Short-range order in a two-dimensional dipole liquid

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Many fascinating quantum phenomena, such as high-temperature superconductivity, were found in a two-dimensional (layered) insulator doped by foreign dopants. Although these dopants have been often neglected in theoretical models for the sake of brevity, it is true that they remain in actual materials. More importantly, these dopants seem to be arbitrarily distributed at first glance, but they may form a short-range order characterized by broad peaks in the structure factor arising from an average distance between dopants. In this talk, I will introduce some of our recent works using angle-resolved photoemission spectroscopy (ARPES) on the effect of this short-range order to the electronic structure. The material system is a two-dimensional layered insulator (black phosphorus) doped by alkali metals. It could be modeled by a system of two-dimensional dipoles that consist of doped electrons and dopant ions. We found the short-range order is responsible for the pseudogap[1] and the anomalously aperiodic dispersion (electronic roton)[2]. If time permits, I will also discuss on the dark state of electrons in a system with two pairs of sublattices[3], and the direct measurement of a full quantum metric tensor in black phosphorus[4].

References

1. S. H. Ryu *et al., Nature* **596,** 68 (2021).
2. S. Park *et al., Nature* **634,** 813 (2024).
3. Y. Chung *et al., Nature Phys.* **20,** 1582 (2024).
4. S. Kim *et al., accepted in Science* (2025).