Detecting the topological winding of superconducting nodes via Local Density of States

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Many systems are topologically trivial in the bulk yet still have non-trivial wavefunctions locally in the Brillouin zone. For example, in a small-gap Dirac material the Berry curvature is strongly peaked, but cancels over the full Brillouin zone, while in semimetals and in nodal superconductors there may be a lower-dimensional winding topology associated to the nodes. Experimentally, it is difficult to directly observe such topology. In this work, we extend the method developed in Dutreix {\it et al.} [1], which detected the winding around Dirac cones in graphene using charge modulations around an impurity. Our method [2] is applied to general nodal Hamiltonians, in particular nodal superconductors in 2d, in presence of a (non)magnetic impurity, measured by standard or spin-polarized STM tip. We derive general conditions on the impurity scattering and on the STM tip, expressed in terms of their preference among the two chiralities, for when the measurement near the impurity captures the winding difference between any chosen pair of (Bogoliubon) Dirac cones. Testing the conditions on the topological nodal superconductor proposed for monolayer $NbSe_2$ under an in-plane magnetic field, we find that spin-polarized STM on a magnetic impurity can detect the winding of each of the 12 nodes.

References

[1] Dutreix C., González-Herrero H., Brihuega I., Katsnelson M., Chapelier C., & Renard V., Nature, 574(7777):219–222 (2019)
[2] Engström L., Simon P., & Mesaros A., arXiv: 2412.13042 (2024)

Figures

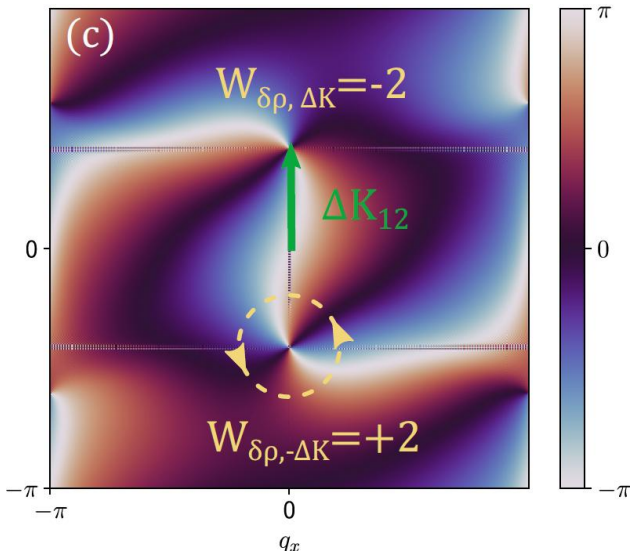

Figure 1: Phase of the Fourier transformed local density of states for two Dirac cones separated by ΔK_{12} and with a difference in topological winding W.