Bipartite Elementary Excitations in Two-Dimensional Quantum Spin Liquid

Yuji Matsuda
Department of Physics, Kyoto University, Kyoto 606-8502, Japan

Spin systems confined to low dimensions exhibit a rich variety of quantum phenomena. Particularly intriguing are quantum spin liquids (QSLs), antiferromagnets with quantum fluctuation driven disordered ground states, which have been attracting tremendous attention for decades. In dimension greater than one, it is widely believed that QSL ground states are likely to emerge in the presence of geometrical frustrations. In 2D, typical examples of systems where such geometrical frustrations are present are the triangular and kagomé lattices. Largely triggered by the proposal of the resonating-valence-bond theory on a 2D triangular lattice and its possible application to high-T_c cuprates, realizing/detecting QSLs in 2D systems has been a long-sought goal. Two recently discovered organic insulators, κ-$(BEDT\text{-}TTF)_2Cu_2(CN)_3$ and $EtMe_3Sb[Pd(dmit)_2]_2$, both featuring 2D spin-1/2 Heisenberg triangular lattices, are believed to be promising candidate materials which are likely to host QSLs.

Here, to unveil how the elementary excitations above a QSL ground state behave, we study the low-temperature heat-transport properties of κ-$(BEDT\text{-}TTF)_2Cu_2(CN)_3$ [1] and $EtMe_3Sb[Pd(dmit)_2]_2$ [2]. In the temperature dependence of thermal conductivity, a sizable linear term is clearly resolved in the zero-temperature limit in $EtMe_3Sb[Pd(dmit)_2]_2$, indicating the presence of gapless excitation. Meanwhile its magnetic-field dependence suggests a concomitant appearance of spin-gap-like excitations at low temperatures. These findings expose a highly unusual dichotomy which characterizes the low-energy physics of this quantum liquid.

In collaboration with M. Yamashita, T. Shibauchi, Y. Senshu, M. Nagata, S. Fujimoto (Kyoto Univ.), T. Sasaki(Tohoku University), H.M. Yamamoto and R. Kato (RIKEN)

[1] M. Yamashita, N. Nakata, Y. Kasahara, T. Sasaki, N. Yoneyama, N. Kobayashi, S. Fujimoto, T. Shibauchi, and Y. M. Nature Physics 5, 44 (2009).
[2] M. Yamashita, N. Nakata, Y. Senshu, M. Nagata, H.M. Yamamoto, R. Kato, T. Shibauchi and Y. M., Science **328**, 1246 (2010).