CRC 1227
Designed Quantum States of Matter

GUEST LECTURE

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Leibniz Universität Hannover
DQ-mat Colloquium
20 January 2023, 1.30 pm
!!! Room D326, Welfengarten 1 !!!

"Ultracold atoms in optical lattices: novel directions in topological matter and microscopy"

Ultracold atoms in optical lattice serve as pristine model systems for quantum simulation allowing fresh insights into quantum many-body systems, e.g. by emulating electrons in solid-state systems. Of particular interest are topological phases such as Chern insulators, which can be realized in optical lattices by Floquet engineering [1]. We have developed methods to access the topology of such systems by circular dichroism or Bloch state tomography.
An important feature of these systems is the possibility to optically image the individual particles in a quantum many-body system. Here I will present the quantum gas magnifier as a novel microscopy technique based on matter-wave optics, which allows sub-lattice-resolved imaging [2]. It also enables high-resolution imaging of 3D systems with large occupation numbers on the lattice sites, which e.g. feature a surprising density-wave formation with spontaneous symmetry breaking when applying a strong tilt [3]. Finally, I will introduce the multi-frequency lattice as a new method for controlling the lattice geometry, which is both fast and stable and will allow accessing new regimes via controlled preparation of higher bands and Floquet protocols involving sublattice modulation [4]. I will conclude with an outlook on the exciting possibilities offered by cold atoms.

[1] C. Weitenberg & J. Simonet, Tailoring quantum gases by Floquet engineering, Nature Phys. 17, 1342 (2021).
[2] L. Asteria et al., Quantum gas magnifier for sub-lattice-resolved imaging of 3D quantum systems, Nature 599, 571 (2021).
[3] H. P. Zahn et al., Formation of spontaneous density-wave patterns in DC driven lattices, Phys. Rev. X 12, 021014 (2022).
[4] M. N. Kosch et al., Multifrequency optical lattice for dynamic lattice-geometry control, Phys. Rev. Res. 4, 043083 (2022).

All DQ-mat members and all interested are cordially invited to attend.