Magnetoelectric Effect in Quasi-two-dimensional Molecule-based Mott insulator

Drichko, N. and Hassan, N.M. (Johns Hopkins U., Physics); Zhilyaeva, E.L.; Turunova, S. and Lyubovskaya, R.N. (Institute of Problems of Chemical Physics, Chernogolovka, Russia)

Introduction

An entanglement of charge and magnetic degree of freedom in spin-liquid candidate quasi-two-dimensional molecular materials on triangular lattice was recently suggested as an origin of spin liquid state in these materials. The first step to study this coupling is to use a better understood example of a charge ordered materials where a similar mechanism of charge-spin coupling can be present. Our study focuses on a charge ordered insulator κ-(BEDT-TTF)$_2$Hg (SCN)$_2$Cl. According to the theoretical suggestion [1] the charge order can be decreased by an application of the magnetic field. We can characterize charge state of the studied molecular based material by observing charge-sensitive molecular vibrations. In our preliminary measurements of Raman scattering in magnetic field up to 18 T we observed a weak effect of magnetic field on charge order. In the planned measurements we are going to measure Raman scattering in fields up to 31 T to observe the predicted magnetooptical effect.

Experimental

Raman scattering measurements were performed at temperatures between 50 and 2 K using Princeton Instruments Raman spectrometer equipped with a fiber-based probe and exchange gas cryostat to reach temperatures down to 2 K on the sample. Measurements were performed using magnetic field up to 31 T in geometry where magnetic field B was parallel to the excitation and scattered light wave vector and perpendicular to the conducting plane of κ-(BEDT-TTF)$_2$Hg (SCN)$_2$Cl single crystal.

Results and Discussion

In our measurements we observed the charge-sensitive vibrations of BEDT-TTF molecule, which can be used as a tool to characterize the charge state [2], and followed their change in magnetic field (see Fig. 1). While the maximum field of 31 T is comparable to the temperature of the charge-order transition of 30 K, we saw no clear evidence of the influence of magnetic field on the charge state of κ-(BEDT-TTF)$_2$Hg (SCN)$_2$Cl in this field geometry. The weak change of vibrational features in the charge ordered state (Fig. 1 b) is comparable to noise, and shows a slight increase in charge order band intensity at high fields. To summarize, no magnetoelectric effect was detected for κ-(BEDT-TTF)$_2$Hg (SCN)$_2$Cl in the fields up to 31 T directed perpendicular to the conductance plane.

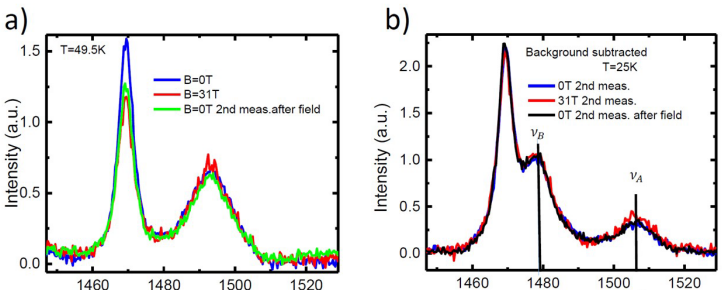

Fig.1 Raman spectra of κ-(BEDT-TTF)$_2$Hg(SCN)$_2$Cl in the region of charge sensitive molecular vibration ν_2 . (a) Spectra in the metallic state at 52 K. (b) Spectra in the charge ordered state at 25 K. ν_2 (A) and ν_2 (B) bands correspond to charge-rich and charge-poor molecular sites

The robustness of the charge order and metallic phases under magnetic field shows that the charge degrees of freedom are not strongly coupled to the magnetic behavior of the material. A preparation of a publication is in progress.

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References

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