

Unexpected robustness of flat band superconductivity against disorder in the two-dimensional Lieb lattice

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Within the last ten years, flat band superconductivity has become the focus of numerous studies due to its connection with quantum geometry as well as its unusual scaling laws which open possibilities for high critical temperatures [1,2]. Until recently, the sensitivity of this superconductivity to disorder remained largely unexplored. Using large-scale numerical calculations, we address this issue and reveal that the interband flat band superconductivity is remarkably robust against disorder-induced fluctuations and quasiparticle localization [3], in striking contrast to conventional intraband superconductivity for which the disorder impact is dramatic. In addition to the behavior of the critical temperature and average pairing, we further investigate the local pairing fluctuations and their statistical distribution in order to complete the picture drawn by our first study. We believe that these findings could have a major impact on the research and development of new compounds whose high purity will no longer be a critical barrier to their synthesis.

References

- [1] Iglovikov, Grémaud, Batrouni, Scalettar, Phys. Rev. B, **90** 094506 (2014)
- [2] Peotta, Törmä, Nat Commun., **6** 8944 (2015)

- [3] Bouzerar, Thumin, Phys. Rev. B Letter, **111** L020506 (2025)
- [4] Thumin, Bouzerar, to be submitted

Figures

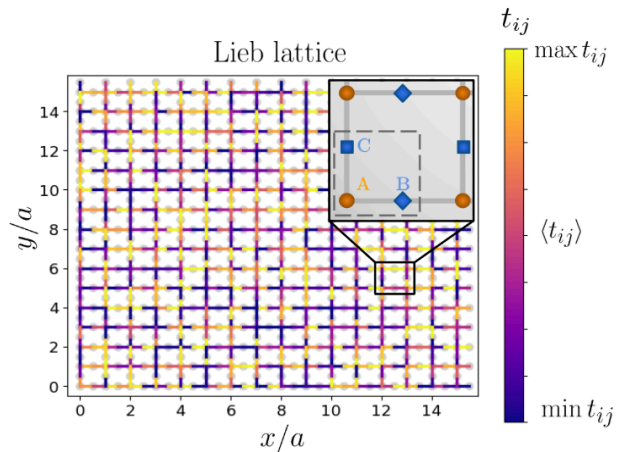


Figure 1: Configuration of disorder in the Lieb lattice. The disorder is realized by randomizing the nearest neighbors hopping integrals.

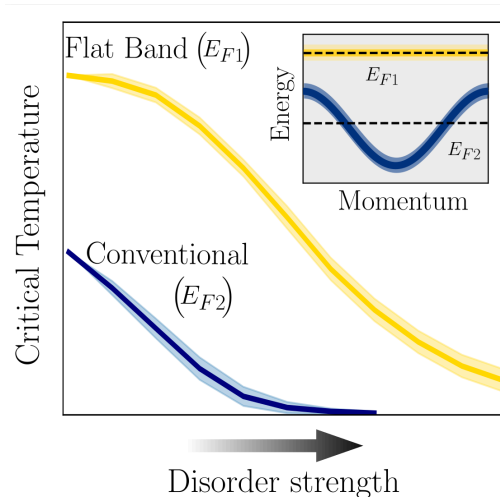


Figure 2: Superconducting critical temperatures in the Lieb lattice as a function of the disorder strength for the Fermi energy crossing (i) a flat band (unconventional superconductivity) and (ii) a dispersive band (conventional superconductivity).