Magnon-mediated topological superconductivity in a quantum wire

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One-dimensional superconducting systems with *p*-wave pairing are known to reside in a topological class that can host non-trivial topological phases, with non-abelian anyons as topologically protected end states.[1-3] Superconductive *p*-wave pairing arises in systems where the effective electronic attraction favors Cooper pairs with a symmetric spin structure. In this work we show that superconductive *p*-wave pairing emerges as the result of interactions between electrons and magnons in a quantum wire and a helical magnet.[4] The magnon-mediated interaction favors *p*-wave superconductivity over a large magnetic phase space region, and stabilizes topological superconductivity over an extended region of chemical potentials. The superconducting gap depends exponentially on the spin-electron coupling, allowing it to be enhanced through material engineering techniques. In addition, the non-collinear magnetic order induces an effective spin-orbit coupling and a Zeeman field among the electrons, that allows to realize an effective single-band regime over a finite range of chemical potentials. Within the single-band regime, the system enters a topological phase, with unpaired Majorana bound states at each end of the wire. Crucially, both the size of the effective single-band regime and the superconducting gap are increasing functions of the spin-electron coupling *g*. Our proposal thereby identifies quantum wires in proximity to helical magnets as a promising platform to realize topological superconductivity, without the need to proximitize the wire to a conventional superconductor.

Figures

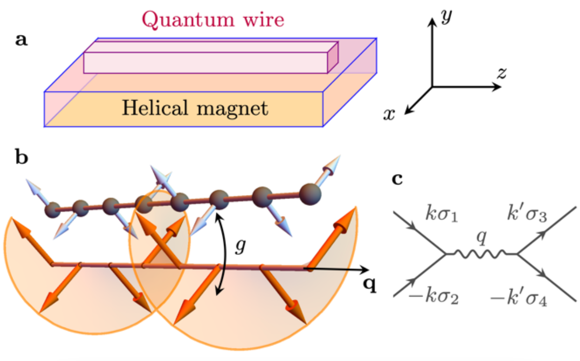

Figure 1: Principles of magnon-mediated superconductivity. **a,** Experimental setup with a quantum wire in proximity to a helical magnet. **b,** The helical magnetic order (orange arrows) induces an effective spin-orbit interaction and Zeeman splitting of the electronic bands via the spin-electron coupling *g*. Magnon fluctuations around the equilibrium magnetic order provide an effective attractive interaction among the electrons (blue arrows). **c,** Due to the non-collinear magnetic structure, magnon fluctuations mediate scattering between electrons with arbitrary spin projections σ_i.

References

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