Anomalous Enhancement of the Upper Critical Field In Fullerene Superconductors Near The Mott Transition

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Introduction

Recent pressure studies of Cs_3C_{60} compounds have revealed that superconductivity emerging out of the antiferromagnetic phase [1-3]. The observed dome-like dependence of T_c as a function of pressure (or lattice volume) is reminiscent of non-BCS mechanism of superconductivity and highlights the importance of electron correlation and Mott physics. Therefore, studies of superconducting properties beyond T_c maximum toward the superconductor-antiferromagnetic Mott insulator transition are important to understand physics behind fullerene superconductors. To access the novel regime even at ambient pressure, we prepared $Rb_xCs_{3-x}C_{60}$ ($0 < x < 1$).

Experimental

We performed penetration depth experiments using proximity detector oscillator (PDO) up to 65 T at NHMFL-LANL down to 1.4 K for $Rb_xCs_{3-x}C_{60}$ ($0 < x < 3$), K_3C_{60} and Na_2CsC_{60}.

Results and Discussion

Figure 1(a) shows the temperature T dependence of the upper ciritical field H_{c2} for the fullerene superconductors. With expanding lattice volume from Na_2CsC_{60} to $Rb_xCs_{3-x}C_{60}$, H_{c2} is clearly enhanced and becomes as high as 90 T, which is comparable to that of pnictide superconductors with similar T_c value. In Fig. 1(b), T-dependence of H_{c2} is plotted in a normalized scale, H_{c2}/T_c as a function of T/T_c. In $Rb_xCs_{3-x}C_{60}$ ($0 < x < 3$), H_{c2}/T_c exceeds the Pauli paramagnetic limit of H_{c2} in the BCS weak-coupling limit, indicating that the strong enhancement of H_{c2} is originated from the enhancement of the superconducting coupling strength towards the Mott transition, which has been also observed in superconductors based on Mott insulator, such as cuprates.

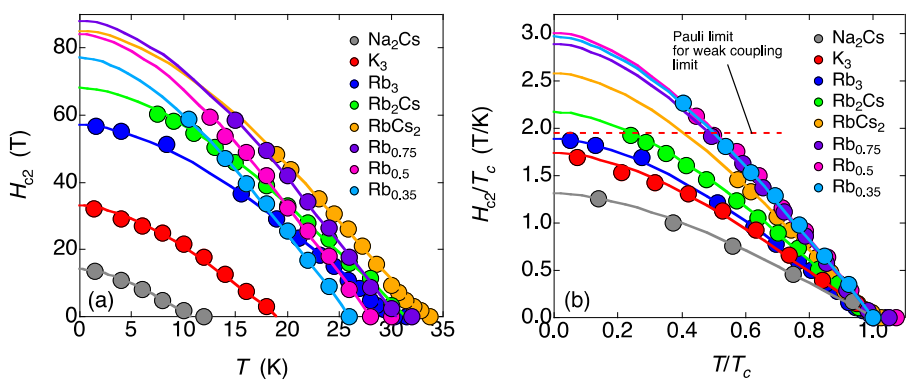

Fig. 1: (a) Upper critical field H_{c2} as a function of temperature T for the fullerene superconductors including $Rb_xCs_{3-x}C_{60}$ ($0 < x < 3$), K_3C_{60} and Na_2CsC_{60}. (b) Normalized upper critical field H_{c2}/T_c as a function of normalized temperature T/T_c. Solid lines are fits using WHH theory [(a) and (b)]. Dashed line indicates the Pauli paramagnetic limit of H_{c2} for spin-singlet superconductors assuming weak coupling BCS limit ($H_{c2}/T_c = 1.84$).

Conclusions

We have observed a large enhancement of H_{c2} towards the Mott transition in fullerene superconductors.

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References

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