INTERNSHIP PROPOSAL: **Electrical resistivity of doped Mott insulators**

Laboratory: Institute for Theoretical Physics, **University of Cologne** (www.thp.uni-koeln.de)
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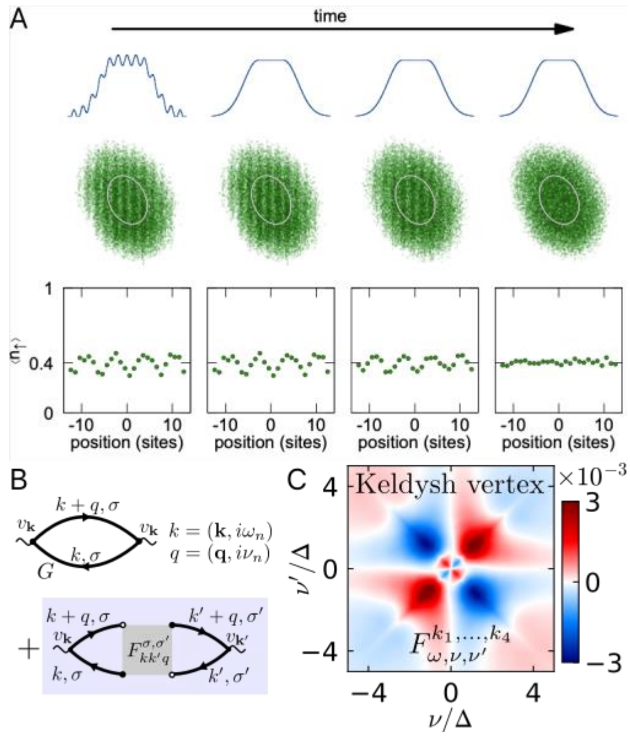
Thesis possibility after internship: YES Funding available for a PhD: YES

The electrical resistivity is one of the most fundamental probes in condensed matter physics. Yet, computing the resistivity (or transport more generally) in systems of strongly correlated electrons remains a formidable challenge. Its difficulty is brought to bear already in the paradigmatic Hubbard model, in the parameter regime of doped Mott insulators (related to the cuprate superconductors). Cold-atom experiments simulating this model [1] revealed bad-metallic transport, with the resistivity increasing linearly with temperature beyond the Mott-Ioffe-Regel limit.




**A** Equilibration of density modulation used to deduce the resistivity via the Nernst-Einstein relation, from [1]. **B** Feynman diagrams for the vertex corrections to transport, from [2]. **C** Frequency dependence of local Keldysh vertex, from [4].

Ref. [1] also revealed that the conventional result for the resistivity obtained by dynamical mean-field theory (DMFT) is qualitatively wrong. Indeed, this quantity must be computed more carefully, by including vertex corrections [2]. Such vertex corrections are extremely difficult to obtain, as one needs real-frequency vertices that became accessible only recently [3-4].

This project aims to unravel the resistivity of doped Mott insulators. In the internship part, the violation of the Mott-Ioffe-Regel limit at high temperatures will be elucidated from DMFT calculations without vertex corrections and from the Nernst-Einstein relation [1]. In the thesis part, the resistivity will be computed in DMFT with vertex corrections. To this end, the local vertices from [3-4] will be equipped with a momentum dependence using field-theoretical techniques and the full Kubo formula will be evaluated. An improved understanding of the vertex corrections will not only explain these quantum-simulator experiments but also enable more accurate treatments of transport in quantum materials.

Methods: Dynamical mean-field theory, numerical renormalization group, quantum field theory
Profile: Good knowledge of quantum many-body theory and interest in scientific programming

[1] Brown et al., Science **363**, 379 (2019)
[2] Vučičević, Kokalj, Žitko, Wentzell, Tanasković, Mravlje, Phys. Rev. Lett. **123**, 036601 (2019)
[3] Kugler, Lee, von Delft, Phys. Rev. X **11**, 041006 (2021)
[4] Lihm, Halbinger, Shim, von Delft, Kugler, Lee, Phys. Rev. B **109**, 125138 (2024)