Low Temperature Physics　　Prof. **Norio Kobayashi** (1990.5~)

【Staff Members】

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【Research Activities】

Magnetic field driven order-disorder transition in $YBa_2Cu_3O_y$ was investigated by using STM/STS from the microscopic point of view on the vortex structure. Direct imaging of the vortex structure demonstrated that the triangular lattice formed in the low field Bragg glass phase took a phase transition into the disordered phase (vortex glass phase) with increasing magnetic fields. In addition, systematic investigation of the relation between the macroscopic vortex state and microscopic electronic state was carried out in $YBa_2Cu_3O_y$ in which substitation of by Zn and Ni took piace as an impurity in the Cu site.

An important result obtained in 2004 was the observation of the real space imaging of the metal-insulator phase separation near the first order Mott transition in the highly correlated organic conductors. The k type BEDT-TTF molecule based organic conductor has an effective half. filled band due to the BEDT-TTF molecule dimmer structure. The band width as compared to the on-site Coulomb interaction can be controlled by applying relatively low pressure and/or chemical substitution of modified molecules. The salts are classified to the band width controlled Mott system. The metal-insulator phase separation was found in the band width controlled k-$(BEDT\text{-}TTF)_2Cu[N(CN)_2]Br$ by using the scanning micro region infrared reflectance spectrum measurement technique using synchrotron radiation at SPring-8. The frequency shift of the strongly EMV coupled molecular vibration was used as the local proof. This is the first direct observation of the real space imaging of the electronic inhomogeneity in micrometer size due to the electronic correlation.

1. N. Kobayashi, T. Nishizaki, K. Shibata, and T. Sasaki.
Vortex state in $YBa_2Cu_3O_y$ crystals: vortex phase diagram and tunneling spectroscopy in magnetic field.
Physica B 346-347 (2004) 329 -333.

2. T. Nishizaki, K. Shibata, M. Maeda, T. Sato, and N. Kobayashi
Vortex order-disorder transition and the effect of Zn and Ni substitution in $YBa_2Cu_3O_y$.
Proceedings of Joint meeting of the International Symposium on JSPS Core-to-Core Integrated Action Initiative "Nanoscience and Engineering in Superconductivity" (CTC-NES) and The 4th International Symposium on Intrinsic Josephson Effect and Plasma Oscillations in High-Tc Superconductors (PLASMA 2004), (2004) pp. II-27 - II-30.

3. T. Sasaki, I. Ito, N. Yoneyama, N. Kobayashi, N. Hanasaki, H. Tajima, T. Ito, and Y. Iwasa.
Electronic correlation in the infrared optical properties of the quasi-two-dimensional k-type BEDT-TTF dimer system.

Phys. Rev. B 69 (2004) 064508-1-064508-7.

4. T. Sasaki, N. Yoneyama, N. Kobayashi, Y. Ikemoto and H. Kimura.
Imaging phase separation near the Mott boundary of the correlated organic superconductors k-(BEDT-TTF)$_{2X}$.
Phys. Rev. Lett. 92 (2004) 227001-1-227001-4.

5. N. Yoneyama, T. Sasaki and N. Kobayashi.
Substitution effect by deuterated donors on superconductivity in k (BEDT-TTF)$_2$ Cu[N(CN)$_2$] Br.
J. Phys. Soc. Jpn. 73 (2004) 1434-1437

【Plan】

Scientific target of the low temperature physics division is to resolve the mechanism and property of the superconductivity in high-Tc superconductors. Our research is carried out on the basis of the experimental techniques which have been built up so far in our laboratory; high quality single crystal growth, high precision bulk property measurement, and scanning tunnel microscopy and spectroscopy (STM/STS) at low temperature and in high magnetic fields. Main interest at present is the local electronic state and the relation to the bulk property of the superconductivity in the highly correlated electron system. We are planning to extend the measurement temperature and magnetic field regions of the STM/STS equipment. Strategic target is the discovery of the novel superconducting state in high magnetic fields, for example, spatial modulation of the superconducting order parameter along magnetic fields (FFLO state) and the magnetic field induced superconductivity. Specific programs in short term are running by using STM/STS as follows. (**Ref.*1***) Local electronic modulation at the impurity atom (Ni, Zn) substituting the Cu site of $YBa_2Cu_3O_y$ and the relation to the superconducting properties. (**Ref.*2***) Charge density modulation on the one dimensional CuO chain of $YBa_2Cu_3O_y$ and the relation to the superconductivity. (**Ref.*3***) Spin and charge modulation structure in the novel one dimensional copper oxide ladder system $Sr_{14}Cu_{24}O_{41}$. (**Ref.*4***) Pseudo gap formation and the suppression in magnetic fields in Bi based copper oxide superconductors. (**Ref.*5***) Charge order and the melting process in the quasi two dimensional organic conductors.