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Topological Superconductivity with Magnetic Atoms

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Chains of magnetic impurities embedded in a conventional s-wave superconductor may induce the formation of a topologically non-trivial superconducting phase. If such a phase is formed along a chain, then its ends carry Majorana fermions. We investigate this possibility theoretically by developing a tight-binding Bogoliubov-de Gennes description, starting from the Shiba bound states induced by the individual magnetic impurities. While the resulting Hamiltonian has similarities with the Kitaev model for one-dimensional spinless p-wave superconductors, there are also important differences, most notably the long-range (power-law) nature of hopping and pairing as well as the complex hopping amplitudes. We develop an analytical theory, complemented by numerical approaches, which accounts for the electron long-range pairing and hopping along the chain [1], inhomogeneous magnetic order in the chain of embedded impurities or spin-orbit coupling in the host superconductor, and the possibility of direct electron hopping between the impurity atoms. This allows us to elucidate the domain of parameters favoring the formation of a topological phase and to find the spatial structure [2] of Majorana states appearing in that phase.

This talk is based on joint work with F. von Oppen, Falko Pientka, and Yang Peng.

[1] Falko Pientka, Leonid I. Glazman, and Felix von Oppen, Phys. Rev. B **88**, 155420 (2013).
[2] Falko Pientka, Leonid I. Glazman, and Felix von Oppen, Phys. Rev. B **89**, 180505(R) (2014).