SYMB 1: Many-Body Physics of Model Systems and Real Materials

Time: Thursday 14:30–17:00 Location: HSZ 01

Invited Talk SYMB 1.1 Thu 14:30 HSZ 01
Synthetic Quantum Many-Body Systems — •Tilman Esslinger — Department of Physics, ETH Zurich, Switzerland

The quantum gas approach to many-body physics is fundamentally different from the path taken by other condensed matter systems, where experimentally observed phenomena trigger the search for a theoretical explanation. In quantum gas research, the starting point is a synthetically created many-body model that can be realized in an experiment. The study of the system then leads to the observation of fundamental phenomena such as crossovers and phase transitions. The challenge for the research field of quantum gases is to gain distinctive and new insights into quantum many-body physics by answering long-standing questions of an underlying model or by creating many-body systems of an entirely new character. In this talk I will discuss quantitative experiments with strongly-correlated fermions in optical lattices and the Dicke quantum phase transition in a Bose-Einstein condensate coupled to a high-finesse cavity which leads to the formation of a supersolid state.

Invited Talk SYMB 1.2 Thu 15:00 HSZ 01
Unconventional quantum phases in quantum magnetism and cold atoms — •Frederic Mila — Institute of Theoretical Physics, Ecole Polytechnique Federale de Lausanne, 1015 Lausanne, Switzerland

The search for new quantum phases with original properties is one of the major themes in quantum many-body physics. Frustrated magnets are a major player in the field, with the prediction of several types of new phases such as nematic phases or quantum spin liquids of various types. The major challenge at the moment is to find good experimental realizations of these phases in the context of quantum magnets. In that respect, cold atoms open new perspectives. In this talk, I will demonstrate this in the context of quadrupolar order in spin-1 antiferromagnets. First, I will show that large and positive biquadratic interactions induce antiferroquadrupolar order (a certain type of nematic order) in several geometries. Then, I will discuss possible origins of biquadratic interactions, with the conclusion that the biquadratic interactions that naturally appear in the context of quantum magnets are negative. Finally, I will show that three-flavour fermions loaded in an optical lattice realize, in the Mott phase with one particle per site, a special case of positive biquadratic interactions, and that in the resulting SU(3) Heisenberg model on the square and cubic lattices quantum and thermal fluctuations compete with each other instead of cooperating, as they usually do in frustrated magnets.

Invited Talk SYMB 1.3 Thu 15:30 HSZ 01
Exploring the physics of disorder with Bose-Einstein condensates — •Giovanni Modugno — LENS, University of Florence, Via Carrara 1, 50019 Sesto Fiorentino, Italy

The combination of disorder and nonlinearities determines the transport properties of many physical systems, including normal conductors and superconductors, biological systems, or light in disordered nonlinear media. A full understanding of the interplay of disorder and nonlinearities is still missing, due to the lack of complete control over experimental parameters in most systems.

I will describe how we are employing Bose-Einstein condensates with tunable interactions in combination with optical potentials to address some of the open questions, related for example to the transport properties and to the transition from insulating to superfluid phases in lattice systems.

Invited Talk SYMB 1.4 Thu 16:00 HSZ 01
Influence of randomness on the Mott transition in the organic molecular conductors — •Takahiko Sasaki — Institute for Materials Research, Tohoku University, Sendai, Japan

Metal-insulator transitions are of considerable importance for strongly correlated electron systems. Among the various types of the transitions, the Mott transition due to electron-electron interactions is one of the most attractive phenomena. Another way of the electron localization originates from the interference of the electron wave functions due to randomness. This is the Anderson insulator derived by introducing disorder into the material. Since the randomness in the correlated electron system is essentially important in real materials, systematic studies of disorder effects are desired in systems nearby a Mott transition for understanding their physical properties. It has been known that x-ray irradiation for the organic materials causes molecular disorder softly and this remains permanently in organic material. Recently, it was found that the weak molecular disorder introduced by x-ray irradiation to the organic superconductor κ-(BEDT-TTF)$_2$Cu[N(CN)$_2$]Br induced the Anderson-type localization insulating state from the strongly correlated metallic/superconducting state [1]. In addition, the hydrostatic pressures to the localization insulator restore the metallic properties. These observations indicate that the stronger electron correlation upon approaching to the Mott transition enhances Anderson-type electron localization due to disorder introduced by x-ray irradiation.

[1] K. Sano, T. Sasaki *et al.*, Phys. Rev. Lett. **101**, 217003 (2010).

Invited Talk SYMB 1.5 Thu 16:30 HSZ 01
Unconventional superconductivity in strongly correlated materials — •Jörg Schmalian — Department of Physics and Ames Laboratory, Iowa State University

In this talk we discuss the emergence of unconventional superconductivity in materials with strong electronic correlations. A combination of first principle based electronic structure calculations, diagrammatic many body theory and strong coupling approaches will be employed to discuss a broad range of correlated materials. In particular, we analyze the role of strong local interactions versus long-wavelength collective excitations in the many body description of organic charge transfer salts, iron based superconductors and copper oxides.