Multigap superconductivity in La_2C_3 and Y_2C_3

J. Akimitsu

Department of Physics and Mathematics, Aoyama Gakuin University

The discovery of high-temperature superconductivity in MgB_2 has activated renewed interest in other boride and carbide superconductors. Among such compounds, sesquicarbides (Ln_2C_3, Ln =La, Y) show relatively high critical temperatures and their T_c values strongly depend on their carbon composition.

Recently, we have found a new superconducting phase in Y_2C_3, exhibiting a much higher $T_c (T_c \sim 18$ K). A recent study on the temperature dependence of the nuclear spin lattice relaxation rate in Y_2C_3 has suggested the multiple superconducting gaps with s-wave symmetry. While a similar electronic structure would be expected for a La_2C_3, the specific measurement of this material suggests single gap superconductivity.

The μSR technique is a powerful microscopic tool to determine the existence of two gap state. In this conference, we present result of μSR measurement on polycrystalline samples of La_2C_3 ($T_c \sim 11$ K) and Y_2C_3 ($T_c \sim 15$ K), where a clear sign of double gap superconductivity was observed in the temperature dependence of muon depolarization rate. The muon depolarization rate ($\sigma_v(T)$) exhibits a characteristic temperature dependence that can be perfectly described by a phenomenological double-gap model for nodeless superconductivity (see Fig. 1). While the magnitude of two gaps is similar between La_2C_3 and Y_2C_3, a significant difference in the interband coupling between those two cases was clearly observed in the behavior of $\sigma_v(T)$.

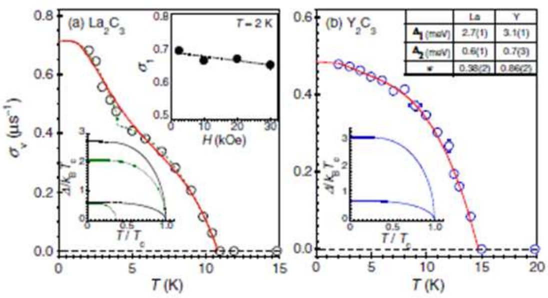

Fig. 1 Temperature dependence of the muon spin relaxation rate for (a) La_2C_3 at 2.5 kOe and (b) Y_2C_3 at 5.0 kOe. Error bars (not shown) are smaller than the symbol size. Solid and dashed curves indicate the result of the fitting analysis using the double-gap model described in the text. Insets show the relaxation rate in the superconducting state ($\sigma 1$) as a function of the magnetic field for La_2C_3 (a) and the order parameters $[\Delta(T)/k_B Tc]$ for the respective cases.

	La_2C_3	Y_2C_3
Transverse field (kOe)	2.5	5.0
T_c (K)	10.9(1)	14.7(2)
$\sigma_v(0)$ (μs^{-1})	0.71(3)	0.48(2)
$\lambda(0)$ (Å)	3800(100)	4600(100)
w	0.38(2)	0.86(2)
$\Delta_1(0)$ (meV)	2.7(1)	3.1(1)
$\Delta_2(0)$ (meV)	0.6(1)	0.7(3)
$2\Delta_1/k_BT_c$	5.6(3)	4.9(3)
$2\Delta_2/k_BT_c$	1.3(3)	1.1(5)

TABLE I. Superconducting properties of La_2C_3 and Y_2C_3 determined from the present experiment, where those obtained from the double-gap analysis correspond to the solid curves in Fig. 1.