Chez Pierre

Presents ...

Monday, April 27, 2020

12:00pm Noon

Broadcast via Zoom

Chez Pierre Seminar

Martin Zwierlein – Massachusetts Institute of Technology

"Charge, spin and heat transport in strongly interacting quantum gases"

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 several strongly interacting Fermi systems: 1. the unitary Fermi gas, 2. a Fermi gas embedded in a Bose-Einstein condensate, and 3. the Fermi-Hubbard lattice gas. For the unitary gas, we observe the propagation and attenuation of first and, in the superfluid state, second sound, and demonstrate a quantum limited sound diffusivity given by Planck's constant divided by the particle mass [1]. Second sound waves are directly imaged via local thermometry, making use of the temperature dependence of radiofrequency spectra [2, 3].

Fermions strongly interacting with a Bose gas feature "Planckian" scattering rates given by temperature and Planck's constant, as well as hydrodynamic flow, in what is possibly the simplest realization of a quantum critical system [4].

For the Fermi-Hubbard gas, we measure spin diffusion and spin conductivity in the Mott insulator at half filling [5], and, using a novel bilayer Fermi gas microscope, directly image the strong doublon-hole correlations responsible for it [6].

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

In recent work on realizing BEC in the lowest Landau level, specifically a macroscopically occupied Landau gauge wavefunction, we have begun to explore Hall transport [7].

[1] Universal Sound Diffusion in a Strongly Interacting Fermi Gas
Parth B. Patel, Zhenjie Yan, Biswaroop Mukherjee, Richard J. Fletcher, Julian Struck, Martin W. Zwierlein
arXiv:1909.02555 (2019)

[2] Spectral response and contact of the unitary Fermi gas
Biswaroop Mukherjee, Parth B. Patel, Zhenjie Yan, Richard J. Fletcher, Julian Struck, Martin W. Zwierlein
Phys. Rev. Lett. 122, 203402 (2019), arXiv-Link

[3] Boiling a Unitary Fermi Liquid
Zhenjie Yan, Parth B. Patel, Biswaroop Mukherjee, Richard J. Fletcher, Julian Struck, Martin W. Zwierlein
Phys. Rev. Lett. 122, 093401 (2019), arXiv-Link

[4] Bose polarons near quantum criticality
Zoe Z. Yan, Yiqi Ni, Carsten Robens, Martin W. Zwierlein
Science, 368, 190-194 (2020), arXiv-Link

[5] Spin Transport in a Mott Insulator of Ultracold Fermions
Matthew A. Nichols, Lawrence W. Cheuk, Melih Okan, Thomas R. Hartke, Enrique Mendez, T. Senthil, Ehsan Khatami, Hao Zhang, Martin W. Zwierlein
Science 363, 383 (2019), arXiv-Link

[6] Measuring total density correlations in a Fermi-Hubbard gas via bilayer microscopy
Thomas Hartke, Botond Oreg, Ningyuan Jia, Martin Zwierlein
arXiv:2003.11669 (2020)

[7] Geometric squeezing into the lowest Landau level
Richard J. Fletcher, Airlia Shaffer, Cedric C. Wilson, Parth B. Patel, Zhenjie Yan, Valentin Crépel, Biswaroop Mukherjee, Martin W. Zwierlein
arXiv:1911.12347 (2019)