SYRY 2: Rydberg Physics in Single-Atom Trap Arrays 1

Time: Wednesday 10:30–12:30 Location: Audimax

Invited Talk SYRY 2.1 Wed 10:30 Audimax

Many-body physics with arrays of Rydberg atoms in resonant interaction — •Antoine Browaeys — Institut d'Optique, 2 av Augustin Fresnel, 91120 Palaiseau France

This talk will present our recent work on the quantum simulation of spin Hamiltonians using arrays of Rydberg atoms in resonant, exchange interaction. Combined with a microwave driving between two Rydberg states, we engineer XXZ models with various anisotropies. We illustrate this engineering by studying the dynamics of the system in 2D arrays and in small 1D chain. Recently we have started to explore the possibility of realizing a Dirac spin-liquid on a Kagome lattice. The talk will present the status of this experiment. I will also mention the experimental improvements we performed in the recent years such as the trapping of atoms in a cryogenic environment.

Invited Talk SYRY 2.2 Wed 11:00 Audimax

Optimization and sampling algorithms with Rydberg atom arrays — •Hannes Pichler — Institute for Quantum Optics and Quantum Information, Austrian Academy of Sciences, Innsbruck, Austria — Institute for Theoretical Physics, University of Innsbruck, Austria

Rydberg atom arrays offer novel opportunities to implement quantum information processing protocols. In this talk we discuss a connection between the physics of Rydberg atom arrays and the combinatorial optimization problem of finding large independent sets on a graph. We discuss various implementations of algorithms designed to find the maximum independent set, approximate solutions, and approaches to sample from probability distributions over independent sets, as well as their performance.

Invited Talk SYRY 2.3 Wed 11:30 Audimax

Slow dynamics due to constraints, classical and quantum — •Juan P. Garrahan — University of Nottingham, United Kingdom

Using the East model and the Fredkin spin chain as examples, I will discuss how kinetic constraints give rise to slow, spatially fluctuating relaxation both under classical stochastic or quantum unitary dynamics. I will consider similarities and differences between the classical and quantum cases, and relevant properties such as dynamic heterogeneity and growth of entanglement, singularities in large deviation functions, and the emergence of non-thermal scar-like eigenstates. I will also discuss possible generalisations to higher dimensions.

SYRY 2.4 Wed 12:00 Audimax

Designing complex spin interactions in Rydberg tweezer arrays — •Lea-Marina Steinert[1], Philip Osterholz[1], Robin Eberhard[2], Ludwig Müller[1], Roxana Wedowski[1], Arno Trautmann[1], and Christian Gross[1,2] — [1]Physikalisches Institut, Eberhard Karls Universität Tübingen, 72076 Tübingen, Germany — [2]Max-Planck-Institut für Quantenoptik, 85748 Garching, Germany

Synthetic quantum systems based on individually trapped neutral atoms allow studying many-body systems which are hard to solve classically. The classes of many-body systems which can be implemented experimentally are limited by the programmability of the interatomic interactions. We report on the realization of a beyond-Ising spin-1/2 model, where the strong and tunable interactions are based on the off-resonant coupling to highly-excited electronic P states (Rydberg dressing). The effective spins are encoded in the hyperfine ground state manyfold and prepared in individual optical traps (tweezer arrays at various geometries). The Van-der-Waals interactions between the Rydberg states lead to a strong mixing between usually well-separated m_j-sublevels. This opens up controllable interaction channels allowing to implement spin hopping as well as flipping two spins of the same state to the opposite spin state. Using these new types of interactions as well as their long-range character paves the way to implement new types and classes of quantum magnets.

SYRY 2.5 Wed 12:15 Audimax

Rydberg-interacting neutral atoms in a scalable platform of optical tweezers with site-selective addressability — •Dominik Schäffner, Tobias Schreiber, Tilman Preuschoff, Lars Pause, Stephan Amann, Jan Lautenschläger, Malte Schlosser, and Gerhard Birkl — Institut für Angewandte Physik, TU Darmstadt, Schlossgartenstraße 7, 64289 Darmstadt, Germany

In this talk, a versatile platform of optical tweezers is introduced comprising hundreds of focused-beam dipole potentials capable to store laser-cooled atoms with spatial separations in the micrometer regime [1]. Based on micro-fabricated lens arrays, this approach is highly scalable while offering three-dimensional tweezer configurations at no additional cost due to the inherent self-imaging [2]. Site-selective addressability giving precise control over the internal and external atomic degrees of freedom facilitates transport of atoms between sites, coherent coupling of the hyperfine ground states as well as excitation to Rydberg states with individual-atom control [3]. On this basis, defect-free 2D clusters of more than 100 single-atom quantum systems can be created. Furthermore, Rydberg-mediated interactions in assembled atom configurations are demonstrated.

[1] D. Ohl de Mello et. al., Phys. Rev. Lett. **122**, 203601 (2019).
[2] M. Schlosser et. al., arXiv, 1902.05424 (2019).
[3] M. Schlosser et. al., J. Phys. B: At. Mol. Opt. Phys **53** 144001 (2020).