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Manipulating Majorana Bound States with Tunable Magnetic Textures[1]

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In condensed-matter systems Majorana bound states (MBSs) are emergent quasiparticles obeying non-Abelian statistics. While realizing the non-Abelian braiding statistics would provide both an ultimate proof for MBSs existence and a key element for fault-tolerant topological quantum computing, even theoretical schemes imply a significant complexity to implement such braiding. The first experimental evidences of MBSs formation were measured in one-dimensional (1D) systems [1]. However, since braiding statistics are ill-defined in 1D, complex wire networks must be used for directly probing the non-Abelian character of the MBSs [2]. In this talk I will discuss the possibility of creating and manipulating MBSs in two-dimensional (2D) systems by using tunable magnetic textures generated by an array of magnetic tunnel junctions (MTJs) located on a 2D superconductor-semiconductor heterostructure [3]. Magnetic textures can provide not only effective spin-orbit and Zeeman fields [4] -two important ingredients for the creation of MBSs- but also spatial confinement [5]. The underlying magnetic texture produced by the MTJs array leads to the formation of effective topological wires supporting MBSs formation. The effective wires can be re-shaped and re-oriented by properly changing the magnetic texture, allowing for the transportation of the MBSs in 2D [5]. I will then show how the proposed platform can be used to measure the non-Abelian statistics of MBSs through braiding and discuss the main challenges regarding materials, scalability, and detection. The effects of the coexistence of native and magnetically-induced spin-orbit fields on the MBSs as well as the possibility of using other magnetic textures will also be addressed.

[1] V. Mourik et al., Science 336, 1003 (2012); S. Nadj-Perge et al., Science 346, 602 (2014). [2] J. Alicea et al., Nat. Phys. 7, 412 (2011); D. Aasen et al., Phys. Rev. X 6, 031016 (2016). [3] J. Shabani et al., Phys. Rev. B 93, 155402 (2016). [4] Kjaergaard et al., Phys. Rev. B 85, 020503 (2012); J. Klinovaja et al., Phys. Rev. Lett. 111, 186805 (2013); G. Yang et al., Phys. Rev. B 93, 224505 (2016). [5] G. L. Fatin, A. Matos-Abiague, B. Scharf, and I. Zutic, Phys. Rev. Lett. 117, 077002 (2016).

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