Vortex like pair of zero mode states in a 2D topological superconductor

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The examination of supposedly well-known condensed matter systems through the prism of topology has led to the discovery of new quantum phenomena that were previously overlooked. Just like insulators can present topological phases characterized by Dirac edge states, superconductors can exhibit topological phases characterized by Majorana edge states. In particular, one-dimensional topological superconductors are predicted to host zero energy Majorana fermions at their extremities. Zero bias anomalies localized at the edge of proximity induced superconducting wires were recently interpreted as fingerprints of the emergence of topological superconductivity [1,2].

By contrast, two-dimensional (2D) superconductors have a one-dimensional boundary which would naturally lead to propagating Majorana edge states characterized by a Dirac-like dispersion. We have recently observed some hint of dispersive Majorana edge states in a single atomic layer Pb superconductor. This material has strong triplet correlations but is not topological by itself [3]. We will show that by applying a Zeeman field with the help of a buried Co-Si nano-magnet one can provoke a transition to a topological state [4].

In addition to their dispersive edge states, 2D topological superconductors are also supposed to support localized Majorana bound states in their vortex cores. However in addition to zero energy states one usually get also a very large amount of Caroli-Matricon de Gennes states that fill the gap. However we will show that one can find vortex like phase defect in a U(1) gauge field that induce zero energy Majorana bound states without additional low energy states. In particular, our recent calculations predict that a phase defect in the spin-orbit field can lead to the formation of energetically isolated pairs of Majorana zero mode in a hard gap of a 2D topological superconductor. Our recent measurements seem to support this theoretical prediction [5].

References

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