ENGINEERING TOPOLOGICAL QUANTUM STATES: FROM 1D TO 2D

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I will present results on exotic bound states in one-dimensional (Majorana fermions and parafermions) and two-dimensional (edge states in topological insulators) condensed matter systems that have attracted wide attention due to their promise of non-Abelian statistics believed to be useful for topological quantum computing. I discuss systems in which topological properties could be engineered per demand. For example, Majorana fermions can emerge in hybrid systems with proximity pairing in which the usually weak Rashba spin-orbit interaction is replaced by magnetic textures. Here, I will discuss candidate materials such as semiconducting nanowires [1-2], graphene nanoribbons [3], atomic magnetic chains or magnetic semiconductors [4]. One further goal is to go beyond Majorana fermions and to identify systems that can host quasiparticles with more powerful non-Abelian statistics such as parafermions in double wires coupled by crossed Andreev reflections [5,6]. In the second part of my talk, I will focus on 'strip of stripes model' consisting of weakly coupled one-dimensional wires [6-8], where interaction effects in the wires can be treated non-perturbatively via bosonization. I will demonstrate that such systems can exhibit the integer or fractional quantum Hall effect [6], spin Hall effect [7], and anomalous Hall effect [8]. In the fractional regimes, the quasiparticles have fractional charges and non-trivial Abelian braid statistics.

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