Tunable Many-body Interactions and Induced Superconductivity in a Helical Luttinger Liquid

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The interplay of topology, superconductivity, and many-body correlations in 1D has become a subject of intense research for the pursuit of non-trivial superconducting pairing. The boundaries of atomically-thin topological insulators in 2D – amongst them the quantum spin Hall (QSH) insulator [1] – provide a natural realization of strictly 1D electronic structure with linear (Dirac) dispersion and spin-momentum locking (helicity).

We show [2] that the topological edge states of the QSH insulator 1T'-WTe_2 harbour a strongly correlated 1D electronic ground state – a helical Tomonaga-Luttinger Liquid (TLL) – whose many-body Coulomb interactions can be effectively controlled by the edge state's dielectric environment.

Temperature-dependent scanning tunnelling spectroscopy measurements down to 4.2K reveal a pseudogap-like zero-bias anomaly (ZBA) within the edge state's local density of states (LDOS), with minimum strictly at the Fermi energy. Consistent with the presence of a TLL, the LDOS of this ZBA exhibits power-law scaling in both bias voltage and temperature, with a universal scaling exponent that is related to the Luttinger parameter as $\alpha=C(K+K^{-1}-2)$ ($C=1/2$ for helical systems).

A statistical analysis across tens of tunnelling points confirms [2] that K is distinct on different edges of the 1T'-WTe_2 crystal and depends on the dielectric environment of the helical edge, provided by its van-der-Waals substrate. This demonstrates tunability of a helical TLL in both its fundamental dependencies on potential and kinetic energy terms, respectively.

Finally, we show that super-conductivity can be induced [3] into the 1T'-WTe_2 quantum spin Hall state by proximity-coupling to a superconducting van-der-Waals substrate, giving rise to an induced superconducting order parameter as large as 0.6meV in WTe_2, stable beyond a B=2T magnetic field [3].

References

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