SYPD 1: Many-body Physics in Ultracold Quantum Systems

Time: Thursday 14:30–16:30 Location: E415

Invited Talk SYPD 1.1 Thu 14:30 E415
Entanglement and quantum metrology with microcavities — •Jakob Reichel — Laboratoire Kastler Brossel (ENS-PSL, SU, CRNS, CdF) Paris

Entanglement is at the heart of quantum science and technology, and is a key resource for quantum-enhanced precision measurement. In cold-atom systems, photon-mediated interactions in optical cavities are a particularly attractive platform for generating high-fidelity entangled states in a scalable way. This relatively new approach is rapidly gaining importance, with important advances being achieved in the last few years. I will try to give an overview of the different ways in which cavities can be used to create and detect entanglement, and discuss some recent advances, showing where we are on the way to entanglement-enhanced metrology-grade clocks and sensors. One of the factors driving the progress in this field is the advancement of optical cavity technology, and I will also highlight the progress of the fiber Fabry-Perot microcavities used in the work in our group.

Invited Talk SYPD 1.2 Thu 15:00 E415
Many-body physics in dipolar quantum gases — •Francesca Ferlaino — Institute for Experimental Physics, University of Innsbruck, Austria — Institute for Quantum Optics and Quantum Information (IQOQI), Austrian Academy of Sciences, Innsbruck, Austria

Brought to quantum degeneracy, ultracold gases enable the study of many-body quantum phenomena, in which the interaction between atoms can be so carefully mastered as to determine the very state of matter. Typically, this interaction has a short-range and isotropic nature, the latter meaning that the atoms globally attract or repel each other. However, there is another possibility that naturally emerges for some specific atomic species, such as erbium and dysprosium, featuring an extraordinarily large magnetic dipole moment. Magnetic properties give rise to dipolar many-body interactions, qualitatively very different from others in that they are long-range and anisotropic, thus adding connectivity and directionality at the quantum level.

In the present talk, we will retrace the fundamental steps in the study of dipolar gases, with emphasis on the Innsbruck results, from their creation to the new phenomena unveiled such as the emergence of rotonic excitations, so named by Landau, to the observation of a new and paradoxical state of matter with multiple spontaneous symmetry breaking, known as supersolid.

Invited Talk SYPD 1.3 Thu 15:30 E415
Quantum Simulation: from Dipolar Quantum Gases to Frustrated Quantum Magnets — •Markus Greiner — Harvard University, Cambridge, Massachusetts, USA

Ultracold atoms in our quantum gas microscope offer a fascinating view of the quantum world. With quantum simulations we can experimentally realize and study quantum-mechanical model systems that are otherwise extremely difficult to compute on classical computers, but relevant to understanding real world quantum materials. I will present recent work on frustrated quantum magnets, fractional quantum Hall physics, and on dipolar physics.

Invited Talk SYPD 1.4 Thu 16:00 E415
Quantum gas in a box — •Zoran Hadzibabic — University of Cambridge

Ultracold atomic gases are used with great success to study fundamental many-body phenomena. While traditionally they were produced in harmonic traps and had inhomogeneous densities, one can now also create homogeneous samples using optical box traps [1,2]. This simplifies the interpretation of experiments, provides more direct connections with theory, and sometimes allows qualitatively new studies [2]. I will give an overview of our recent experiments with box-trapped Bose gases, focusing on non-equilibrium phenomena such as turbulence and evolution of far-from-equilibrium closed quantum systems [3-5].

[1] Bose-Einstein condensation of atoms in a uniform potential, A. L. Gaunt et al., Phys. Rev. Lett. 110, 200406 (2013).
[2] Review: Quantum gases in optical boxes, N. Navon, R. P. Smith, and Z. Hadzibabic, Nat. Phys. 17, 1334 (2021).
[3] Emergence of a turbulent cascade in a quantum gas, N. Navon, A. L. Gaunt, R. P. Smith, and Z. Hadzibabic, Nature 539, 72 (2016).
[4] Bidirectional dynamic scaling in an isolated Bose gas far from equilibrium, J. A. P. Glidden et al., Nat. Phys. 17, 457 (2021).
[5] Universal equation of state for wave turbulence in a quantum gas, L. H. Dogra et al., arXiv:2212.08652.