Quantum Gas Microscopy of Fermions in the Continuum

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Quantum gas microscopy has emerged in the last years as a powerful technique to probe and manipulate quantum many-body systems at the single-atom level. For over a decade, however, it has only been used to study lattice and spin chain physics, prominently to explore the Hubbard model and its generalizations. In this poster, we will present our recent work on quantum gas microscopy of ultracold fermions in continuous space and their characterization at previously inaccessible levels of resolution and precision. Firstly, we will report on the imaging of the in-situ density probability of deterministically prepared single-atom wave packets as they expand in a plane, and how we obtain a crucial benchmark for the reliability of our imaging protocol [1]. Secondly, we will report on quantum gas microscopy of 2D and quasi-2D ideal Fermi gases, where we measure spatially-resolved density correlation functions of the second and third order, and reveal their temperature dependence [2]. Finally, we will show how using single-atom resolved images, we extract the number fluctuations in the system and perform accurate fluctuation-thermometry over a large dynamical range, from nearly zero temperature to several times the Fermi temperature. By probing number fluctuations on small subsystems, we are able to find a regime where quantum fluctuations play an important role, leading to a significant deviation from the behavior predicted for fermions by the fluctuation-dissipation theorem in the thermodynamic limit [3]. These results represent the first application of quantum gas microscopy to continuous-space many-body systems. Our approach offers radically new possibilities for the exploration of strongly interacting Fermi gases at the single-atom level.

[1] J. Verstraten, K. Dai, M. Dixmerias, B. Peaudecerf, T. De Jongh, T. Yefsah, "In Situ Imaging of a Single-Atom Wave Packet in Continuous Space", Phys. Rev. Lett. 134, 083403, 2025.

[2] T. De Jongh, J. Verstraten, M. Dixmerias, C. Daix, B. Peaudecerf, T. Yefsah, arXiv:2411.08776, 2024.

[3] M. Dixmerias, J. Verstraten, C. Daix, B. Peaudecerf, T. De Jongh, T. Yefsah, arXiv:2502.05132, 2025.