Center for Artificial Low D Electronic Systems

2023 IBS-CALDES Science Meeting Seminar

- ✓ **Date & Time:** April 17 (Mon), 2023, 9:00AM
- ✓ **Zoom ID : 885 1657 5577 / PW : 304373**

- ✓ **Speaker & Title**

09:00AM~ Prof. Hanno H. Weitering (U. of Tennessee)

- Title: Chiral Superconductivity on a Silicon Surface

10:10AM~ Dr. Julian Ingham (Boston Univ.)

- Title: Excitonic condensation and superconductivity in kagome metals

Organized by Dr. Jhin Hwan Lee (jhinhwan@ibs.re.kr, 054-279-9894)

Center for Artificial Low D Electronic Systems

- **09:00AM~**

Chiral Superconductivity on a Silicon Surface

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Chiral superconductors represent an exotic and heavily pursued state of matter where the angular momentum state of the superconductive Cooper pairs is ‘unconventional’ and time-reversal symmetry is broken. While there are several candidates for the realization of chiral superconductors, including e.g. NaxCoO2 [1] and hole-doped graphene [2], conclusive evidence for the existence of chiral superconductivity has yet to be established. Here we present evidence for the existence of chiral d-wave superconductivity in a dilute monatomic Sn layer on the Si(111) surface. This triangular single-band antiferromagnetic Mott insulator becomes superconducting upon hole doping [3], with a critical temperature reaching 9 K. With a coverage of only 1/3 monolayer of Sn, this represents the thinnest and most dilute superconductor known to date. Importantly, chirality produces a unique feature in quasi-particle interference images below the superconducting Tc, while the experimental edge state spectra are consistent with the calculated edge states for a chiral d-wave order parameter [4]. Whereas most candidates for chiral superconductivity are complex materials, the simplicity and experimental control of simple adsorbate systems provide a powerful testbed for theoretical models and discovery of elusive phases of quantum matter.

*In collaboration with F. Ming, K. Wang, S. Johnston and others

References

1.K. Takada, H. Sakurai, E. Takayama-Muromachi, F. Izumi, R.A. Dilanian, and T. Sasaki, Nature 422, 53 (2003).
2.R. Nandkishore, L.S. Levitov, and A.V. Chubukov, Nature Phys. 8, 158 (2012).
3.X. Wu, F. Ming, T. S. Smith, G. Liu, Fei Ye, K. Wang, S. Johnston, and H. H. Weitering, Phys. Rev. Lett. 125, 117001 (2020).
4.F. Ming et al., Nature Phys. (2023); https://www.nature.com/articles/s41567-022-01889-1

- **10:10AM~**

Excitonic condensation and superconductivity in kagome metals

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The kagome lattice is a network of corner-sharing triangles. Historically, the kagome structure has been closely studied in the context of insulating materials; due to the geometric frustration of the lattice, such systems are expected to host exotic magnetic states. Recent interest in metallic kagome systems has undergone a crescendo with the discovery of topological metal AV3Sb5, a superconductor with Tc ~ 2.5 K and a variety of novel ordered states at higher temperatures, including charge density wave (CDW) and nematic order. Initial theoretical work proposed that the charge density wave state may break time-reversal-symmetry (TRS), but experimental reports have conflicted – with some experiments indicating the presence of CDW but no TRS breaking.

Recent ARPES measurements have demonstrated the existence of twofold van Hove singularities near the Fermi level – a pair of saddle points with opposite concavity – the result of which are two hexagonal Fermi surfaces, one electron-like and the other hole-like. In this talk I will discuss some theoretical consequences of the Fermi surface structure in these materials. The presence of an electron and hole Fermi surface results in a strong tendency towards the formation of a condensate of excitons, i.e. electron-hole pairs, which I show may coexist with charge density wave order. The dominant excitonic state is chiral d-wave, resulting in the spontaneous breaking of TRS. I shall argue that these materials exhibit a coexisting phase of CDW and excitonic order, that TRS breaking and CDW are therefore independent, and that experiments may probe regions of phase space with CDW and no excitonic order. Time permitting, I will discuss some possible mechanisms for superconductivity arising from the topological properties of these materials