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Séminaire AXE 1 - Sciences et Matériaux Quantiques



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Flat band superconductivity: quantum geometry, disorder and nanostructuration

In the last decade, flat band (FB) superconductivity has attracted considerable interest for its remarkable features, such as a direct connection to quantum geometry [1], the possibility of high critical temperatures, and potential realization in twisted bilayer graphene [2]. This talk gives a selective and pedagogical overview of this unconventional type of superconductivity (*no prior knowledge of flat bands or quantum geometry is required*). We will first define the basic properties of FB states in the single-particle picture and introduce the quantum geometric tensor. After validating our mean-field Bogoliubov–de Gennes approach, we will discuss the nature of this superconductivity (in terms of pairing and phase coherence) and its connection to the quantum metric [3,4]. In particular, we will show how quantum geometry can provide an efficient strategy to enhance superconductivity in nanostructured systems [5]. Finally, we will address the impact of disorder in a simple FB model, the two-dimensional Lieb lattice. Our results on the pairing amplitudes and the BKT temperature reveal a striking robustness of flat band superconductivity against disorder, which contrasts with conventional intraband superconductivity [6].

References

[1] S. Peotta and P. Törmä, Nature Communications (2015)
[2] Y. Cao et al, Nature (2018)
[3] M. Thumin and G. Bouzerar, Phys. Rev. B (2023)
[4] G. Bouzerar and M. Thumin, SciPost Physics (2024)
[5] M. Thumin and G. Bouzerar, Phys. Rev. B (2024)
[6] G. Bouzerar and M. Thumin, Phys. Rev. B (2025)

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