SYQL 1: From molecular spectroscopy to collisions control at the quantum limit (SYQL)

Time: Thursday 11:00–13:00 Location: e415

Invited Talk SYQL 1.1 Thu 11:00 e415

The unity of physics: the beauty and power of spectroscopy — •Paul Julienne — Joint Quantum Institute, College Park, Maryland, USA

Physics exhibits a deep unity across all its disciplines. This is nowhere so evident as in the power of spectroscopy, the highly specific frequency dependent interaction of light with matter, to inform us about a wide range of phenomena. We rightly honor Professor Eberhard Tiemann today for his beautiful applications of spectroscopy to essential science needed for ultracold matter studies. His work on molecular potentials enables highly predictive models to be developed for the interactions of magnetically controllable ultracold atoms. I will illustrate this for the specific case of the unusual three-body physics of potassium atoms done in collaboration with theorist Jose D'Incao and experimental studies from the groups of Eric Cornell and Jun Ye at JILA. The precise molecular potentials of potassium dimer molecules that came from Professor Tiemann's group are essential to the theory. Ultracold matter studies across a wide range of phenomena would not be as successful as they have been without such detailed and accurate knowledge of atomic and molecular interactions that is only made possible through conventional and novel spectroscopic tools and analysis.

Invited Talk SYQL 1.2 Thu 11:30 e415

Using spectroscopy to explore the Rb_2 molecule and its formation — •Johannes Hecker Denschlag — Universität Ulm

Understanding the internal structure of Rb_2 in all details has been a key for our group to explore the molecule's internal dynamics, its formation and its reactions. I will give an overview of our work on Rb_2 which has been carried out in close collaboration with Prof. Tiemann. I will point out interesting insights about Rb_2 we have gained along the way.

Invited Talk SYQL 1.3 Thu 12:00 e415

Cold molecules: a chemistry kitchen for physicists — •Olivier Dulieu — Université Paris-Saclay, CNRS, Laboratoire Aimé Cotton, Orsay, France

The title of this talk refers too a special issue of Journal of Physics B in 2006, that I had the honor to jointly edit with Professor Tiemann [1]. In the original publication the title contained a question mark that I removed here, as the amazing results obtained since then demonstrated the impact of ultracold molecule research in many areas, including not only chemistry, but also molecular spectroscopy, ultracold collisions, and exquisite control of quantum systems. In this talk I will review some of these aspects that we investigated in our group in Orsay, in particular regarding the formation and destruction processes of ultracold molecules, and the control of their interactions using laser light.

[1] J. Phys. B: At. Mol. Opt. Phys. 39 (2006)

Invited Talk SYQL 1.4 Thu 12:30 e415

The birth of a degenerate Fermi gas of molecules — •Jun Ye — JILA, NIST and University of Colorado

It is an honor to help celebrate the scientific legacy of Prof. Eberhard Tiemann. I wish to elaborate an important role Prof. Tiemann played during the early stages of the first experiment in producing a high phase-space density gas of polar molecules in the absolute ground state. The experiment was jointly performed with my late colleague Prof. Deborah Jin in 2008, and we received invaluable theory guidance from Profs. Tiemann, Julienne, and Kotochigova.

With this successful approach of making ultracold molecules, we observed for the first time that molecular collisions and chemical reactions are controlled via quantum statistics and single collisional partial waves. When molecules are loaded in a 3D optical lattice, a spin lattice system is formed where many-body spin dynamics are controlled by long-range and anisotropic dipolar interactions.

In 2018 we finally produced the first degenerate Fermi gas of polar molecules, with up to 100,000 KRb molecules and T/T_F as low as 0.3. Density fluctuations in the degenerate molecular gas are observed to be sub-Poissonian, and confirm its full thermalization. To control molecular interactions, we use microwave fields and large DC electric fields with adjustable gradients. By confining the molecules in a 2D geometry, we observe a strong suppression of chemical reaction loss and an increase of the molecular phase-space-density via evaporative cooling. This sets the stage to discover new insights to strongly correlated quantum systems and chemistry in the quantum regime.