The Superconducting Phase in $Cu_xBi_2Se_3$

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Topological insulators (TI) are a new state of matter attracting a lot of interest in recent years. TIs are fully gapped in the bulk while the surface (or edge in 2D) exhibits metallic conduction due to gapless surface states protected by time-reversal symmetry and with a Dirac-like energy dispersion [1, 2]. Examples are $Bi_{1-x}Sb_x$, Bi_2Se_3, or Bi_2Te_3. Among them, Bi_2Se_3 attracted special interest since Cu intercalation into Bi_2Se_3 introduces superconductivity [3]. Therefore, this system is discussed as a possible topological superconductor (TSC), characterized by a topologically protected gapless surface state, namely an Andreev bound state consisting of Majorana fermions.

$Cu_xBi_2Se_3$ was experimentally found to superconduct for $0.1 \leq x \leq 0.3$ with a maximum critical temperature T_c of ~3.8 K [3]. However, the zero-field-cooled (ZFC) shielding fractions of the samples available at the time were usually less than 20% and zero-resistance was never found. Therefore some questions remained about the true nature of the superconducting state in $Cu_xBi_2Se_3$. If it is a bulk superconductor, it would be a prime candidate for being topological: on the one hand, if its bulk is an ordinary s-wave superconductor, the superconducting proximity effect may turn the topological surface state into a two-dimensional TSC [4]. On the other hand, if the bulk turns out to be an odd-parity superconductor, it might be a three-dimensional TSC [5]. Hence samples of higher quality were strongly called for, which recently became available by employing a different preparation method [6]. These new-generation samples exhibit ZFC shielding fractions of up to ~50% and feature a drop to zero resistance at T_c, see Figs. 1 (a) and (b).

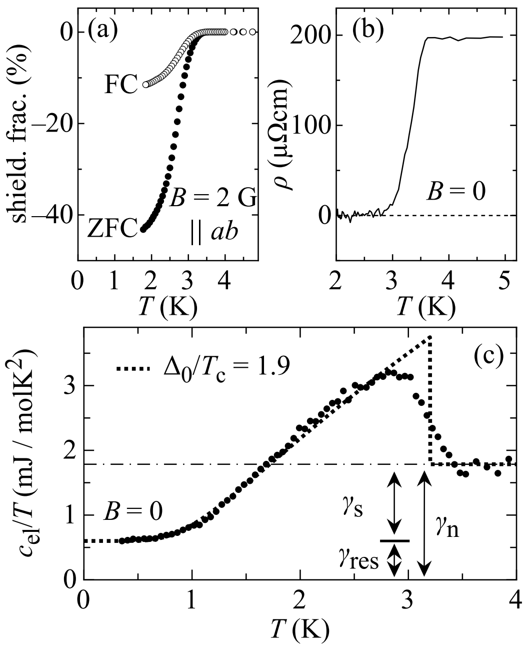

Fig. 1: (a) Shielding fraction, (b) resistivity and (c) specific heat of $Cu_{0.29}Bi_2Se_3$.

In this talk, the superconductivity in $Cu_xBi_2Se_3$ will be characterized by discussing recent results of thermodynamic and transport measurements. Field-dependent magnetization data reveal a small lower critical field strength B_{c1} of less than 0.5 mT and consequently the superfluid density is rather small ~ 5×10^{19} cm^{-3}. An analysis of the specific-heat data shown in Fig. 1 (c) suggests strongly-coupled possibly fully-gapped bulk type-II superconductivity in this system [7]. In addition, it was found from a point-contact spectroscopy study, that this system exhibits a surface Andreev bound state and hence the superconductivity in $Cu_xBi_2Se_3$ is unconventional. An analysis of all possible superconducting gap functions allowed the conclusion, that $Cu_xBi_2Se_3$ is indeed a TSC [8].

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