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PAPER

Multiple metamagnetism, extreme magnetoresistance and nontrivial topological electronic structures in the magnetic semimetal candidate holmium monobismuthide

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Abstract

Inconceivably large changes (up to 10^6%) of the resistivity induced by external magnetic field—a phenomenon known as the extreme magnetoresistance effect has been reported in a great number of exotic semimetals. The very recent and exciting discoveries mainly pay attention to the compounds without magnetic ground states, which appears to limit the potential growth of semimetal family. For fundamental scientific interests, introduction of spin degree of freedom would provide an almost ideal platform for investigating the correlation effect between magnetism, crystallographic structure and electric resistivity in materials. Here, we report the experimental observation of metamagnetic behaviors and transport properties of HoBi single crystals. Being a magnetic member of the rare earth monopnictide family, the magnetoresistance of HoBi is significantly modulated by the magnetic orders at low temperature, which shows a nonmonotonic increment across the successive magnetic phases and reaches 10^4% (9 T and 2 K) in the ferromagnetic state. Kohler's rule predicts that more than one type of carriers dominates the transport properties. Well fitted magnetoresistance and Hall resistivity curves by the semiclassical two-band model suggest that the densities of electron and hole carriers are nearly compensated and the carrier mobilities in this compound are ultrahigh. Besides, the inverted band structures and nonzero Z_2 topological invariant indicate that possible nontrivial electronic states could generate in the ferromagnetic phase of HoBi. Combining the experimental and theoretical results, it is found that the cooperative action of carrier compensation effect and ultrahigh mobility might contribute to the extreme magnetoresistance observed in the titled compound. These findings suggest a paradigm for obtaining the extreme magnetoresistance in magnetic compounds and are relevant to understand the rare-earth-based correlated topological materials.

1. Introduction

Magnetoresistance (MR), which means that the resistance of materials can be tuned by external magnetic field, brings revolution to modern industry through its device applications, such as magnetic sensors, hard drives and so on [1]. Besides the anisotropic magnetoresistance, giant magnetoresistance, colossal magnetoresistance and