Invited Talk

SYRA 2.1 Tue 14:00 V47.01
Ultrasound-range Rydberg molecules

Thomas Pohl — MPI for the Physics of Complex Systems, Dresden, Germany

Ultrasound-range Rydberg molecules represent an extreme and peculiar example of chemical binding, where a ground state atom is bound inside the electronic wave function of a highly excited Rydberg atom. Owing to their large bond length of several thousand Bohr radii, these molecules - first produced in 2009 [1] - exhibit several unusual properties, some of which will be discussed in this talk.

Following a simplified discussion of the basic interaction mechanisms, I will describe more sophisticated calculations, which reveal, yet another new binding mechanism based on internal quantum reflection [2]. Good agreement with experiments on ultracold Rubidium molecules, gives strong indication that the predicted molecular states indeed provide a manifestation of such elementary quantum phenomena. A close look at small-electric field effects uncovers the existence of a sizable molecular electric dipole moment [3], which comes as a surprise for homo-nuclear molecules.

Besides being of fundamental interest, such exotic molecules turn out to be also of relevance to other Rydberg-atom settings. In order to illustrate this point, I will consider their collective exciton dynamics in mesoscopic ultracold gases and discuss possible implications for ensemble-based quantum information/optics applications.


Quantum Information Processing with Rydberg Atoms

Philippe Grangier — Institut d’Optique, RD128, 91127 Palaiseau, France

We will present an overview of the use of direct interactions between trapped cold Rydberg states for quantum information processing. A first approach is to use dipole blockade between individually trapped atoms, used as quantum bits. This allows one to generate entangled pairs of atomic qubits, and to perform quantum gates, as it has been demonstrated by several recent experiments that will be presented.

A second approach is to use atomic ensembles, and to excite Rydberg polaritons in order to generate “giant” optical non-linear effects, that may lead to quantum gates for photonic qubits. Perspectives in that direction will be also discussed.

SYRA 2.3 Tue 15:00 V47.01
Electric field impact on ultra-long-range triatomic polar Rydberg molecules

Michael Mayle1, Seth T. Rittenhouse2, Peter Schmelcher3, and Hossein R. Sadeghpour2 — 1JILA, University of Colorado Boulder and NIST, USA — 2ITAMP, Harvard-Smithsonian Center for Astrophysics, USA — 3Zentrum für Optische Quantentechnologien, Universität Hamburg

We explore the impact of external electric fields on a recently predicted species of ultra-long-range molecules that emerge due to the interaction of a ground state polar molecule with a Rydberg atom. The external field mixes the Rydberg electronic states and therefore strongly alters the electric field seen by the polar diatomic molecule due to the Rydberg electron. As a consequence the adiabatic potential energy curves responsible for the binding can be tuned in such a way that an intersection with neighboring curves occurs. The latter leads to an admixture of s-wave character to the Rydberg wave function and should significantly facilitate the experimental preparation of this novel species.

SYRA 2.4 Tue 15:15 V47.01
Synergetic physics of Rydberg polaritons: New experiments and theoretical predictions

Hendrik Weimer1, Liza Huijse1, Alexey Gorbshov2, Guido Pupillo3, Peter Zoller4, Mikhail Lukin2, and Eugene Demler1 — 1Physics Department, Harvard University, Cambridge, MA, USA — 2IQI, Caltech, Pasadena, CA, USA — 3University of Strasbourg, Strasbourg, France — 4University of Innsbruck and IQOQI, Innsbruck, Austria

Synergetic physics of Rydberg polaritons is a powerful tool that allows the characterization of strongly correlated many-body systems, in particular in the case of supersymmetric extensions of the fermionic Hubbard model [1]. At the same time, these models can exhibit rich and exotic physics on their own, such as flat bands with a vanishing dispersion relation. We will discuss the unique possibilities of ultracold atoms for the detection of supersymmetry and the effects of tuning the system away from the supersymmetric point.


SYRA 2.5 Tue 15:30 V47.01
Aufbau eines Experiments zur Rydberganregung von 40Ca+ Ionen

Thomas Feldker, Julian Naber, Ferdinand Schmidt-Kaler, Daniel Kolbe, Matthias Stöffel und Jochen Walz — Quantum, Institut für Physik, Johannes Gutenberg Universität, Mainz


SYRA 2.6 Tue 15:45 V47.01
Strongly interacting single photons in an ultra-cold Rydberg gas

Stephan Jennwien, Huu Nguyen, Michael Schlammüller, Christoph Tresp, and Sebastian Hofferberth — Phys. Institut, Universität Stuttgart

Strong photon-photon coupling can in principle be achieved inside extremely nonlinear media. The search for few-photon nonlinearities is a highly active field, including such diverse systems as quantum dots, NV centers in diamond, atomic ensembles, and single atoms in optical resonators. However, no robust and scalable realization of, for example, a single-photon switch has been achieved so far. Here, we present a new approach that aims to realize dramatically enhanced photon-photon interactions by mapping quantum correlations between strongly interacting atoms inside an ultra-cold gas onto single photons. We show that this technique can be used to implement building blocks for photonic quantum information processing, such as a deterministic single-photon source and a quantum phase gate.