A 16: Collisions, scattering and correlation phenomena II

Time: Tuesday 14:30–16:30 Location: f142

Invited Talk A 16.1 Tue 14:30 f142

Observation of the Efimov state of the helium trimer — •Maksim Kunitski[1], Stefan Zeller[1], Jörg Voigtsberger[1], Anton Kalinin[1], Lothar Ph. H. Schmidt[1], Markus Schöffler[1], Achim Czasch[1], Wieland Schöllkopf[2], Robert E. Grisenti[1], Till Jahnke[1], Dörte Blume[3], and Reinhard Dörner[1] — [1]Institut für Kernphysik, Goethe-Universität Frankfurt/M — [2]Department of Molecular Physics, Fritz-Haber-Institut, Berlin — [3]Department of Physics and Astronomy, Washington State University, USA

In 1970 Vitali Efimov predicted remarkable counterintuitive behaviour of a three-body system made up of identical bosons. Namely, a *weakening* of pair interaction in such a system brings about in the limit appearance of *infinite* number of bound states of a huge spatial extent. The helium trimer has been predicted to be a molecular system having an excited state of this Efimov character under natural conditions.

Here we report experimental observation of the Efimov state of $^4He_3$ by means of Coulomb explosion imaging of mass-selected clusters [1]. Structures of the excited Efimov state of the $^4He_3$ are about eight times larger than those of the ground state, which is in accordance with theory. Whereas the ground state corresponds to an almost randomly distributed cloud of particles [2], the excited Efimov state is dominated by configurations in which two atoms are close to each other and the third one further away.

[1] M. Kunitski et al, *Science* 348, 551-555, 2015
[2] J. Voigtsberger et al, *Nat. Comm.* 5, 5765:1-6, 2014

A 16.2 Tue 15:00 f142

Universal three-body recombination and Efimov resonances in an ultracold Li-Cs mixture — •Stephan Häfner[1], Juris Ulmanis[1], Rico Pires[1], Felix Werner[2], Dmitry S. Petrov[3], Eva D. Kuhnle[1], and Matthias Weidemüller[1] — [1]Physikalisches Institut, Ruprecht-Karls-Universität Heidelberg, Im Neuenheimer Feld 226, 69120 Heidelberg, Germany — [2]Laboratoire Kastler Brossel, ENS-PSL, UPMC-Sorbonne Université, Collège de France, CNRS, 24 rue Lhomond, 75231 Paris Cedex 05, France — [3]LPTMS, CNRS, Univ. Paris Sud, Université Paris-Saclay, 91405 Orsay, France

Universality of few-body systems has been a driving force in fundamental quantum physics. One paradigm is the Efimov effect, where a infinite geometical progession of bound three-body states emerges from pairwise resonantly interacting particles. In an ultracold Bose-Fermi mixture of ^{133}Cs and ^6Li the scaling factor is drastically reduced due to its large mass imbalance, making it an indeal system for the experimental observation of a series of Efimov resonances. Here we present our recent measurements of the three-body event rate constant of the Li+Cs+Cs scattering channel close to a broad Feshbach resonance. We observe a series of three consecutive Efimov resonances at temperatures of 450nK and 120nK and compare the recombination spectra with the universal zero-range theory at finite temperature [1]. For the first and second excited Efimov resonance, located in the window of universality, good agreement is found, whereas for the ground state deviations from universality become apparent.

[1] D.S. Petrov and F. Werner, Phys. Rev. A 92, 022704 (2015)

A 16.3 Tue 15:15 f142

Two-channel model for cold collisions of metastable neon atoms — •Christian Cop and Reinhold Walser — TU Darmstadt, Institut für Angewandte Physik, Hochschulstr. 4a, D-64289 Darmstadt

Although metastable noble gas has begun in the 1980s for various species, Bose-Einstein condensation has only been demonstrated for metastable helium so far. At the technical university of Darmstadt, the group of G. Birkl investigates experimentally the prospects to condense metastable neon atoms (Ne*) to degeneracy. High internal energy of Ne* (16 eV) leads to loss rates through Penning ionization (PI). PI may be suppressed by spin polarization of the atoms, which has been demonstrated for Ne* [1]. Additionally, experimental data is now available on cross sections and loss rates of isotope- and spin-mixtures of the three stable isotopes of Ne*.

We set up a two-channel model, where the scattering channel is given by a realistic interaction potential for Ne*, coupled to an arbitrary loss channel via an arbitrary coupling. Suppression of PI is modeled by varying the coupling strength [2]. We present recent results and show, that the calculated values of the loss rates and cross sections of the different isotope- and spin-mixtures are in very good agreement with the experimental data points.

[1] P. Spoden, M. Zinner, N. Herschbach, W.J. Van Drunen, W. Ertmer, G. Birkl, 2005, Phys. Rev. Lett. 94, 223201
[2] C. Cop, A. Martin, G. Birkl, R. Walser, to be published

A 16.4 Tue 15:30 f142

Spontanious symmetry breaking in He resonances — •Hubert Klar — DHBW Lörrach

A ficticious force acting between the electrons breaks the electron exchange symmetry. This is not in contradiction with experimental data, because this effect is extremely small in the ground state, in singly excited states, and in lower double Ryberg states. Very high resonaces near threhold for double escape, hwoever, are neither singlets nor triplets.

A 16.5 Tue 15:45 f142

Laser-driven relativistic charged and neutral twisted matter waves — •Armen Hayrapetyan[1] and Jörg Götte[2] — [1]Max-Planck-Institut für Physik komplexer Systeme, Dresden, Germany — [2]School of Physics and Astronomy, University of Glasgow, Glasgow G12 8QQ, U.K.

With an advent of improved instrumentation it has recently become possible to generate vortex beams of electrons and neutrons. These new types of waves propagate with twisted wavefronts and carry a non-zero topological charge resulting in a vortex-type distribution of beams' profile. In this work, we explore how the profile of such charged and neutral matter waves can be controlled and manipulated by means of intense laser fields. For this purpose, we develop an exact relativistic quantum theory by constructing Bessel-type solutions to generalized Dirac equations that describe the interaction of charged and neutral spin-half fermions with electromagnetic fields. Given the different mechanisms for the "minimal coupling" scheme of charged and neutral particles with external fields, we discuss the similarities and peculiar differences between laser-driven twisted electrons and neutrons.

A 16.6 Tue 16:00 f142

Quantum interference in bichromatic Kapitza-Dirac scattering — •Matthias Maximilian Dellweg and Carsten Müller — Institut für Theoretische Physik I, Heinrich-Heine-Universität Düsseldorf, Universitätsstraße 1, 40225 Düsseldorf

In this contribution, we study Kapitza-Dirac scattering of an electron from a bichromatic standing light wave of commensurate frequency ratio. On the one hand, we investigate the underlying quantum dynamics within a dimensionally reduced model based on the involved ponderomotive potentials. This approach is complemented, on the other hand, by numerical simulations of the associated Schrödinger equation [1]. Our analysis allows us to predict the Rabi frequency of the only possible scattering transition in the Bragg regime. Furthermore we describe how this frequency can be coherently controlled – up to total suppression – by quantum interference via variations of the laser parameters.

[1] M. M. Dellweg and C. Müller, Phys. Rev. A 91 (2015) 062102

A 16.7 Tue 16:15 f142

Scattering Processes with Relativistic Twisted Electrons: Mott– and Compton Scattering — •Daniel Seipt[1,2], Stephan Fritzsche[1,2], Andrey Surzhykov[1], Valery G. Serbo[3], and Igor P. Ivanov[4] — [1]Helmholtz-Institut Jena — [2]Friedrich-Schiller-Universität Jena — [3]Novosibirsk State University — [4]CFTP, Instituto Superior Tecnico, University of Lisbon

Twisted electrons, also known as electron vortex beams, are novel types of electron beams characterized by a well defined projection of total angular momentum onto their beam axis. We investigate two different fundamental scattering processes involving high–energetic twisted electrons based on Dirac's relativistic wave equation: Mott scattering of twisted electrons on atoms and the inverse Compton scattering of laser light off twisted electron beams.

For the Mott scattering, special attention is placed on the angular distribution and the polarization of the outgoing electrons. It is shown that the distribution of scattered electrons depends sensitively on the properties of the initial twisted electron states, thus, rendering the Mott scattering a promising diagnostic tool for relativistic vortex beams.

In the process of inverse Compton back-scattering of laser light off ultra-relativistic electrons, the frequency of the photons is Doppler up-shifted to the x-ray regime. We analyze how the characteristics of the backscattered x-ray beam can be controlled by tuning the properties of the twisted electrons, in order to synthesize tailor-made x-ray beam profiles with a well-defined spatial structure.