UNIVERSITÄT DUISBURG ESSEN

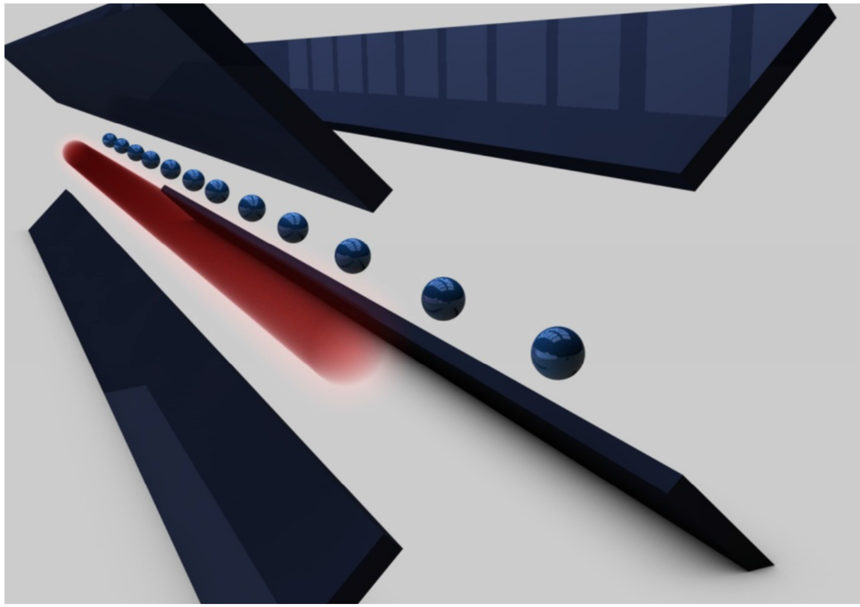
PHYSIK E=

Physikalisches Kolloquium

Mittwoch, 23.04.2014
17:15 Uhr
Hörsaal MC 122

Quantum Simulations with Ultracold Atoms: Beyond Standard Optical Lattices

Prof. Dr. Walter Hofstetter
Goethe-Universität Frankfurt am Main



The last years have witnessed dramatic progress in experimental control and refinement of quantum simulations based on ultracold atoms. One major recent development is the realization of synthetic gauge fields for neutral atoms, allowing the simulation of topologically nontrivial phases of matter. Particularly rich many-body physics arises in the presence of multiple atomic or ionic species and strong interactions, which I will highlight for several examples:

1) We propose and theoretically investigate a hybrid system composed of a crystal of trapped ions coupled to a cloud of ultracold fermions. This system combines the advantages of scalability and tunability of ultracold atomic systems with the high fidelity operations and detection offered by trapped ion systems. It also features close analogies to natural solid-state systems, as the atomic degrees of freedom couple to phonons of the ion lattice, thereby emulating a solid-state system. Starting from the microscopic many-body Hamiltonian, we derive the low energy Hamiltonian including the atomic band structure and give an expression for the atom-phonon coupling. We discuss possible experimental implementations such as a Peierls-like transition into a dimerized state.

2) We consider a non-abelian and time-reversal invariant version of the Hofstadter problem - a quantum particle on a lattice in a synthetic magnetic field - which has recently been realized in ultracold atoms. Without interactions, the system exhibits various phases such as topological and normal insulator, metal as well as semi-metal phases with multiple Dirac cones. Using a combination of dynamical mean-field theory and analytical techniques, we investigate the stability of topological insulator phases in the presence of strong interactions.

3) We discuss nonequilibrium effects arising in the preparation of strongly correlated states in optical lattices, in particular the "dynamical arrest" of ultracold fermions, which provides an experimental challenge.