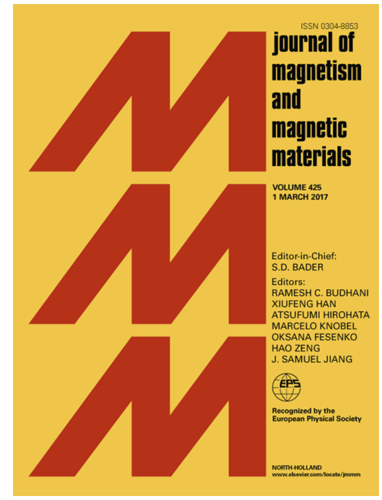

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Spin-flop phase transition in the orthorhombic antiferromagnetic topological semimetal $Cu_{0.95}MnAs$

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Abstract

The orthorhombic antiferromagnetic compound CuMnAs was recently predicted to be an antiferromagnetic Dirac semimetal if both the R_y gliding and the S_{2z} rotational symmetries are preserved in its magnetic ordered state. In our previous work on $Cu_{0.95}MnAs$ and $Cu_{0.98}Mn_{0.96}As$, we showed that in their low temperature commensurate antiferromagnetic state the b axis is the magnetic easy axis, breaking the S_{2z} symmetry and resulting in a polarized surface state that could make this material potentially interesting for antiferromagnetic spintronics. In this paper, we report a detailed study of the anisotropic magnetic properties and magnetoresistance of $Cu_{0.95}MnAs$ and $Cu_{0.98}Mn_{0.96}As$. Our study shows that in $Cu_{0.95}MnAs$ the magnetic easy axis is along the b direction and the hard axis is along c. Furthermore, it reveals that $Cu_{0.95}MnAs$ features a spin-flop phase transition at high temperatures and low fields when the field is applied along the easy b axis. However, no metamagnetic transition is observed for $Cu_{0.98}Mn_{0.96}As$, indicating that the magnetic interactions in this system are very sensitive to Cu vacancies and Cu/Mn site mixing.

Keywords: Metamagnetism, Spin flop transition, topological semimetal

1. Introduction

Antiferromagnetic (AFM) materials have recently brought new excitement to the field of condensed matter physics due to their potential applications in spintronics, a field which studies the effect of the charge carrier spin in conduction. AFM systems lack a net magnetic moment although the individual atoms are magnetic, and this makes them "invisible" to external magnetic fields, which originally led researchers to believe that they could not be used for practical applications [1]. It was not until a few years ago that it was realized that antiferromagnets have many characteristics that make them suitable for spintronics; they are insensitive to magnetic field perturbations, do not generate stray fields, and have faster spin dynamics than ferromagnets since their resonant frequencies are higher [1, 2]. The prediction and subsequent discovery of the anomalous Hall effect [3, 4] and the spin Hall effect [5, 6, 7] in AFMs have also contributed to their recent popularity.

Tetragonal CuMnAs has been studied for its potential applicability as an AFM spintronic material since 2013 [8, 9]. Recently, its orthorhombic polymorph was proposed to host Dirac fermions[10]. If the combination of inversion and time-reversal symmetries, $\mathcal{PT}$, is preserved, the existence of Dirac fermions can be achieved when both the R_y gliding and the S_{2z} rotational symmetries are preserved in the magnetic state. The Dirac fermions in CuMnAs have also been predicted to be controlled by the spin-orbit torque reorientation of the Néel vector [11] .

In our previous paper, we first reported on the synthesis and magnetic structures of single crystalline $Cu_{0.95}MnAs$, which crystallizes in the $Pnma$ space group with lattice parameters a = 6.5716(4) Å, b = 3.8605(2) Å, and c = 7.3047(4) Å, and $Cu_{0.98}Mn_{0.96}As$, with lattice parameters a = 6.5868(4) Å, b = 3.8542(3) Å, and c = 7.3015(5) Å[12]. Although an additional intermediate incommensurate AFM state exists in $Cu_{0.98}Mn_{0.96}As$,

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