Low Temperature Correlated Insulating State in SmB_6

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Introduction

The recent discovery of a novel class of materials known as topological insulators [1] has sparked a new wave of research in the field of condensed matter physics. These materials, as a result of strong spin-orbit coupling, enter an unusual quantum state – they possess an insulating bulk topologically distinct from vacuum, resulting in a metallic boundary. Examples of such topological insulating phases have been discovered in weakly interacting systems such as Bi_2Se_3, Bi_2Te_3 etc [2,3]. Recently transport experiments [5,6] have suggested that the Kondo insulator SmB_6 which be a topological insulator. Within this interpretation, the appearance of a low temperature plateau in resistance at low temperatures saturation signifies a cross-over from bulk resistivity to one dominated by the surface states.

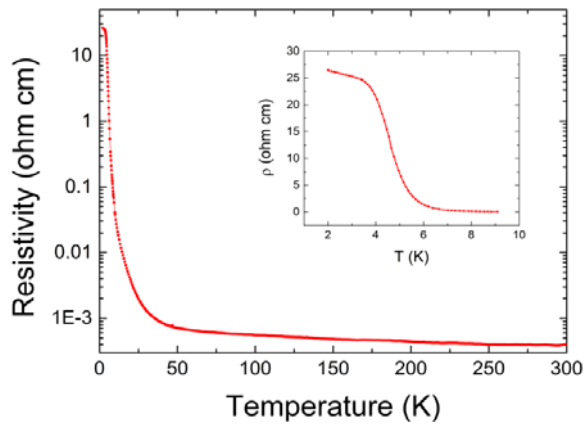

Fig. 1. Resistivity of a high quality single crystal of SmB_6 with RRR~10^5

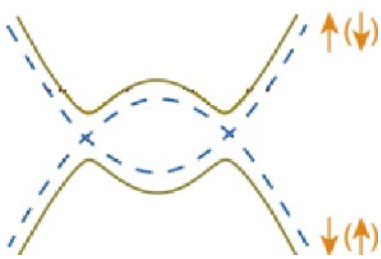

Fig. 2. Schematics of exciton pair formation across a direct gap [4]

Another proposed novel category of insulators is the class of excitonic insulators, in which an insulating state is formed in compensated systems such as semiconductors with a direct gap across which electrons and holes are bound into 'excitonic' pairs [4]. However, the existence of this novel insulating state remains elusive - while theoretically proposed, no clear experimental evidence has thus far been yielded for the existence of an excitonic insulator except in artificial systems of cold atoms.

Experimental

Our recent transport measurements in both magnetoresistance and Hall resistance (R_{xx} & R_{xy}) using high quality single crystals of SmB_6 at pulsed magnetic fields up to 65T at NHMFL, Los Alamos revealed intriguing behavior. A surprising change occurs from strongly negative magnetoresistance at temperatures above the low temperature plateau region, to an absence of any significant magnetoresistance in the low temperature plateau region.

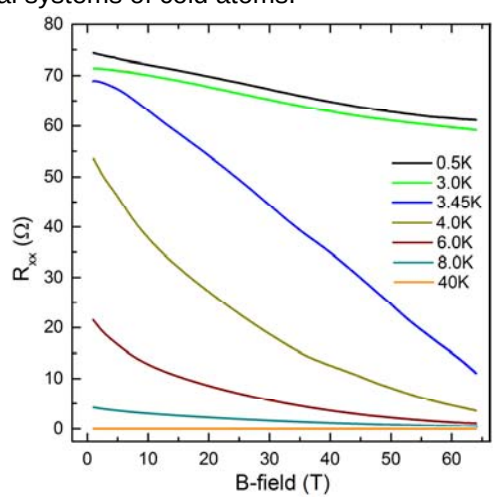

Fig. 3. Magnetoresistance of SmB_6 up to 65T for a range of temperatures.

Results and Discussion

Possibilities to be considered are whether the change in magnetoresistive behavior at temperatures above the low temperature plateau phase, and within the low temperature plateau phase indicate evidence either for a topological insulating state, or for an alternative form of correlated insulating state, such as an excitonic insulator.

References

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