Superconductivity and the normal state's quantum geometry: a conflicting influence

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Résumé

Superconductivity has, since 1911, become a pillar and a flagship of condensed matter physics. The main paradigm is given by BCS theory which, in its standard form, consists of quasiparticles in a single, partially filled band, pairing and thus condensating in a collective dissipationless state. This single band approximation has its limits. Indeed, since the 1980s, physicists have come to realize that in a multiband setting, even adiabatic, each band will carry an influence of the other bands in the form of two geometric quantities, namely the Berry curvature and the quantum metric. These quantities form what we call band/quantum geometry, and they are consequences of the "quasi" in quasiparticles. In the context of superconductivity, this means that even if a single band is involved in the Cooper pairing, it can carry a quantum geometry if the normal state has more than one band. The influence of this normal state's quantum geometry on the superconducting state is the subject of this talk. On one side, we study the influence of the normal state's Berry curvature on BCS theory in the context of two-dimensional massive Dirac fermions. We find that it generally lowers the critical temperature, in a quantifiable way. On another side, we consider the two-dimensional (111) ${LaAlO}_3/{SrTiO}_3$ interface. Our results suggest that the quantum metric has a sizeable role in the appearance of superconducting domes in this interface, as a function of gate voltage. This positive influence of the normal state quantum metric points towards a conflicting relationship between quantum geometry and superconductivity.
Associated works:

FS, L. Pagot, M. Gabay, and M.O. Goerbig, Role of the Berry curvature on BCS-type superconductivity in two-dimensional materials, Phys. Rev. B 106, 214512 (2022)
FS, Mark-Oliver Goerbig, Marc Gabay, Normal state quantum geometry and superconducting domes in (111) oxide interfaces, arXiv:2307.13993

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