

# H-T phase diagram of high- $T_c$ Ba-K-Bi-O

Larisa N. Zherikhina <sup>a,1</sup>, A.I. Golovashkin <sup>a</sup>, A.V. Gudenko <sup>a</sup>, G.V. Kuleshova <sup>a</sup>,  
A.M. Tskhovrebov <sup>a</sup>, M.L. Norton <sup>b</sup>

<sup>a</sup> *P.N.Lebedev Physical Institute of Russian Academy of Sciences, Leninskii Pr.53, Moscow, 117924, Russia*

<sup>b</sup> *Department of Chemistry, Marshal University, Huntington, WV 25755, USA*

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## Abstract

The magnetic behavior of Ba-K-Bi-O single crystals below  $T_c$  was investigated. The magnetic moment hysteresis loops were examined with the help of a small Hall detector. The complex analysis of the data on the temperature dependencies of the residual magnetic moment and  $H_{c1}$ , obtained from the magnetic experiments, and the resistive superconducting transition curves give rise to the following picture: at  $T_c = 30K$  the transition to the continuous superconducting phase takes place, while at  $T^* = 17K$  one more transition happens - to the spatially inhomogeneous superconductor-insulator state, that also could be destroyed either by temperature or by magnetic field.

*Key words:* BaKBiO ;magnetic moment ;hysteresis loop

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## 1. Introduction

Earlier [1] we have observed a series of anomaly properties of high temperature superconductor  $Ba_{0.6}K_{0.4}BiO_3$  in superconducting state. First experiments were performed on polycrystal samples. The above mentioned anomalies showed up in 1) the reentrance of the resistive state below critical temperature  $T_c$ , that could be suppressed by magnetic field, 2) nonmonotonic temperature dependence of critical current, 3) the positive curvature of the dependence of the magnetic field versus temperature *etc* . The package of all observed anomalies was explained in the framework of the model of the spatially inhomogeneous superconductor-insulator state (SISIS) [2] that appears in the Ba-K-Bi-O system at some temperature  $T^*$  below  $T_c$ . The followed investigations on  $Ba_{0.6}K_{0.4}BiO_3$  single crystals [3] confirmed that the anomalous behavior (for instance, the reentrance of resistive state below  $T_c$ ) is the inherent prop-

erty of Ba-K-Bi-O system and not the consequence of the morphology of the sample. The present work is devoted to the research of magnetic properties of  $Ba_{0.6}K_{0.4}BiO_3$  single crystals in superconducting state ( $T < T_c$ ) in different magnetic fields.

## 2. Experiment

The magnetic moment ( $M$ ) of sample placed in the external magnetic field ( $H$ ) was measured with small Hall detector. The first run curves  $M(H)$  and hysteresis loops  $M(H)$  were studied at constant temperature below  $T_c = 30K$ . The  $M(T)$  dependencies both zero field cooled and field cooled ( $0 < H < 650Oe$ ) were also investigated.

## 3. Results and discussion

In Fig.1 the temperature dependencies of the residual magnetic moment ( $M_0$ ) and first critical magnetic field ( $H_{c1}$ ) are demonstrated.  $M_0$  was obtained from

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<sup>1</sup> Corresponding author. Present address: P.N.Lebedev Physical Institute of Russian Academy of Sciences, Leninskii Pr.53, Moscow, 117924, Russia E-mail: zherikh@sci.lebedev.ru

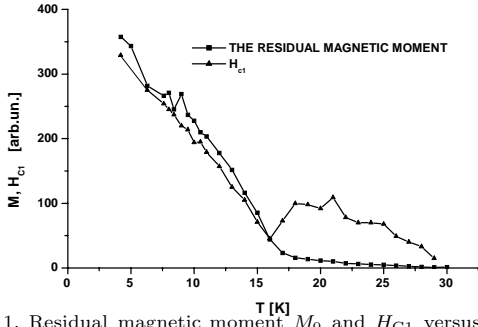


Fig. 1. Residual magnetic moment  $M_0$  and  $H_{C1}$  versus temperature.

the hysteresis loop  $M(H)$  and  $H_{C1}$  was determined from the first run curve  $M(H)$  as a field of the end of linear enhancement of  $M$  versus  $H$ . Both dependencies are quite similar and have a stand out peculiarity: a bend at  $T^* = 17K$ . In the temperature interval  $T^* < T < T_C$  the residual magnetic moment is practically absent while below  $T^*$  the magnetization becomes strongly irreversible. The start point of the  $M(H)$  irreversibility ( $T^* = 17K$ ) coincides with the beginning of the reentrance of resistive state [1,3]. The observed behavior of magnetization fits well into the whole picture, described by SISIS model, according to which at certain circumstances the SISIS state becomes more energetically favorable with respect to the common homogeneous superconducting state (HSS) (Fig.2). The enhancement of  $M_0$  means that a lot of pinning centers appear below  $T^*$  and dielectric regions in SISIS state could just serve as an effective pinning centers. The monotonic increase of  $M_0(T)$  at  $T < T^*$  may be the account of  $H_C$  and hence  $H_{C2}$  enhancement with temperature lowering in the SISIS state due to the increase of the depth of modulation of the superconducting order parameter [1,2]. The possible alternative explanation of the bend on  $M_0(T)$  curve by the existence of two superconducting phases with different critical temperatures 17 K and 30 K occurs to be wrong due to the fact that the slope of initial linear parts of the first run curves  $M(H)$  for temperatures below and above  $T^*$  are just equal. It means that volumes of superconducting phase below and above  $T^*$  are just the same. At  $T^* < T < T_C$  the energy of homogeneous superconducting state happens to be lower than that of SISIS (Fig.2), but due to the close values of the energy of both states local fluctuations of SISIS could arise that are not locked in space and thus inhibit effective shielding of magnetic field that leads to a decrease of  $M_0$  and  $H_{C1}$ .

## References

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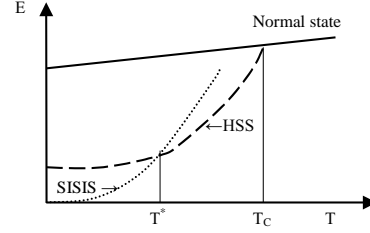


Fig. 2. Free energy of different phase states of the system versus temperature.

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