Universität Basel

Research Project

TopSupra / Engineered Topological Superconductivity in van der Waals Heterostructures

Third-party funded project

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Topological matter is a new research focus with great perspectives. These are insulators with an inverted "negative" bandgap and a conducting surface state. While the surface state in a topological insulator (TI) is composed of chiral fermions carrying charge and spin, in **topological superconductors** it is pinned to zero energy due to particle-hole symmetry and composed of fermions that carry neither charge nor spin. Instead, they are non-abelian fermions, **Majorana** and **parafermions** (MF/PF), that have been proposed for topological quantum computing. Evidence for MFs have been found in nanowires. However, the scaling-up challenge requires a platform in which networks of MFs can be realized. Here, we propose to use graphene-based **van der Waals heterostructure** for this purpose. The unprecedented versatility is enabled by combining high-mobility graphene with other layered materials, such as transition-metal dichalcogenide, few-layer ferromagnets and superconductors (SCs). This allows to **design topological systems**, e.g. the quantum spin, anomalous and valley Hall effect, by combining Zeeman energy, spin-orbit and pairing interaction. We will **design 2D quantum matter** using different approaches, including strain tuning and the dressing of the bandstructure by photon-fields (Floquet TI), and couple it to SCs to induce topological superconductivity. We will use our expertise from studies of Cooper-pair splitters to not only add pairing in a single edge-state, but also between different edge-states, beneficial for obtaining MFs and more exotic quasiparticles. We will apply advanced high-frequency techniques, e.g. emission and noise - in addition to local tunneling spectroscopy - to characterize the in-gap states and to **prove their topological nature**. We will **deliver a versatile technology** with which new states of matter can be obtained in a platform which can be engineered in a top-down manner into **networks** allowing **for quantum-state manipulation** of MFs and PFs.

Keywords topological insulator, van der Waals material, two-dimensional materials, quantum transport, topological superconductivity, Majorana physics
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Add documents

Specify cooperation partners