

ANOMALOUS PRESSURE RESPONSE OF MAGNETIC PROPERTIES IN $\text{RuSr}_2\text{GdCu}_2\text{O}_8$ *

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Electrical resistance and magnetization of $\text{RuSr}_2\text{GdCu}_2\text{O}_8$ have been measured at high pressure in order to clarify the interplay between the magnetic ordering and superconductivity. It is found that the magnetic ordering temperature (T_m) and the superconducting transition temperature (T_C) increase with increasing pressure. These results imply that the superconductivity coexists with magnetic ordering at least up to 2.1 GPa.

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1. Introduction

The hybrid ruthenate-cuprate compound $\text{RuSr}_2\text{GdCu}_2\text{O}_8$ (abbreviated as Ru-1212), in which superconductivity ($T_C \sim 40$ K) and magnetic ordering ($T_m \sim 130$ K) coexist, has attracted much attention because of the possibility to find a new mechanism of superconductivity [1,2]. Since high pressure is

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well known as a good tool to control the electronic state, it is worthwhile to study the magnetic and electrical properties of Ru-1212 under high pressure. In the present work, we attempted to observe the electrical resistance and magnetization of Ru-1212 under pressure in order to clarify the interplay between magnetic ordering and superconductivity at high pressure.

2. Experimental

The specimens of Ru-1212 were prepared by solid state reaction. High pressure was generated by using piston-cylinder device and a mixture of Fluorinert FC70 and FC77 as a pressure transmitting medium. The details of the present apparatus were described previously [3]. Electrical resistance was measured using standard four-probe method. The magnetization was measured by means of micro high pressure clamp cell and SQUID magnetometer up to about 0.8 GPa [4].

3. Results and discussion

3.1. Effect of pressure on the magnetic transition and superconducting temperatures (T_m and T_C)

Temperature dependent electrical resistance $R(T)$ of Ru-1212 is shown in Fig. 1 at various pressure. $R(T)$ at ambient pressure decreases smoothly with decreasing temperature down to 150 K and shows a small anomaly near 130 K ($= T_m$) due to magnetic ordering followed by a smooth increase in $R(T)$, which is reminiscent of underdoped high T_C superconductors.

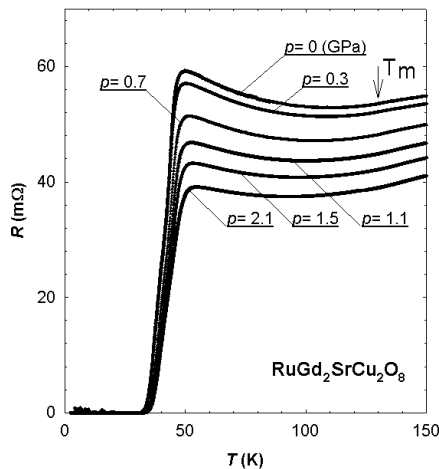


Fig. 1. Temperature dependence of the electrical resistance of Ru-1212 under high pressure. Magnetic ordering temperature T_m is shown by an arrow.

The magnetic transition temperatures T_m are defined as a temperature showing a maximum in dR/dT [5]. The same anomaly is found also in the temperature dependence of the thermal expansion coefficients $\alpha(T)$ [6]. After the smooth increase, the $R(T)$ curve shows sudden decrease due to superconducting transition. T_C was determined as the temperature having the value of $R = 0.05 \text{ m}\Omega$.

T_C and T_m are shown in Fig. 2 as a function of pressure. Both T_C and T_m are found to increase with pressure in almost linear fashion: $\partial T_m/\partial P$ and $\partial T_C/\partial P$ are estimated to be 5.7 K/GPa and 1.6 K/GPa , respectively. These results indicate that both the magnetic interaction and the superconductivity are enhanced by pressure.

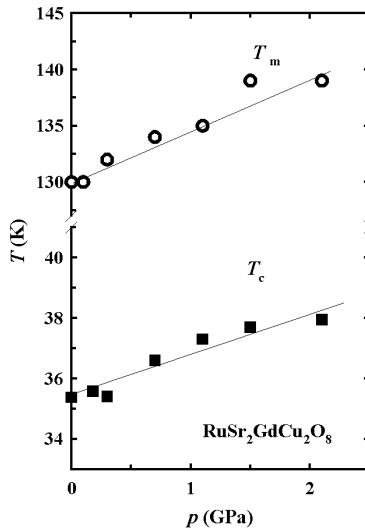


Fig. 2. T_C and T_m of Ru-1212 as a function of pressure.

3.2. Effect of pressure on the magnetization

Fig. 3 shows the temperature dependence of magnetization M (emu/mol) at 1 kOe at high pressure up to 0.8 GPa. $M(T)$ is almost zero above 170 K but increases steeply near T_m due to magnetic ordering. Here we define ΔM as the magnitude of discontinuous change in the magnetization M near T_m , which reflects the small ferromagnetic component or the net magnetization of canted antiferromagnetic Ru moment. ΔM is found to decrease as pressure increases. Below 20 K, $M(T)$ increases again due to the magnetic ordering of Gd moment. T_m is defined as the temperature where $\chi_m^{-1}(= H/M)$ becomes zero. T_m increases with increasing pressure having the rate of about 17 K/GPa , which is larger than that mentioned above. This fact indicates

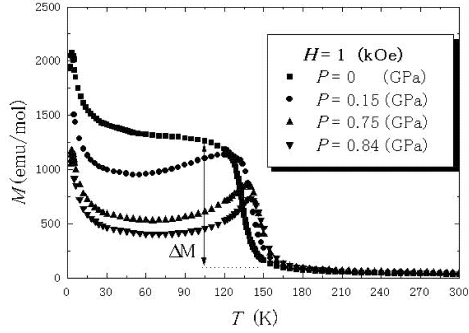


Fig. 3. Temperature dependence of magnetization of Ru-1212 under high pressure.

that ΔM decreases but T_m increases by the evolution of antiferromagnetism as pressure increases (see Fig. 4). This fact suggests that the angle between the canted moments decreases at high pressure.

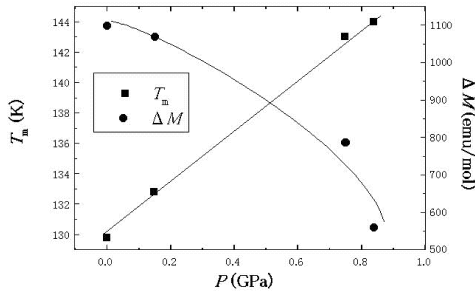


Fig. 4. T_m and ΔM of Ru-1212 as a function of pressure. The solid lines are the guide of eyes.

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