Electronic properties of emergent topological defects in chiral *p*-wave superconductors and topological phase transitions in small disks

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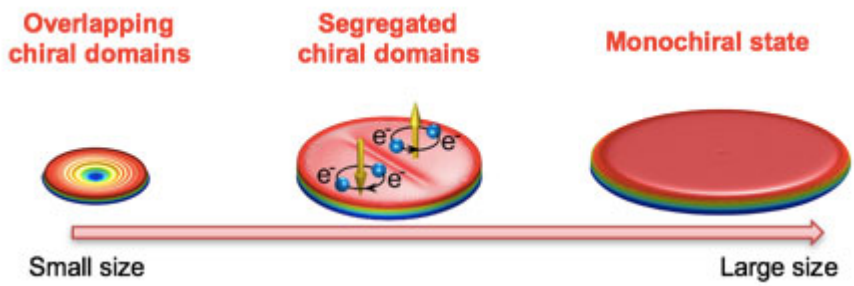
Chiral p-wave superconductors in applied magnetic field can exhibit more complex topological defects than just conventional superconducting vortices, due to the two-component order parameter (OP) and the broken time-reversal symmetry. By solving the Bogoliubov–de Gennes equations self-consistently, we first present the electronic structure of those exotic states [1], some of which contain skyrmionic character in the relative OP space. We reveal the link between the local density of states (LDOS) of the novel topological states and the behavior of the chiral domain wall between the OP components, enabling direct identification of those states in scanning tunneling microscopy. For example, a skyrmion always contains a closed chiral domain wall, which is found to be mapped exactly by zero-bias peaks in LDOS. Moreover, the LDOS exhibits electron-hole asymmetry, which is different from the LDOS of conventional vortex states with same vorticity. The skyrmion can be surprisingly large in size depending on magnetic field and temperature.

Next, we present the equilibrium phase diagram for small mesoscopic chiral p-wave superconducting disks in the presence of magnetic field [2]. In the ultrasmall limit, the cylindrically symmetric giant-vortex states form the ground state of the system. However, with increasing sample size, the cylindrical symmetry is broken as the two components of the order parameter segregate into domains, and the number of fragmented domain walls between them characterizes the resulting states. Such domain walls are topological defects unique for the p-wave order, and constitute a dominant phase in the mesoscopic regime. Moreover, there are two possible types of domain walls, identified by their chirality-dependent interaction with the edge states.



The total OP in a confined p-wave superconducting disk, showing the evolution of the lowest-energy state with increasing size of the p-wave superconductor, in absence of any magnetic field.

References

[1] L.-F. Zhang, V. F. Becerra, L. Covaci, and M. V. Milošević, Electronic properties of emergent topological defects in chiral p-wave superconductivity, Phys. Rev. B **94**, 024520 (2016).
[2] L.-F. Zhang, L. Covaci, and M. V. Milošević, Topological phase transitions in small mesoscopic chiral p-wave superconductors, Phys. Rev. B **96**, 224512 (2017).

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