## **Observing Quantum Magnetism under a Microscope**

Jayadev Vijayan

Quantum many-body physics division (I. Bloch) Max-Planck-Institut für Quantenoptik, 85748 Garching, Germany

Richard Feynman famously proposed the use of quantum simulators to study complex quantum systems that are impossible to model with classical computers. One of the most successful implementation of such an analogue simulator has been with ultracold quantum gases in optical lattices. The ability to have single-site resolution of both the density and spin of atoms in optical lattices [1] has enabled our quantum gas microscope to observe the interplay between spins and charges in the Fermi-Hubbard model, which is predicted to capture the essential physics of high temperature superconductors.

In 2D systems, the competition between the spin and charge degrees of freedom in doped antiferromagnets leads to the formation of magnetic polarons. We identify the formation of such a polaron by looking at the dressed spins around a single dopant [2,3]. In stark contrast, in 1D systems, the phenomenon of spin-charge separation decouples the spin and charge degrees of freedom, creating holons and spinons that move with independent velocities. We probe this phenomenon by locally quenching an antiferromagnet to form holons and spinons and dynamically tracking their propagation [4].



## References

[1] M. Boll, T. A. Hilker, G. Salomon, A. Omran, J. Nespolo, L. Pollet, I. Bloch, and C. Gross, "Spin- and density-resolved microscopy of antiferromagnetic correlations in Fermi-Hubbard chains" Science **353**, 1257 (2016).

[2] G. Salomon, J. Koepsell, J. Vijayan, T. A. Hilker, J. Nespolo, L. Pollet, I. Bloch, and C. Gross, "Direct observation of incommensurate magnetism in Hubbard chains", Nature **565**, 5660 (2019)

[3] J. Koepsell, J. Vijayan, P. Sompet, F. Grusdt, T. A. Hilker, E. Demler, G. Salomon, I. Bloch and C. Gross, "Imaging magnetic polarons in the doped Fermi-Hubbard model", ArXiv 1811.06907 (2018)

[4] J. Vijayan, P. Sompet, G. Salomon, J. Koepsell, S. Hirthe, A. Bohrdt, F. Grusdt, I. Bloch and C. Gross, "Time-Resolved Observation of Spin-Charge Deconfinement in Fermionic Hubbard Chains", ArXiv 1905.13638 (2019)