From Majorana- to Parafermions in Single and Double Nanowires

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I will present recent progress on Majorana fermions and other exotic excitations with non-Abelian braid statistics that can emerge in condensed matter systems. These excitations have attracted wide attention over the years, also because of their potential applications in topological quantum computing. Majorana fermion zero-modes and their generalizations, parafermions, can emerge in single and double nanowires and atomic chains in the presence of spin orbit interaction or spatially periodic magnetic fields, in RKKY systems forming intrinsic spin helices, and in topological insulators, in the presence of superconductivity where finite size effects play an important role for the proximity effect [1,2]. I will discuss parafermions, which, in contrast to Majorana fermions, can emerge only in the presence of strong electron-electron interactions [3] and have a more powerful braid statistics enabling entanglement and exact CNOT gates by braiding alone (without the need of any measurement) [4]. I will also present some recent results on hybrid platforms for quantum computing which combine spin qubits with topological qubits on a surface code architecture [5].

[1] C. Reeg, J. Klinovaja, and D. Loss, arXiv:1701.07107.
[2] C. Schrade, M. Thakurathi, C. Reeg, S. Hoffman, J. Klinovaja, and D. Loss, arXiv:1705.09364.
[3] J. Klinovaja and D. Loss, PRL 112, 246403 (2014); PRB 90, 045118 (2014).
[4] A. Hutter and D. Loss, PRB 93, 125105 (2016).
[5] S. Hoffman, C. Schrade, J. Klinovaja, and D. Loss. Phys. Rev. B 94, 045316 (2016).