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Relevance of electronic interactions at quasiperiodicity-driven localization transitions

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In real materials, disorder can induce (Anderson) insulating phases. Interestingly, incommensurate or quasiperiodic modulations in crystals can also profoundly affect the localization properties of the electronic wavefunction. As the quasiperiodic perturbation strength increases, single-particle states can transition from delocalized (plane-wave-like), to critical (fractal-like) and finally to localized. While some properties of these phases resemble those in disordered systems, the metal-insulator transitions are fundamentally different from their uncorrelated counterparts.

The simplest model that captures the transition between extended and localized phases at a critical quasiperiodic modulation strength is the celebrated Aubry-André model, which features a remarkable duality between localized and delocalized states. Recently, this duality —previously thought to be fine-tuned —was shown to be a generic feature, but somehow hidden, near the localization-delocalization transition. Remarkably, for one-dimensional systems of interacting spinless fermions, interactions of this type were shown to become irrelevant around the transition, with eigenstates following the hidden duality scenario of the non-interacting limit.

However, the role of spinful interactions in quasiperiodicity-driven transitions remains unexplored. The aim of this project is to explore the effects of electronic interactions near the quasiperiodicity-driven localization-delocalization transition. Specifically, we seek to determine whether such interactions become relevant at the transition, as in higher-dimensional disorder-driven transitions, or remain irrelevant, as in the spinless case.

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