Simulating topological phases with discrete-time quantum walks in two-dimensional optical lattices

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I will report on quantum walk experiments employing ultracold Caesium atoms trapped in *polarisation-synthetized (PS) optical lattices* [1]. Polarisation-synthetized optical lattices are a conceptually novel realization of spin-dependent optical lattices, which enable a wide range of quantum walk experiments. Atoms in spin-up and spin-down states are trapped in two distinct optical standing waves, whose position and depth can be individually controlled in time. This allows us to perform arbitrary shift operations of atoms in a fully independent manner for spin-up and spin-down components, on the timescale of microseconds and with a spatial precision of about 1Å.

The next frontier for our ultracold-atom experiments is the realization of 2D discrete-time quantum walks. The implementation of a novel scheme for spin-dependent transport in the x-y plane with polarization-synthesized optical lattices is currently underway. We plan to use this setup to study Floquet topological phases in one [2] and two dimensions [3]. I will also present our most recent technological advances [4] about the construction of the 2D experimental setup.

[1] C. Robens, J. Zopes, W. Alt, S. Brakhane, D. Meschede, and A. Alberti, "Low-entropy states of neutral atoms in polarization-synthesized optical lattices," arXiv:1608.02410 [quant-ph], accepted in Phys. Rev. Lett.

[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] 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).

[4] C. Robens, S. Brakhane, W. Alt, F. Kleißler, D. Meschede, G. Moon, and A. Alberti, "A high numerical aperture (NA = 0.92) objective lens for imaging and addressing of cold atoms," arXiv:1611.02159, accepted in Opt. Lett.