凝縮系物理学ゼミナール
Condensed Matter Theory Seminar

Date: 13:30-15:00, Wednesday, 17 July 2024

Title: Tuning monolayer superconductivity in twisted $NbSe_2$ graphene heterostructures

Speaker: Mr. Shun Asano

Abstract:

The physics of two-dimensional materials have been offered a wealth of fascinating phenomena. The recent advent of van der Waals (vdW) materials spurred further research in this topic. For example, transition metal dichalcogenides such as $NbSe_2$, TaS_2 and doped MoS_2 exhibit superconductivity even to the monolayer limit [1], which lead to captivate the attention of many researchers. In parallel, another unique aspect of vdW materials is their high functionality which enables to create an artificial heterotructure assembled with blocks defined with one-atomic-plane precision [2]. As represented by moiré superlattices, this strategy induces novel electronic states and intriguing phenomena. In particular, a discovery of superconductivity in magic-angle twisted bilayer graphene marked a milestone [3, 4], which drew a great deal of attention to the superconductivity as the first emerging by the twist.

Nevertheless, the modulation of the intrinsic SC property is not yet well understood in twisted heterostructures of monolayer superconductors and other materials. Especially when a monolayer superconductor is stacked with a twist on a monolayer substrate, the system is regarded as a twisted bilayer, where the monolayer SC state is expected to be strongly tuned by the substrate. In addition, the presence of an experimental parameter, i.e., the twist angle, can make it possible to design physical properties infeasible so far, leading to tune unconventional SC states on the monolayer superconductor.

In our study [5], we investigate the property of monolayer superconductivity, especially in a monolayer $NbSe_2$ stacked with a twist on doped graphene, which is regarded as a twisted bilayer. Although the previous work [6] revealed that there are two scenarios of the interlayer band hybridization in this system, the details of SC states in $NbSe_2$ layer have not been uncovered. Here, we mainly focus on the property of the $NbSe_2$ layer and reveal the twist angle dependence of the SC states by solving a self-consistent gap equation. The resultant twist angle dependence of the SC order parameters indicates that both enhancement and suppression of monolayer SC states are possible, which is explained by a formation of new van Hove singularities by the interlayer coupling. Moreover, we will talk the origin of chiral quasiparticle interference reported in this system [7].

References :

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[6] Y. S. Gani *et al*., Phys. Rev. B **99**, 235404 (2019).
[7] M. Naritsuka *et al*., arxiv 2405.14662 (2024).