Juliette Simonet (University of Hamburg, Germany): *Optical lattices and Artificial Gauge Fields*

Quantum gases in optical lattices have proven to be a powerful tool for the investigation of various phenomena related to the field of many-body physics. These artificial crystals of light have triggered a huge amount of theoretical and experimental interest during the past two decades. Increasingly sophisticated preparation and probing schemes have further boosted quantum simulation in optical lattices. A paradigm example of this advancement is the development of quantum gas microscopes that allow for single-site resolved detection and manipulation of atoms in lattices. Yet, despite its great success, some ingredients are still missing in the toolbox of quantum simulation for solid-state systems. For instance, neutral atoms owing to their zero electric charge do not couple to external gauge fields. Thus, many intriguing phenomena such as the quantum Hall effect or topological insulating phases seem to be illusive in the context of ultracold atoms in optical lattices. Great effort has been spent to develop new tools for engineering and probing artificial gauge potentials for neutral atoms. In this context, time-periodic driving constitutes a powerful technique, which is subsumed under the term of Floquet engineering. The central idea is that the long-time dynamics of periodically driven quantum systems is governed by a time-independent effective Hamiltonian. Thus, appropriate driving schemes allow tailoring effective Hamiltonians that give rise to new quantum phases of matter. Periodic forcing of atoms in an optical lattice indeed enables the realization of complex-valued tunneling matrix elements with Peierls phases mimicking the effect of an external electromagnetic gauge potential. By now, diverse types of gauge potentials can be experimentally realized: Abelian gauge potentials, giving rise to synthetic electric and magnetic fields for neutral atoms as well as non-Abelian gauge potentials, such as spin-orbit coupling.

The motivated students could read the 2 following reviews:

[1] Bloch et al., Many-body physics with ultracold gases, RMP 80, 885 (2008) https://journals.aps.org/rmp/abstract/10.1103/RevModPhys.80.885

[2] Dalibard et al., Colloquium: Artificial gauge potentials for neutral Atoms, RMP 83, 1523 (2011) https://journals.aps.org/rmp/abstract/10.1103/RevModPhys.83.1523