Magnetization measurements in high pulsed magnetic fields on single crystals $BaCuSi_2O_6$ doped with Sr

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Introduction

Undoped $BaCuSi_2O_6$ is one of the spin model system for field-induced antiferromagnetic (AFM) ordering that can be described as Bose-Einstein condensation of triplons. Comprehensive investigations of the phase boundaries and the critical exponent close to the lower critical field H_{c1} revealed a change of dimensionality from 3 to 2 when going below 1K in temperature [1] that was attributed to frustrated inter-layer exchange interactions. However, a recent theoretical study of the magnetic coupling constants excluded significant frustration to be present in the underlying spin model and questioned previous interpretations [2]. Instead, it is discussed, if the change in critical exponents is actually rooted in a structural phase transition that occurs at 90T and changes the $I4_1/acd$ tetragonal crystal structure into a slightly distorted monoclinic lattice for lower temperatures. The structural phase transition was also found to be the reason for inequivalent intra-dimer exchange coupling of ~ 16%.

Experimental

We have succeeded in growing high quality single crystals $BaCuSi_2O_6$ with 10% Sr doping that do not exhibit the structural phase transition, which leaves room to contribute with new experimental data to the discussion of the critical exponents close to the onset of the AFM order [3]. In a first step of our high field investigations, we carried out magnetization measurements $M(H)$ in pulsed magnetic fields to 50T at the NHMFL in Los Alamos down to ^{3}He temperatures.

Results and Discussion

At low temperature, the magnetization of $BaCuSi_2O_6$ shows small impurity contributions at low fields that are saturated in ~ 5T. Above 20T, the onset of AFM ordering is indicated by a kink in $M(H)$ and followed by a continuous increase of $M(H)$ up to a second critical field H_{c2}, where all Cu moments are fully polarized. A careful analysis of the critical field at lowest T reveals that its value is only slightly reduced when compared to the pure system (22.5T instead of 23.5T). Fig. 2 shows the phase diagram assuming constant temperature during the $M(H)$ measurements. This assumption is most likely incorrect as indicated by comparing the phase boundary with the maximum temperature of the AFM dome in pure $BaCuSi_2O_6$. We conclude a significant decrease of the temperature takes place during the magnetic field pulse that will be investigated in a follow up study of the magnetocaloric effect in pulsed magnetic fields.

References
[1] S. E. Sebastian *et al*., Nature **441**, 617 (2006).
[2] V. V. Mazurenko *et al*., Phys. Rev. Lett. **112**, 107202 (2014).
[3] N. Well *et al*., Cryst. Growth Des. **90**, 205120 (2016).

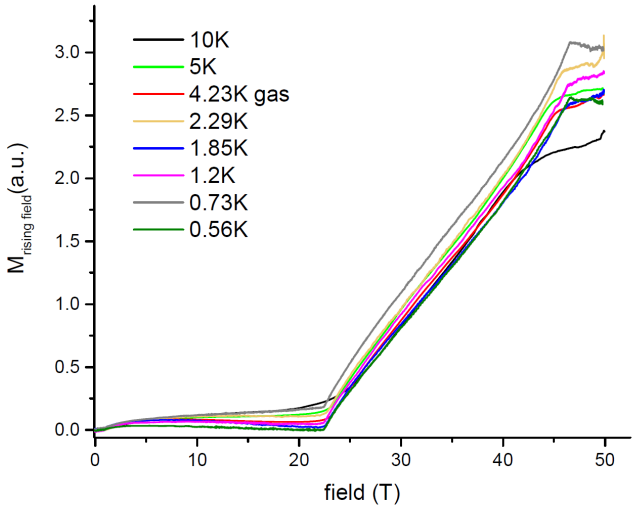

Fig. 1 Magnetization measurements up to 50T of 10% Sr-doped $BaCuSi_2O_6$ single crystals for *H* ll *c*. The magnetization shows similar behavior when compared to the pure material with field-induced order between 22.5T and 47T.

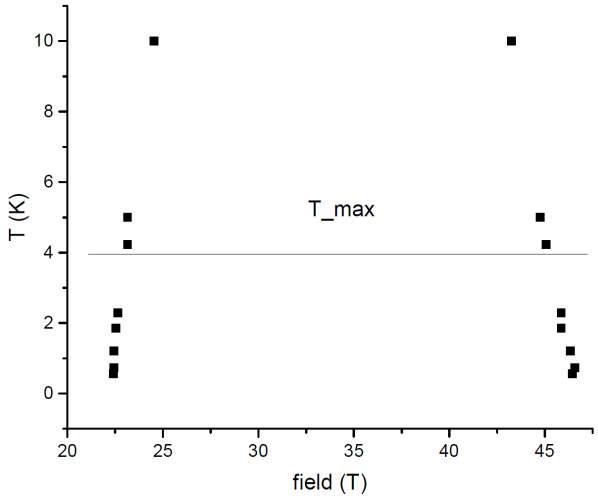

Fig. 2 Magnetic phase diagram of 10% Sr-doped $BaCuSi_2O_6$. The line marks maximum transition temperature of the AFM dome in the undoped compound, which points to a significant magnetocaloric effect during the magnetization experiments.