Charge Density Waves Orderings in $LiCu_2O_2$ Single Crystal Studied by X-ray Scattering

Tzi-Wen Huang (黃子文)[1], Maw-Kuen Wu (吳茂昆)[1],
Yen-Fa Liao (廖彥發)[2], and Kuan-Li Yu (于冠禮)[3]

[1]Institute of Physics, Academia Sinica, Taipei, Taiwan
[2]Department of Engineering and System Science, National Tsing Hua University, Hsinchu, Taiwan
[3]National Synchrotron Radiation Research Center, Hsinchu, Taiwan

Single crystals of $LiCu_2O_2$ were grown using the self-flux methods in an alundum crucible at air atmosphere. The lattice structure which was verified by X-ray diffraction was an orthorhombic with Pnma group. The lattice parameters a=5.730, b=2.8606, and c=12.417 were also refined in this experiment periods. From the measurements, it follows that crystals of the $LiCu_2O_2$ phase are p-type semiconductors as judged from their electrical resistivity, its temperature behavior, and the sign of the Seebeck coefficient. Under the preliminary measurement, the slope of the d(ρ)/d(T) curve decreases with decreasing temperature, which indicates a gradual decrease in the differential activation energy for charge transport from a value of 0.17 eV in the temperature region 180–290 K to 0.08 eV in the range 80–100 K (for dc resistivity). Increasing the measuring field frequency to 100 kHz brings about a noticeable decrease in resistivity in the range 80–250 K. The main finding of this experiment is that below Tc ~ 22-24^{o}C $LiCu_2O_2$ acquires incommensurate magnetic long-range order or the for-mation of charge-ordered stated of charge density waves (CDWs) in Cu-O chain which is also hinted in Fig. 1.

Figure 2 shows the measured temperature dependence of (0.5, 0.810, 9) Bragg reflection peak integrated intensity of $LiCu_2O_2$. Obviously the peak intensity is vanishing when samples temperature arise up to 25 K. From our investigation, the phase transition leads to an appearance of new Bragg reflections that can be indexed as {[(2n+1)/2],k±ξ,l}, n,k,l integer, ξ~0.189. Comparing with neutron experiment results reported by T. Masuda *et. al.*, the ξ~0.174 for neutron diffraction was smaller than ours. This difference should be cleared as the reason of original mechanism which Bragg reflections come from, except of the incommensurate magnetic long-range order. Some researches suggest the origin of this disorder would be the possibility of the formation of charge-ordered stated of charge density waves (CDWs) in Cu-O chain. The possible relation between charge localization and the formation of a CDW is suggested by data on the $(Sr,Ca,La)_1Cu_2O_2$ phase with similar crystallochemical properties, in which hopping conduction, localization of electronic states, and nonlinearity are associated with CDWs. However, it still should be more detail to distinguish the weighting for these Bragg reflections which comes from spin or electron redistribution. Moreover, it needs more time to calibrate representational analysis of the crystallographic space group with the propagation vector and mapping the intensity of Bragg reflection peaks to overview the charge or spin density wave distribution in real space. In shortly concluding, the temperature dependence of the Bragg reflection peaks were observed below the phase transition temperature (Tc~22-24K) in this experiments, and more detail analysis to find out the original physical reason should be carried out in the future.

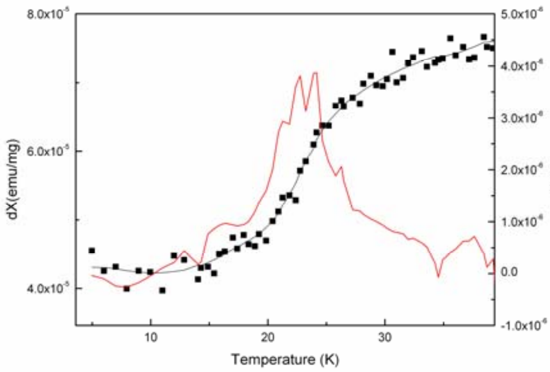

Figure 1. Temperature dependence of magnetic suscepti-bility of $LiCu_2O_2$ measured in a magnetic filed H= 100 Oe. Taking a numerical derivative (red solid line) reveal a phase transition Tc=22-24 K.

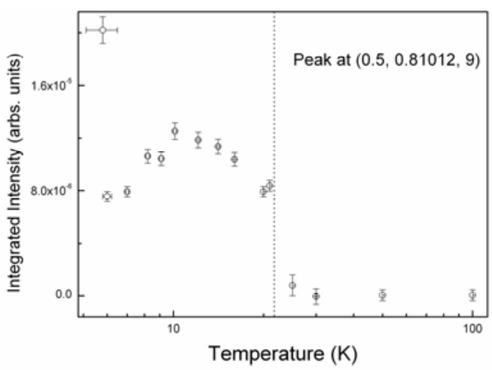

Figure 2. Measured temperature dependence of (0.5, 0.81012, 9) Bragg reflection peak integrated intensity in $LiCu_2O_2$.

Reference

T. Masuda, A. Zheludev, B. Roessli, A. Bush, M. Markina, and A. Vasliev, Phys. Rev. B **72**, 014405 (2005).