CO.CO.MAT

SFB/TRR 21 - Seminar

28. März 2017, Ulm

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Discrete-time simulations with quantum walks in optical lattices

Discrete-time quantum walks describe the motion of a spin-1/2 particle that is delocalised over a large Hilbert space through discrete steps in space and time. A host of topological phenomena can be directly explored with quantum walks: Topologically robust edge states are expected to be fully delocalized along two-dimensional spatial boundaries and to allow chiral propagation of matter waves without dissipation into the bulk [1,2]. We experimentally implement discrete-time quantum walks using ultracold atoms trapped in state-dependent optical lattices. Recently, we have developed a new concept of state-dependent optical lattices, which is based on light polarization synthesis [3]. Polarization-synthesized optical lattices allowed us to demonstrate a bottom-up approach to arbitrary low-entropy states [4], where we rearranged thermal atoms until selected regions of the periodic potential are filled with one particle per site, and we subsequently removed their vibrational entropy by sideband cooling methods. Using optical addressing [5], we expect that our results can be scaled up in the future to thousands of atoms by employing an atom-sorting algorithm with logarithmic complexity.

References: [1] T. Groh, S. Brakhane, W. Alt, D. Meschede, J. K. Asbóth, and A. Alberti, Robustness of topologically protected edge states in quantum walk experiments with neutral atoms, Phys. Rev. A 94, 013620 (2016). [2] J. Asbóth, T. Rakovszky, and A. Alberti "Detecting topological invariants in chiral symmetric insulators via losses," arXiv:1611.09670 [cond-mat.mes-hall]. [3] C. Robens, S. Brakhane, W. Alt, D. Meschede, J. Zopes, and A. Alberti, "Fast, high-precision optical polarization synthesizer for ultracold-atom experiments," arXiv:1611.07952 [quant-ph]. [4] C. Robens, J. Zopes, W. Alt, S. Brakhane, D. Meschede, and A. Alberti, "Low-entropy states of neutral atoms in polarization-synthesized optical lattices," Phys. Rev. Lett. 118, 065302 (2017) [5] C. Robens, S. Brakhane, W. Alt, F. Kleißler, D. Meschede, G. Moon, G. Ramola, and A. Alberti, "A high numerical aperture (NA = 0.92) objective lens for imaging and addressing of cold atoms," Opt. Lett. 42, 1043 (2017).

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