Ferromagnetism and Giant Magnetoresistance in EuropiumC_{60} Compounds

Kenji Ishii

Synchrotron Radiation Research Center (SPring-8), Japan Atomic Energy Research Institute

1-1-1 Kouto Mikazuki-cho Sayo-gun, Hyogo 679-5148, JAPAN

Some rare earth metals are known to make compounds with C_{60}. Superconductivity was observed in the compounds with Yb and Sm [1,2] and those atoms are in the non-magnetic state. On the other hand, little effort has been made to study the magnetic properties of rare earth fullerides, though magnetism is one of the interesting issues in rare earth metal compounds. Recently we have succeeded to synthesize two europium fullerides, $Eu_{\sim3}C_{60}$ and Eu_6C_{60} and determined the crystal structure by x-ray diffraction experiments [3]. Eu_6C_{60} has a bcc structure which is an isostructure of other M_6C_{60} (M is an alkali or alkaline earth atom). Here we report the magnetic and electric transport properties of Eu_6C_{60}.

Polycrystalline samples of Eu_6C_{60} were synthesized by the heat treatments of the mixture of Eu and C_{60} powders. The sample quality was confirmed by synchrotron radiation x-ray diffraction measurements.

Figure 1 shows the temperature dependence of magnetization at a weak field of 3mT and a steep increase of magnetization was observed, indicating a ferromagnetic transition. We confirmed the ferromagnetic transition by heat capacity measurement, as shown in Fig. 2. The transition temperature (T_C) is determined to be 11.6 K from the peak position of heat capacity. At high temperature, magnetic susceptibility follows the Curie-Weiss law. The Curie constant and the saturation magnetic moment are consistent with the divalent state of Eu (S=7/2, L=0, and J=7/2), which is consistent with the Eu L_{III}-edge XANES experiments.

In the resistivity measurements of Eu_6C_{60}, we found a striking feature that resistivity decreases significantly by applying the magnetic field below around T_C. The reduction ratio of resistivity ρ/ρ_0 is almost 10^{-3} at 1 K. Such large negative magnetoresistance in Eu_6C_{60} suggests the existence of strong interaction between conduction carries and localized moments, that is, π-f interaction. Because the resistivity was measured for a pressed pellet of polycrystalline samples, the measured resistivity may include that at the grain boundary, which may be attributed to the origin of the magnetoresistance as spin-dependent tunneling at intergrain boundary.

[1] E. Özdaç *et al.*, Nature (London) **375**, 126 (1995).
[2] X. H. Chen and G. Roth, Phys. Rev. B **52**, 15534 (1995).
[3] H. Ootoshi *et al.*, Mol. Cryst. and Liq. Cryst. **340**, 565 (2000).

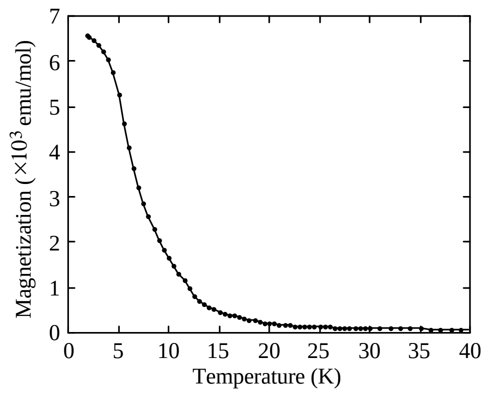

Fig. 1: Temperature dependence of magnetization of Eu_6C_{60}.

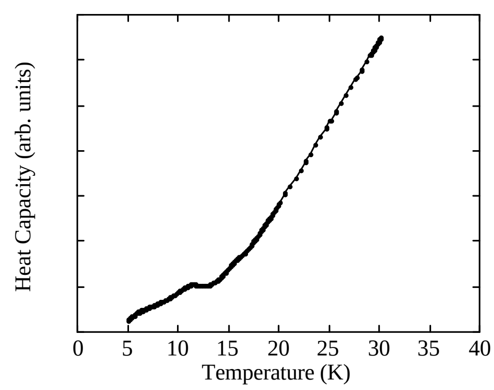

Fig. 2: Temperature dependence of heat capacity of Eu_6C_{60}.

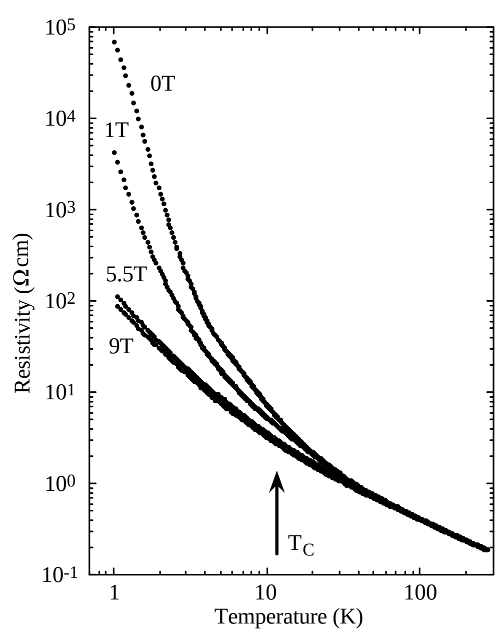

Fig. 3: Temperature dependence of resistivity of polycrystalline Eu_6C_{60} at some magnetic fields. The arrow indicates the ferromagnetic transition temperature determined from the peak position of heat capacity.