum angle θ of about 65° near 170 K. Below this temperature, the easy axis moves back towards the c-axis, reaching a θ of about 30° at 4.2 K. This complex easy-axis orientation is generally not observed in magnetization and magnetic susceptibility measurements of polycrystalline samples, usually performed under intermediate and high applied magnetic field values. At relatively low

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applied magnetic fields, there are some early reports on magnetization and AC susceptibility measurements indicating a more complex behaviour for polycrystalline Gd metal, not well understood at that time (Belov *et al* 1961, Nigh *et al* 1963, McWhan and Stevens 1965). Extensive studies on pure Gd, by low field AC magnetic susceptibility (χ_{AC}) have been reported, mostly limited, however, to a narrow temperature range around T_C (Wantenaar *et al* 1979 and references therein). Relatively low field magnetization (30 Oe) data for a Gd single crystal sample give an indication of the basal plane spin orientation, below about 230 K, as reported by Legvold *et al* (1980).

La metal exhibits double hexagonal close-packed (dhcp) structure. When alloying Gd with La a sequence of crystalline structures can be obtained with increasing La content: hcp, Sm-type, dhcp and fcc (Thoburn *et al* 1958, Legvold 1979). Due to the large La atomic radius compared to that of Gd, the effect caused by increasing the La content in the Gd matrix resembles that of an overpressure applied to pure Gd. It is well known that applying pressure to Gd yields the same structural sequence as mentioned above (McWhan and Stevens 1965, Akella *et al* 1988). According to Thoburn *et al* (1958), in the Gd rich phase of the Gd–La system, the alloys show simple ferromagnetism with T_C value decreasing with increasing La content. At intermediate compositions, the Sm-type crystallographic structure may be stabilized and antiferromagnetic phase transitions were suggested at lower temperatures. For La atomic concentration at about 53%, the dhcp alloy showed an antiferromagnetic-like transition at a temperature close to 18 K, with magnetic order not well understood at that time. Dilute Gd–La alloys ($>$90 at.% La) were also extensively studied by other authors due to interest in the effects of the magnetic impurities of Gd in the La matrix. These dilute alloys have an fcc structure and showed magnetic transitions at low temperatures which were interpreted as being as of spin-glass type (Finnemore *et al* 1968, Larsen *et al* 1980).

In this work low field AC magnetic susceptibility measurements obtained from polycrystalline samples of Gd and Gd–La alloys, in low demagnetizing factor geometry, will be discussed. Evidence will be shown of the spin reorientation effect in low field χ_{AC} data for the pure Gd case. The sensitivity of the results to applied magnetic fields and to the usual experimental setups will be emphasized, showing that the character of the magnetic transition of these alloys may be completely masked. Distinguishing temperature behaviours of χ_{AC} and electrical resistivity will be presented and will be interpreted consistently, considering the magnetic and crystallographic structures of the alloys. Finally, a tentative magnetic phase diagram for the Gd–La system will be presented.

2. Experiment

The $Gd_{1-x}La_x$ alloys were prepared in an arc furnace under pure argon atmosphere for $x = 0.0$, 0.15, 0.25, 0.27 and 0.50 and sucked into a copper block model in a cylindrical shape with 2 mm of diameter. The starting chemical elements were 99.9% pure. One nearly cylindrical shape pure Gd sample was also cut from a 99.99% batch for comparison. The obtained alloys were sealed in separated small quartz tubes, under high vacuum, annealed in a resistive tubular furnace for eight days at 750 °C (600 °C for $x = 0.25$ and 0.27) and then quenched in cold water. In order to minimize the demagnetizing factor some samples ($x = 0.0$, 0.15, 0.25 and 0.27) were spark eroded to a needle-like shape about 0.8 mm diameter and 10 mm long.

The AC magnetic susceptibility was measured with a conventional AC susceptometer, with the in- and out-of-phase induced emf voltages read by a double phase lock-in amplifier. The frequency of the applied AC probe field could be varied in the range from 0.15 kHz to 5 kHz with amplitude values below about 0.13 Oe. In some cases, external DC magnetic field, up to 300 Oe, was applied along the sample shape axis and, therefore, parallel to the AC probe field. Measurements with temperatures down to 1.5 K were performed at the Imperial College of Science and Technology (London) and Centro Brasileiro de Pesquisas Físicas (Rio de Janeiro). In the latter institute, a vibrating sample magnetometer was used to measure the magnetization for the sample with $x = 0.50$.

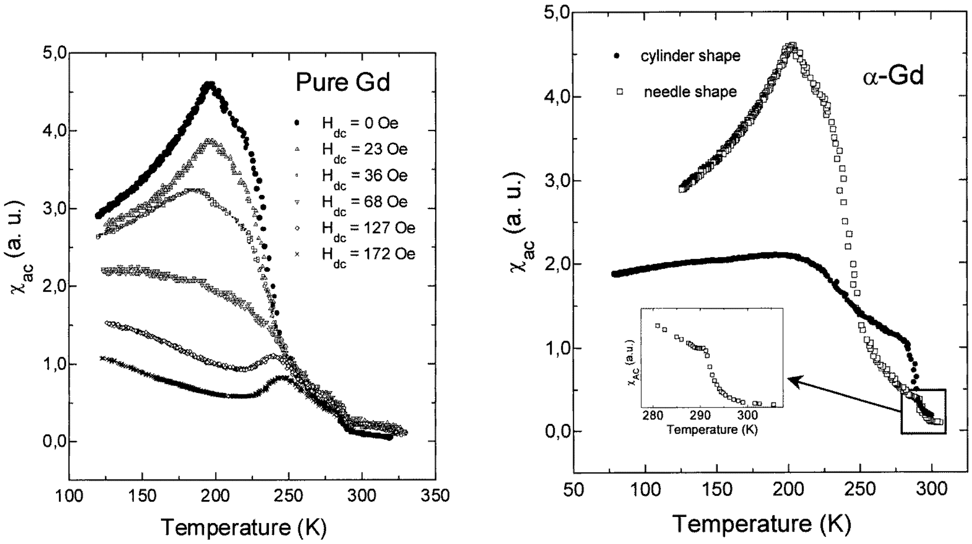
Electrical resistivity measurements were performed for samples with $x = 0.15$, 0.25 and 0.50, at Imperial College, using a four contact method, with the three samples connected in a series circuit. The voltage drop across the samples was read with a Tinsley Stabaumatic standard potentiometer with resolution of 2×10^{-9} V and an electric current stable within 10^{-5} A.

3. Results and discussion

The measurements of the AC magnetic susceptibility temperature dependence for the metallic Gd (nominal purity of 99.9%), with the AC probe field along the sample needle shaped direction, are shown in figure 1(*a*). Other curves shown in the same figure are for the cases with external DC bias field, also applied parallel to the probe field direction. The ferromagnetic transition T_C is revealed by the knee-like shape around 291 K (see inset in figure 1(*b*)). As the temperature is decreased, in the zero DC bias field curve, from 290 K down to about 246 K, the magnetic response shows a slow increase. A steep increase in the χ_{AC} value occurs for further temperature reduction followed by an intense and broad maximum at about $T_m = 200$ K. These observations are consistent with the spin reorientation phenomena observed by neutron diffraction (Cable and Koehler 1982) and torque measurements (Corner and Tanner 1976). Between 290 K and 246 K the easy axis of magnetization is parallel to the crystallographic *c*-axis and the signal response is rather insensitive to the applied DC fields. The sharp χ_{AC} increase below 246 K roughly coincides with the reported equally sharp spin reorientation, which moves the easy axis away from the *c*-axis to a maximum $\theta = 65^\circ$ at about 200 K. Thus, in order to explain the relative agreement between the reported spin reorientation effect and large χ_{AC} values, at about T_m, the following conclusion can be drawn: in the temperature range below T_C, the broad maximum in the temperature dependence of χ_{AC} is consistent with the assumption that the basal components of the Gd magnetic moments are free to rotate with the AC probe field. The fact that the samples studied here were polycrystalline, in contrast with single crystals studied by torque and neutron diffraction measurements, does not invalidate the latter conclusion. In the present case, larger magnetic moment basal components, free to rotate, should produce larger average response to the AC probe field.

According to figure 1(*a*), the application of the bias DC magnetic field progressively reduces the χ_{AC} values, for increasing field values at temperatures below about 246 K; for applied fields values above 40 Oe the χ_{AC} maximum at 200 K is no longer distinguished. The pattern of the 68 Oe curve is similar to the result of Nigh *et al* (1963) from magnetization measurements in a Gd single crystal with 100 Oe applied magnetic field value in the *c*-axis direction. Furthermore, it is interesting to observe the appearance of a weak maximum at about 250 K for applied DC bias field values at and above 127 Oe. This broad maximum, revealed by the presence of the relatively large bias field, may be associated with the maximum value of the coercive field at about 250 K, followed by a strong reduction and a minimum value at 200 K, as reported by Belov *et al* (1961) for polycrystalline samples and Berger *et al* (1995) for Gd films.

In order to verify the role of the impurities and the sample shape in the results just described, two experiments were run using cylindrical shaped Gd samples. For a sample from the same batch as before, the χ_{AC} versus temperature curve for zero DC bias field is also plotted in figure 1(*b*) together with the results for the needle shape sample for comparison. The curve resembles that of the 36 Oe curve in figure 1(*a*), for the needle shaped sample, with a shallow



(*a*) (*b*)

Figure 1. AC magnetic susceptibility of Gd metal: (*a*) at different applied DC magnetic fields as indicated; (*b*) for samples with different shapes.

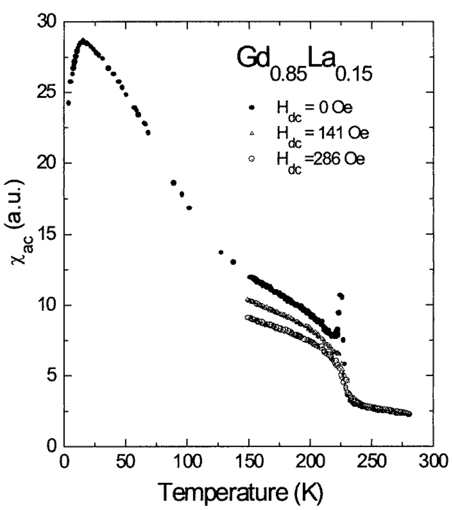


Figure 2. AC magnetic susceptibility of $Gd_{0.85}La_{0.15}$ alloy at different applied DC magnetic fields as indicated.

maximum at about 200 K and a slower decrease of χ_{AC} at lower temperatures. The different magnetic response below T_C of the cylinder shaped sample as compared with the needle shaped sample can only be due to the larger demagnetizing factor in the cylinder case. A similar χ_{AC} measurement was performed for a cylindrical shape sample prepared from a 99.99% Gd batch. The result, not shown here, is similar to the present case, which indicates that the temperature dependence of χ_{AC} is not related to the metal residual impurities.

The χ_{AC} results for $Gd_{0.85}La_{0.15}$ alloy with the applied AC probe field along the needle shaped sample axis are shown in figure 2, for different applied DC magnetic fields, as indicated. This alloy has the same crystalline structure as the pure Gd so one expects a magnetic response similar to that of the pure metal, except for the dilution of the magnetic species. At zero applied DC bias field, the χ_{AC} curve shows a very sharp peak at $T_C = 225$ K which is related to a magnetic order–disorder transition. Also, an intense but broad maximum is shown at $T_m = 15$ K, which may be related to a spin reorientation effect, resulting from the same type of magnetic response process as discussed above for pure Gd. The similarity between the χ_{AC} versus T curves of $Gd_{0.85}La_{0.15}$ and pure Gd and the temperature behaviour of the electrical resistivity, to be discussed below, strongly suggest that the magnetic moments are ferromagnetically ordered just below T_C. The paramagnetic Curie–Weiss temperature (θ_p), obtained from the reciprocal χ_{AC} data, above 230 K, is 92 K. This indicates predominant ferromagnetic interactions among the magnetic moments. The sharp transition at T_C, in the present case, may indicate a more rigid magnetization easy axis, along the crystallographic c-axis, when compared to that of pure Gd (see inset in figure 1(*b*)). Figure 2 also shows the effect on the χ_{AC} temperature dependence when a bias DC magnetic field is applied. Field values above 140 Oe completely suppress the χ_{AC} peak at T_C. The spin reorientation effect, indicated for the Gd metal and the $Gd_{0.85}La_{0.15}$ alloy by the χ_{AC} maximum at 200 K and 15 K, respectively, seems to be an effect associated only with the ferromagnetic alloys, since no indication for spin reorientation has been observed in the other Gd–La cases, as will be shown below.

The alloys $Gd_{0.73}La_{0.27}$ and $Gd_{0.75}La_{0.25}$, both with Sm-type crystal structure, show similar χ_{AC} versus T curves. These curves reveal distinct character when compared with the Gd metal and the $Gd_{0.85}La_{0.15}$ alloy, as can be noted in figures 3(*a*) and 3(*b*) for $Gd_{0.73}La_{0.27}$. A very sharp peak is observed at $T_N = 135$ K which is related to a magnetic order–disorder transition. This peak height is very sensitive to any external DC magnetic fields, as shown in figure 3(*b*) for some field values. It should be emphasized that the susceptibility value at T_C increased by 50% when a small DC field (smaller than 0.5 Oe) was applied along the sample axis (see

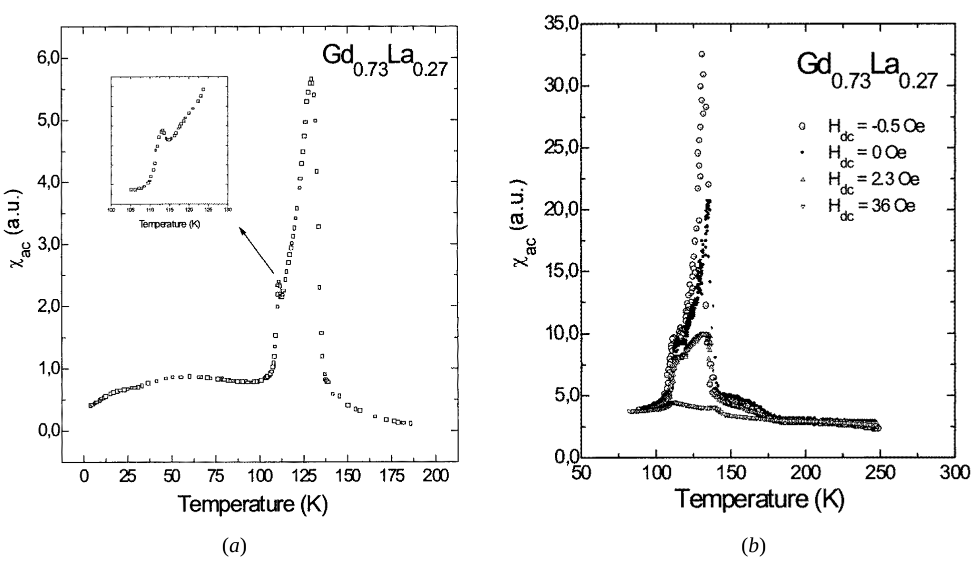


Figure 3. AC magnetic susceptibility of $Gd_{0.73}La_{0.27}$ alloy: (*a*) at zero applied DC field and (*b*) different applied DC magnetic fields as indicated.

negative applied field curve in figure 3(*b*)). This small magnetic field may have compensated the Earth field component thereby enhancing the magnetic response to the AC probe field. Also, a secondary weak peak is observed at 113 K (see inset in figure 3(*a*)). This weak peak may be due to a magnetic order–order transition, as reported for Gd–Y alloys (Legvold *et al* 1980) or due to a magnetic disorder–order transition associated with Gd atoms located at lattice sites with local nearly cubic symmetry, as observed in the pure Sm case (Koehler and Moon 1972). Also, Gd metal under pressure shows two peaks in the initial susceptibility, for pressure above 25 kbar, where the Sm-type phase is expected to occur (McWhan and Stevens 1965, Akella *et al* 1988). It seems that metals and alloys with Sm-type crystalline structure exhibit similar magnetic behaviour. Below 113 K, the χ_{AC} values strongly decrease, suggesting an antiferromagnetic type structure of the Gd moments. In the temperature region between the two peaks in figure 3(*a*) (from 113 K to 135 K) a conclusive argument on the type of its magnetic structure cannot be drawn.

Jayaraman *et al* (1966) and Speight (1970) report magnetization experiments on several RE–RE alloys with Sm-type crystalline structure. Specifically for the case of an Sm-type Gd–La alloy, these authors suggested antiferromagnetic order below about 130 K. On the other hand, the results of both mentioned authors also show an increase in the magnetization versus temperature curves when the temperature is reduced below 130 K, with a broad maximum occurring at about 5 K in the data for higher magnetic field. This effect has no correspondence in the present low AC field susceptibility curve (figure 3(*a*)). This difference may be due to the relatively high external magnetic field used in their measurements: e.g., Jayaraman *et al* (1966) used fields from 4.9 kOe to 15.3 kOe, the low temperature maximum in the magnetization versus temperature curves being more pronounced for the higher field curve and with no apparent indication in the lowest field case.

The antiferromagnetic character of the $Gd_{0.73}La_{0.27}$ and $Gd_{0.75}La_{0.25}$ alloys, at low temperatures, is in accord with what is expected when diluting Gd metal with non-magnetic impurities. In fact, similar conclusions have been pointed out by Sarkissian and Coles (1976), Foldeaki *et al* (1995), Eccleston *et al* (1991), Melville *et al* (1988) and others, for related Gd–Y, Gd–Lu and Gd–Sc alloys. It has been shown that the antiferromagnetism of these alloys, with intermediate to low concentrations of Gd, is of helical type with the spins lying on the hexagonal basal plane. As will be shown, electrical resistivity measurements strongly indicate the antiferromagnetism of the Gd–La Sm-type alloys has the same helical character as in the Gd–RE cases mentioned above.

The χ_{AC} results for the $Gd_{0.50}La_{0.50}$ alloy with dhcp crystalline structure are shown in figure 4, for three different probe AC field frequencies. The curves show a pronounced maximum at about $T_g = 30$ K. A careful analysis of the χ_{AC} data indicates that T_g increases by about 1.5 K when the probe AC field frequency is increased from 340 to 5000 Hz (figure 4). The character of the curves shown in figure 4 is similar to the one reported by Larsen *et al* (1980) for spin-glass fcc Gd_8La_{92} alloy. Magnetization experiments were performed on the sample studied here in order to obtain more information on the magnetic structure of the alloy below T_g. Consistently, the magnetization versus temperature curve peaks at 27.5 K, as shown in figure 5, for the lowest applied magnetic field (100 Oe). The small temperature discrepancy in the peak position, compared with the χ_{AC} peak, may be related to the larger applied magnetic field in the magnetization measurement case. For higher applied magnetic field (5.4 kOe) the curve shows a different character: a broad peak, at about 20 K, indicating a tendency to a ferromagnetic-like transition, induced by the applied magnetic field. Figure 5 also shows the remanence effects in the zero field cooling (ZFC) and field cooling (FC) measurements. In addition, a linear fit to the reciprocal magnetic susceptibility was carried out, using the results of magnetization measurements for 8.7 kOe applied field. A Curie–Weiss behaviour was observed (see figure 5),

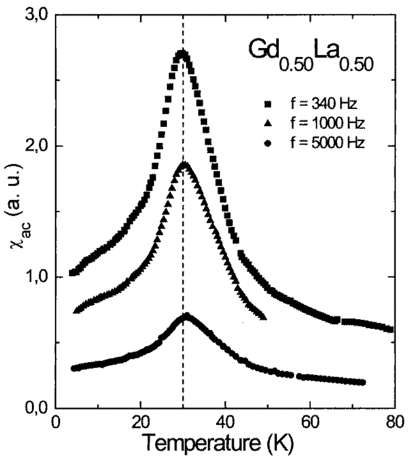


Figure 4. AC magnetic susceptibility of $Gd_{0.50}La_{0.50}$ alloy at different probe AC field frequencies. The dashed straight line at 30 K emphasizes the shift in the peak temperature with frequency.

with an extrapolated temperature $\theta_p = -4$ K and a calculated effective magnetic moment of 8.54 μ_B. These values are close to -3 K and 8.70 μ_B, of Thoburn *et al* (1958), for an alloy with nearly the same La concentration (53%). One also observes that the linear region of the reciprocal magnetic susceptibility (χ_{DC}^{-1}) extends from high temperatures down to about 50 K. Below this temperature, short range magnetic interactions set in, yielding a deviation from Curie–Weiss law. Finally, for further temperature reduction, magnetic transition occurs at T_g.

From the results described above, for the $Gd_{0.50}La_{0.50}$, some experimental facts can be resumed as follow: (1) relatively sharp magnetic transition at T_g (30 K); (2) small frequency dependence of T_g; (3) the obtained value for the paramagnetic temperature θ_p (-4 K) is close to zero and weakly negative; (4) χ_{DC}^{-1} deviates from Curie–Weiss behaviour at 50 K, a temperature well above T_g; (5) the remanence effect is very pronounced in FC magnetization data. These results strongly suggest the alloy studied here has a spin-glass-like phase below T_g. However, it is worth emphasizing the high concentration of the magnetic species in the Gd–La system where the spin-glass phase is indicated. For other chemically similar diluents, such as Y and Sc, spin-glass phase was reported only for Gd concentrations below about 22% and 3%, respectively (Sarkissian and Coles 1976). It is possible that, substituting Gd atoms with the larger La volume, the electronic mean free path may be highly reduced producing the observed effects.

The temperature dependent electrical resistivity $\rho(T)$ of the $Gd_{1-x}La_x$ alloys is shown in figure 6 for $x = 0.15$, 0.25 and 0.50. The character of each $\rho(T)$ curve is consistent with the magnetic phases indicated by the previous low field χ_{AC} results. For the alloy with 15% La, as the temperature is decreased below T_C, the resistivity decreases nonlinearly deviating sharply from the linear high temperature behaviour. This is consistent with a ferromagnetic transition, as suggested by the χ_{AC} data. The character of the resistivity curves of $x = 0.25$ and 0.50 can be, respectively, associated with helical and spin-glass phase transitions, in analogy with the results for Gd–Y, Gd–Sc, Y–Tb and Sc–Tb alloys (Sarkissian and Coles 1976). The $\rho(T)$ curve of the Sm-type alloy (figure 6) deviates from a nearly linear high temperature behaviour at about $T_N = 135$ K, a value close to the strong pronounced peak observed in the χ_{AC} data for the alloy with $x = 0.27$ (figure 3(*a*)). Opposed to the previous ferromagnetic case,

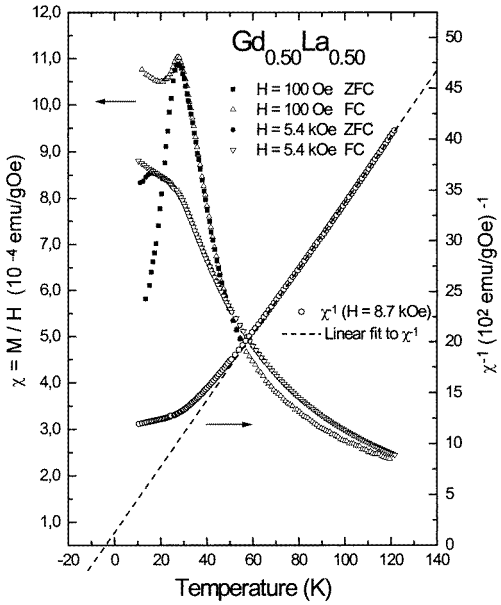


Figure 5. Magnetization of $Gd_{0.50}La_{0.50}$ alloy at indicated applied magnetic fields. Curves obtained with field cooling (FC) and zero field cooling (ZFC) are indicated. The reciprocal magnetic susceptibility for $H = 8.7$ kOe is also shown.

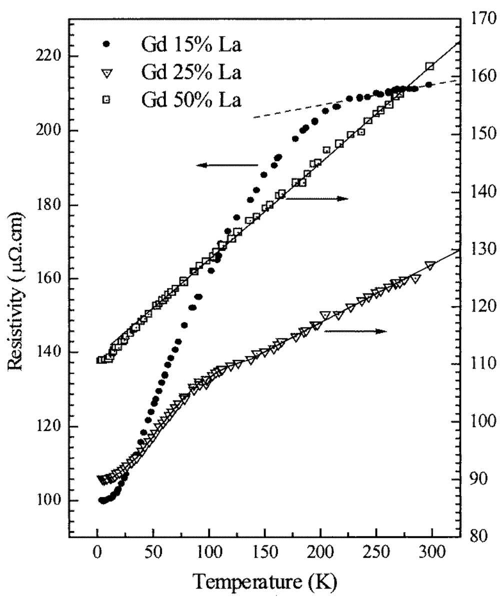


Figure 6. Electrical resistivities of some Gd–La alloys.

as the temperature decreases, just below T_N, the $\rho(T)$ curve shows a weak, but observable, tendency to increase, relative to the higher temperature data. This relative increase of $\rho(T)$, below T_N, is probably due to an additional electron scattering mechanism, associated with the appearance, near the Fermi surface, of antiferromagnetic superzone boundaries. Such an effect was discussed for α-Mn and other RE–RE helical antiferromagnetic alloys as mentioned above (see Sarkissian and Coles 1976 and references therein). In the case of the spin-glass transition of the $x = 0.50$ alloy, the $\rho(T)$ curve is not very sensitive to the phase transition but careful analysis indicates that the curve is nearly linear for temperatures above 50 K. Below this temperature an inflection point may be noted at about 30 K, the same temperature as the susceptibility peak. Similar temperature dependence of $\rho(T)$ was also reported for other rare earth spin-glass alloys by Sarkissian and Coles (1976), reinforcing the argument of the spin-glass phase in the $Gd_{0.50}La_{0.50}$ alloy.

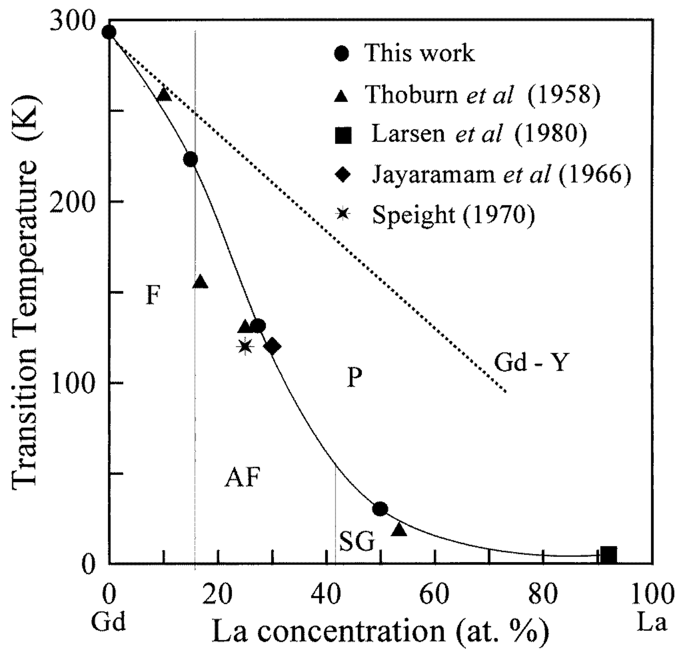


Figure 7. Magnetic transition temperatures for the Gd–La alloys. Dashed vertical lines indicate the interphase for crystalline structure changes. The full line is a guide to the eyes. Dotted lines indicate the high temperature magnetic transition tendency of Gd–Y alloys.

Figure 7 shows a tentative magnetic-phase-like diagram derived from the magnetic transition temperatures reported for various Gd–La alloys. The concentration regions for different crystalline structures and the alloy magnetic phases are also indicated in this figure. This diagram extends the ideas presented by Thoburn *et al* (1958) by including the new information about the spin-glass alloys and allowing conjectures about the limits of each magnetic phase. It is clearly seen that the changes in the crystalline structure (hcp, Sm-type and dhcp) occur at roughly the same La concentrations as the changes in the magnetic character of each sample (ferromagnetic, helical and spin-glass).

For comparison, the Gd–Y high temperature magnetic transition is schematically represented in figure 7 (dotted line), for increasing Y content (Foldeaki *et al* 1995). As expected, the figure evidences the large difference when diluting Gd with La or Y. For the Gd–La alloys the decrease of the magnetic transition temperature with the increase of the non-magnetic element content is much more intense than that in the Gd–Y system. The overall effect of the Y dilution is to promote stabilization of the (helical) antiferromagnetic phase in the system, without any change in the crystalline structure. Similar behaviour is observed in other rare earth alloys, such us Gd–Sc and Gd–Lu.

4. Conclusions

Results of AC magnetic susceptibility and electrical resistivity measurements of $Gd_{1-x}La_x$ alloys, with different crystalline structures, hcp for pure Gd and $x = 0.15$, Sm-type for $x = 0.27$ and 0.25 and dhcp for $x = 0.50$, have respectively shown ferro-, helical antiferro- and spin-glass-like magnetic phases. The spin reorientation effect in pure Gd and in the ferromagnetic alloy is indicated by AC magnetic susceptibility measurements. The strong magnetic response below T_C, peaking around T_m, is associated with the basal components of the Gd magnetic moments which are free to rotate with the AC probe field. It has been shown that such an effect can only be observed by the χ_{AC} technique if an experimental setup with low demagnetizing factor geometry is provided and low magnetic fields are applied. The critical spin fluctuation at T_N, observed in the χ_{AC} versus T curve for the helical antiferromagnetic alloy, shows strong sensitivity to the sample shape and to any applied DC magnetic field. In this case, the two peaks observed in the χ_{AC} versus T curve for the $Gd_{0.73}La_{0.27}$ alloy could be probably due to distinct ordering temperatures for Gd atoms located at the sites with different local symmetry of the Sm-type crystal structure. This possibility, however, cannot be conclusive since an order–order magnetic transition may also be able to occur below the high temperature order–disorder transition, as reported for other Gd–RE alloys. Magnetization, AC susceptibility and electrical resistivity indicate a spin-glass-like ground state for the alloy with 50% La, below 30 K. The possible occurrence of a spin-glass phase at such high Gd concentration is rather unexpected, compared with other similar Gd–RE systems. Comparing with the reported Gd–Y case, the overall effect of diluting Gd with La atoms consists of a much stronger reduction of the alloy order–disorder magnetic transition temperature.

Finally, the present work gives clear evidence that the strength of the applied magnetic field masks the character of the magnetic transition of the alloys studied here. It was revealed that even the Earth's magnetic field may influence the χ_{AC} curve at the magnetic transition temperature. Also, it was shown that the sample shape and the geometry of the experimental setup may strongly affect the magnetization and the magnetic susceptibility data of these Gd–La alloys around and below the critical temperature for magnetic transition.

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