Quantum glass of interacting electrons on triangular lattices

H. Murase[1], S. Arai[1], T. Sato[1,+], K. Miyagawa[1], H. Mori[2], T. Hasegawa[1] and K. Kanoda[1]

[1] *Dept. of Appl. Phys., Univ. of Tokyo, Bunkyo-ku, 113-8656 Tokyo, Japan. kanoda@ap.t.u-tokyo.ac.jp*
[2] *ISSP, Univ. of Tokyo, Kashiwa, 277-8581 Chiba, Japan.*
+ Present address: Inst. for Mol. Sci., Myodaiji, 444-8585 Okazaki, Japan

In the science of glass, a new class of matter has emerged – electron glass (called charge glass to distinguish it from spin glass) formed by Coulomb interacting electrons on a triangular molecular lattice that fail to undergo Wigner crystallization owing to the lattice mismatch. We have so far revealed that the charge glass exhibits properties common to the conventional glass (formed by atoms, molecules, polymers, and colloids), which include slow dynamics, aging, middle-scale spatial correlation and crystallization [1]. However, charge glass qualitatively differs from the conventional glasses; i) it forms on a regular lattice, which gives a new dimension to glass research, as it provides an opportunity to control the stage for the glass formation; ii) the glass former has a quantum nature [2], which introduces the discipline of quantum physics to the glass physics thus far developed in the realm of classical physics. In this workshop, we present our recent observations of quantum manifestations of charge glasses in layered organic conductors, θ-$(ET)_2X(SCN)_4$ (X=TlCo, RbZn and CsZn).

First, with Raman microspectroscopy, we successfully performed real-space and real-time imaging of electronic crystallization and found that the growth rate is many orders of magnitude larger than that in the conventional case, which may be attributable to the quantum effect [3].

Secondly, we analyzed Raman spectrum to capture a snapshot of the charge density distribution of each molecule in the series of charge glasses in θ-$(ET)_2X(SCN)_4$ with different geometrical frustrations. In less frustrated glass, the charge density profile exhibits a particle-like two-valued distribution; however, it becomes continuous and narrowed with increasing frustration, demonstrating the classical-to-quantum crossover [4]. Moreover, the charge density distribution shows contrasting temperature evolution in classical and quantum glasses, enabling us to delineate energy landscapes with distinct features [4]. These results experimentally identify the quantum charge glass and show how it emerges from classical glass.

References

[1] F. Kagawa *et al., Nat. Phys*. **9**, 419 (2013) ; T. Sato *et al., Phys. Rev. B*. **89**, 121102 (2014) ;T. Sato *et al., J. Phys. Soc. Jpn*. **83**, 83602 (2014) ; T. Sato *et al., J. Phys. Soc. Jpn*. **85**, 123702 (2016) ; K. Miyagawa *et al, J. Phys. Soc. Jpn*. **88**, 034705 (2019) ; T. Sato *et al., Science* **357**, 1378 (2017).
[2] T. Sato *et al., Nature Mat*. **18**, 229 (2019).
[3] T. Sato *et al., Phys. Rev. Lett*. **125**, 146601 (2020).
[4] H. Murase *et al*., arxiv.2201.04855.
[5] H. Murase *et al*., submitted..