# Theory of Chiral Topological Superconductivity and Pair Density Wave in Twisted Bilayer WSe2

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We theoretically explore possible intriguing phases induced by interactions between electrons in twisted bilayer transition metal dichalcogenides (e.g., WSe2) in the presence of an out-of-plane electric field [1, 2, 3]. Using renormalization group analysis, we predict that topological chiral superconducting states with Chern number $\mathcal{N}$ =1, 2, 4 (namely, $p+ip$, $d+id$, and $g+ig$) can appear over a large parameter region with a moiré filling factor around v=1. At some special values of applied electric field and in the presence of a weak out-of-plane Zeeman field, spin-polarized pair-density-wave (PDW) superconductivity can emerge [1]. For very recent discovery of unconventional superconductivity in twisted WSe2 homobilayers at filling v = − 1, considerable interest has arisen in revealing its mechanism. We developed a three-band tight-binding model with non-trivial band topology. Incorporating both onsite Hubbard repulsion and next-nearest-neighbor attraction, we then performed a Hartree-Fock analysis of the microscopic model and obtained a phase diagram qualitatively consistent with the experiment results. For zero or weak displacement field, the ground state is a chiral topological superconductor with inter-valley pairing dominant $d_{xy} \pm id_{x2-y2}$-wave. For a relatively strong displacement field, the ground state is a correlated insulator with the 120° antiferromagnetic order [2].

References:

[1] Yi-Ming Wu, Zhengzhi Wu, and Hong Yao, *Phys. Rev. Lett.* 130, 126001 (2023)

[2] Chuyi Tuo, Ming-Rui Li, Zhengzhi Wu, Wen Sun, and Hong Yao, *Nature Communications* 16, 9525 (2025)