Majorana Bound States in Semiconductor/Ferromagnetic insulator/Superconductor nanowire heterostructures

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Hybrid semiconducting nanowire devices combining epitaxial superconductor and ferromagnetic insulator layers have been recently explored experimentally as an alternative platform [1-3] for topological superconductivity at zero applied magnetic field. In this proof-of-principle work [4] we show that the topological regime can be reached in actual devices depending on some geometrical constraints. To this end, we perform numerical simulations of InAs wires in which we explicitly include the superconducting Al and magnetic EuS shells, as well as the interaction with the electrostatic environment at a self-consistent mean-field level. Our calculations indicate that the topological phase is robustly achieved in significant portions of the phase diagram only in configurations where the Al and EuS layers overlap on some wire facet due to their rather local induced proximity effects. Moreover, we find that the spin polarization induced directly in the semiconductor by the EuS is much stronger than the one induced indirectly through the superconductor. Finally, we comment on how the topological phase can be tuned and optimized using external gates.

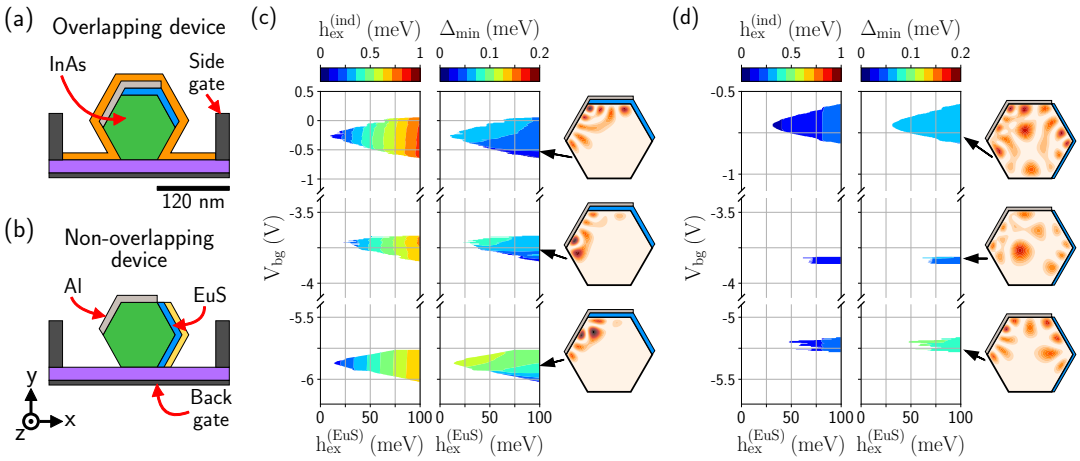

Figure 1: (a-b) Sketch of the devices studied in this work, in which an InAs wire is proximitized by two layers: one superconducting (Al) and another one ferromagnetic insulator (EuS). There are several gates used to tune the chemical potential inside the hybrid wire. Note that in (a) the EuS and the Al overlap in one facet, while in (b) they lie in different ones. (c-d) Topological phase diagrams of the devices (white means trivial, colours mean topologically non-trivial). It is also shown the induced exchange field, topological mini-gap, and wavefunction profile of the topological states, respectively.

References

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