SYEM 1: Symposium Extreme Matter I

Time: Wednesday 11:00–13:00 Location: C/gHS

Invited Talk SYEM 1.1 Wed 11:00 C/gHS

Generation of Structure under Extreme Conditions: Ultracold Atoms meet Heavy-Ion Collissions — •Jens Braun — Institut für Kernphysik, TU Darmstadt, Germany

The theory of the strong interaction describes the appearance of the fundamental building blocks of matter in the early Universe. This state of matter is currently probed in relativistic heavy-ion collision experiments, where we encounter temperatures much larger than those of any other experiment. As a complement, experiments with fermionic atoms in the nano-Kelvin regime provide a remarkably clean and versatile environment to test our understanding of a broad range of phenomena: from superconductivity and the formation of condensates to the generation of bound states in strongly coupled systems.

What do these systems have in common? As I will explain in this talk, studies of ultracold atomic gases and the theory of the strong interaction are actually similar in many ways, yet a consistent first-principles description of the experimental data remains challenging. I will present an overview of some of the most intriguing open questions on the phase diagrams of the theory of the strong interaction and ultracold gases, and discuss how an exchange of techniques between these fields is helping us to understand collective phenomena and phase transitions in strongly coupled matter in general.

Invited Talk SYEM 1.2 Wed 11:30 C/gHS

Strongly Interacting Fermi Gases of Atoms and Molecules — •Martin Zwierlein — MIT-Harvard Center for Ultracold Atoms, MIT, Cambridge, USA

In recent years, ultracold gases of fermionic atoms have become a new platform for the realization of paradigmatic forms of strongly interacting matter. Feshbach scattering resonances allow to tune the interactions between atoms at will and to realize the crossover from Bose-Einstein condensation of molecules to Bardeen-Cooper-Schrieffer superfluidity of long-range Cooper pairs. On resonance, we encounter the unitary Fermi gas, with universal properties that closely correspond to those of dilute neutron matter in the crust of neutron stars, and to nuclear matter. I will present our recent study of solitonic excitations in this novel superfluid, the creation of planar solitons and the subsequent cascade into vortex rings and solitonic vortices. To induce strong interactions one may also quench the atoms' kinetic energy in optical lattices. Of great interest here is the realization of the Fermi-Hubbard model, believed to hold the key to understanding high-temperature superconductors. We recently realized imaging of fermionic atoms with single-site resolution in optical lattices, an important step towards the direct observation of magnetic order. Finally, strong, long-range dipolar interactions can lead to novel states of fermionic matter such as topological superfluids. We have created chemically stable, strongly dipolar fermionic molecules, opening up prospects for observing a strongly interacting degenerate Fermi gas with dominant dipolar interactions.

Invited Talk SYEM 1.3 Wed 12:00 C/gHS

Towards ultracold RbSr ground-state molecules — •Florian Schreck — Institute of Physics, University of Amsterdam, The Netherlands

RbSr ground-state molecules possess a strong electric dipole moment and an unpaired electron, providing a magnetic moment. Interactions between the molecules can be tuned by electric and magnetic fields, enabling the creation and exploration of a wide range of many-body quantum systems. An exciting possibility is to induce repulsive van der Waals interactions between the molecules, which might enable evaporative cooling to a quantum gas of ground-state molecules. Another prospect is to exploit the long-range electric dipole interaction to engineer lattice-spin models. I will present our progress towards the creation of ultracold RbSr ground-state molecules and give an overview of the opportunities opened by them.

Invited Talk SYEM 1.4 Wed 12:30 C/gHS

Multiflavor phenomena and synthetic gauge fields in strongly interacting quantum gases — •Walter Hofstetter — Goethe-Universität Frankfurt, Germany

Recent years have witnessed dramatic progress in experimental control and refinement of quantum simulations based on ultracold atoms. One major development are synthetic gauge fields, which allow simulating the dynamics of charged particles and topologically nontrivial phases of matter.

Particularly rich physics arises in multiflavor gases, for example earth-alkalines, which allow implementing higher symmetry groups such as SU(N), and where "color" superfluids and exotic magnetic states have been predicted.

Spectroscopy and real-time dynamics have revealed novel collective modes, in particular the Higgs-amplitude mode of strongly correlated bosons.

I will discuss recent theoretical insights along these directions, which have been obtained by non-perturbative approaches such as variational wavefunctions and Dynamical Mean-Field Theory.