Deconfinement of Majorana vortex modes in a topological superconductor

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A topological superconductor can bind a Majorana fermion as a midgap state in the core of a magnetic vortex. This Majorana zero-mode has been dubbed the "Zen particle", because it embodies nothingness: it has zero charge, zero spin, zero energy, and zero mass. It does have a definite chirality, set by the sign of the winding of the superconducting phase around the vortex.

A superflow couples to the circulating phase, producing a sideways force on the vortex known as the Magnus force. It was recently discovered [1] that the superflow also acts on the zero-mode, causing a deconfinement transition when the Cooper pair momentum exceeds a critical value. The deconfined Majorana fermion forms a dispersionless Landau level, protected by chiral symmetry against broadening due to vortex scattering. Unlike a conventional electronic Landau level, the Majorana Landau level has a non-uniform density profile: quantum interference of the electron and hole components creates spatial oscillations with a wave vector set by the Cooper pair momentum that drives the deconfinement transition. The striped pattern also provides a means to measure the chirality of the Majorana fermions.

Here we discuss this development, in connection with experiments on topological insulators and with an outlook towards the dynamical manipulation of "flying" Majorana fermions.

References

[1] M.J. Pacholski, G. Lemut, O. Ovdat, I. Adagideli, and C.W.J. Beenakker, *Deconfinement of Majorana vortex modes produces a superconducting Landau level*, Phys. Rev. Lett. **126**, 226801 (2021).

Figures

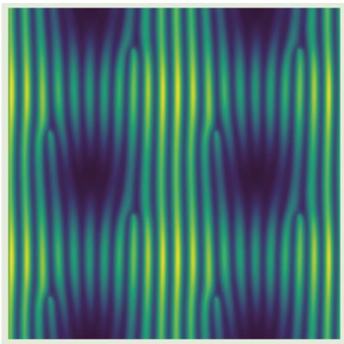

Figure 1: Computer simulation of the striped density of a Majorana Landau level in the 2D plane of a proximitized topological insulator.