凝縮系物理学ゼミナール

Condensed Matter Seminar

Location: **Room 413**, School of Science Bldg. 5 and online via Zoom

Date: **13:30-15:00**, Friday, 6 August 2021

“Probing the three-state Potts nematic fluctuation by ultrasound”

Speaker: **Kazuhiro Kimura** (Kyoto Univ.)

Abstract:

Recent discoveries of electron nematic phases, which break the point group symmetry of the system, have suggested that the superconducting pairing mechanism may be strongly related to nematicity in correlated electron systems, such as cuprates, iron-based compounds, doped-Bi_2Se_3, and magic-angle twisted-bilayer graphene (MA-TBG). One of the great interests in electron nematic states is why the electron nematic states emerge so ubiquitously in many unconventional superconductors in condensed matter physics. In the case of MA-TBG, an electron nematic state, which breaks the lattice C_{3z} symmetry, is reported by scanning tunneling microscopy and transport measurements. This C_{3z} breaking electron nematic state, denoted as a three-state Potts nematic state[1], is of interest for its competition with nematic superconductivity[2] and the mystery of the Landau level degeneracy in different regions of its phase diagram. Moreover, in the case of doped-Bi_2Se_3, the three-state Potts nematic state[3] are reported above the superconducting transition temperature and it is pointed out that this nematic state is a vestige of the nematic superconductivity[4]. In addition to the relationship between nematicity and superconductivity, it is also very important problem to identify critical behavior of electron nematic states and to distinguish whether it is induced spontaneously or from trivial strains.

Motivated by recent studies of the three-state Potts nematic state, we analyze[5] the effects of critical nematic fluctuation on phonons. Despite a lot of research, however, an identification of such a three-state Potts nematic state and clarifying whether it is induced spontaneously or from trivial strains are not an easy task. In this study, we analyze the impact of the nemato-elastic coupling on the low energy properties of phonon by a phenomenological argument using a Gaussian-Ginzburg-Landau-Wilson action. It is shown that nematic fluctuations induce an isotropic divergence of the transverse sound attenuation coefficient and an isotropic lattice softening. Moreover, we analyze microscopic calculation for an electron nematic phase transition and estimate the critical behavior of sound attenuation coefficients. In addition to the MA-TBG, our results can be applied to a vestigial nematic state of doped-Bi_2Se_3.

References:

[1] R. M. Fernandes and J. W. F. Venderbos, Science Advances 6, eaba8834 (2020).

[2] Y. Cao, et. al., arXiv:2004.04148 (2020).

[3] C.-w. Cho, et. al., Nat. Commun. 11, 3056 (2020).

[4] M. Hecker and J. Schmalian, npj Quantum Mater. 3, 26 (2018).

[5] K. Kimra, M. Sigrist and N. Kawakami, in preparation