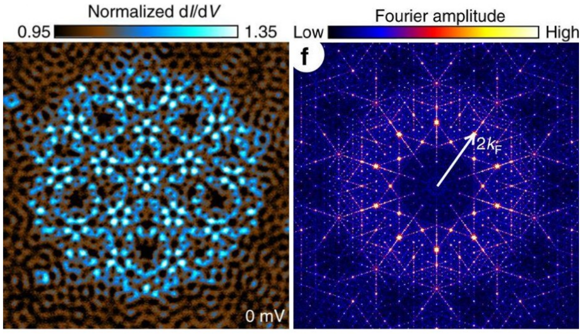
Master's thesis project

Superconductivity in Quasicrystals: Theory and High-Performance computing

Motivation: Quasicrystals are peculiar materials with self-similar structures like fractals – they lack the periodicity of normal crystals, but they still exhibit a long-range order. This long-range order enables a number of interesting condensed matter physics phenomena, like the quantum spin-hall effect and superconductivity [1]. Due to the lack of periodicity, these phenomena are expected to exhibit unique properties not present in regular crystals, which might be exploited to make new quantum devices. Furthermore, with recent advances in nanotechnology, it has become increasingly feasible to fabricate and study quasicrystals with single-atom precision [2]. Quasicrystals therefore provide an interesting new platform to study fundamental aspects of condensed matter physics both experimentally and theoretically, with the promise of new exciting physics.



Project description: You will team up with a doctoral and a postdoctoral researcher in the Applied Quantum Physics Laboratory. Your goal will be to set up theoretical models and numerical simulations of the electronic properties of quasicrystals, and in particular, study superconductivity in these materials. With only a handful of previous studies on superconductivity in quasicrystals, your work will be both unique and genre-defining. In particular, you will

- write an algorithm to generate a quasicrystal Penrose lattice,
- construct a Hamiltonian in a tight-binding model,
- diagonalize the matrix using high-performance computing and parallelization on GPUs,
- perform data analysis (big data).

Learning outcomes:

Throughout this project, you will use a number of skills that are highly desired in *both academia and industry*. You will

- improve your analytic problem-solving and programming skills,
- work with high-performance computing and big data,
- learn how to work as a part of a team in a goal-oriented project in a competitive field.

Contact:

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References:

[1] K. Kamiya, et al. "*Discovery of superconductivity in quasicrystals*". *Nat. Commun.* **9**, 154 (2018)

[2] L. C. Collins, et al. "*Imaging quasiperiodic electronic states in a synthetic Penrose tiling*". *Nat. Commun.* **8**, 15961 (2017)