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Quantum transport in strongly interacting Fermi gases[1]

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Transport is the defining property of states of matter, but often the most difficult to understand. Strongly interacting Fermi gases are especially challenging, despite their ubiquitous presence across many fields of physics.

Experiments on ultracold fermionic atoms allow the direct measurement of transport properties in ideal model systems where the hamiltonian is precisely known while transport properties are difficult to calculate theoretically.

In this talk I will present transport measurements on two strongly interacting Fermi systems, the unitary Fermi gas and the Fermi-Hubbard gas, both realized in uniform box potentials. In the unitary gas, we excite first and, for the superfluid, also second sound waves and demonstrate a quantum limited sound diffusivity given by Plancks constant divided by the particle mass. Second sound waves are directly imaged via local thermometry, making use of the temperature dependence of radiofrequency spectroscopy. For the Fermi-Hubbard gas, we measure spin diffusion and spin conductivity in the Mott insulator at half filling. For strong interactions, spin diffusion is driven by super-exchange and doublon-hole-assisted tunneling, and strongly violates the quantum limit of charge diffusion. This work sheds light on the complex interplay between spin and charge transport in the Hubbard model.

Our experiments provide benchmarks for the highly challenging theoretical calculations of these transport coefficients.

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