Narrow bands and dissipation in quantum materials

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Whereas fine-tuning to a quantum critical point leads to long-lived excitations in tightly defined regions of parameter space, narrow bands may more generally be caused by built-in mechanisms:

(a) if a continuous structural phase transition is suppressed to low temperatures (e.g. [1]), low-energy vibrational excitations can arise that boost superconductivity and cause a linearly temperature dependent electrical resistivity. In aperiodic high-pressure host-guest structures, such as that found in high-pressure bismuth [2], a low-energy sliding phonon mode is built in. Related findings in high pressure antimony and in Nowotny chimney-ladder phases suggest that strongly damped low-frequency vibrations are essential for thermodynamic and transport properties.

(b) On-site electronic interactions such as the Coulomb interaction near the threshold of Mott localisation, and Kondo coupling in *d*- and *f*- electron systems, in some cases augmented by Hund's coupling, can cause strong electronic mass renormalisation. Quantum oscillation measurements resolve the electronic Fermi surface and carrier mass in the pressure-metallised Mott insulator NiS_2 [3] and in the Fe-based superconductor YFe_2Ge_2 [4], enabling detailed comparison with theoretical scenarios.

The interplay between local mechanisms and fine-tuning to a quantum critical point is explored in the Kondo lattice system $CeSb_2$, which superconducts over a narrow pressure range at magnetic fields that exceed the Pauli limit by nearly an order of magnitude.

References

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[3] Semeniuk, K. *et al.*, arXiv:2202.04024 (2022)
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