Poster 25

Subgap states and quantum phase transitions in one-dimensional superconductor-ferromagnetic insulator heterostructures

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We theoretically study the spectral properties of a one dimensional semiconductor-superconductor-ferromagnetic insulator (SE-SU-FMI) hybrid nanostructure, motivated by recents experiments where such devices have been fabricated using epitaxial growing techniques. We model the hybrid structure as a one-dimensional single-channel semiconductor nanowire under the simultaneous effect of two proximity-induced interactions: superconducting pairing and a (spatially inhomogeneous) Zeeman exchange field. The coexistence of these competing mechanisms generates a rich quantum phase diagram and a complex subgap Andreev bound state (ABS) spectrum. By exploiting the symmetries of the problem, we classify the solutions of the Bogoliubov-de Gennes equations into even and odd ABS with respect to the spatial inversion symmetry $x \to -x$. We find the ABS spectrum of the device as a function of the different parameters of the model: the length L of the coexisting SU-FMI region, the induced Zeeman exchange field h_0, and the induced superconducting coherence length ξ. In particular we analyze the evolution of the subgap spectrum as a function of the length L. Interestingly, we generically find spin-polarized ABS emerging in the subgap region which, depending on the ratio h_0/Δ, can eventually cross below the Fermi energy at certain critical values L_c, and induce spin- and fermion parity-changing quantum phase transitions. We argue that this type of device constitute a promising highly-tunable platform to engineer subgap ABS.