A 33: Collisions, scattering and recombination

Time: Thursday 14:30–16:30 Location: C/kHS

A 33.1 Thu 14:30 C/kHS

Singularimetry of light with electron vortex beams — •Armen Hayrapetyan and Jörg Götte — Max-Planck-Institut für Physik komplexer Systeme, Nöthnitzer Straße 38, 01187 Dresden

We study the interaction of electron vortex beams (EVBs) with the standing wave of laser light, where electrons impinge perpendicularly on two counter propagating light beams. For such a crossed-beam scenario, we derive analytical expression for the wave function of the transmitted EVB by employing the Hamiltonian Analogy between electron optics and quantum mechanics. By analyzing the phase of the EVB after passing through the field, we show the splitting of a single electron vortex into a constellation of unit vortices, similar to the analogous splitting of optical vortices from dielectric interfaces, predicted recently by Dennis and Götte. Thereupon, by interchanging the roles of light and matter and considering the light as a refractive medium for electrons, we demonstrate that the concept of singularimetry, that is the probing of a scatterer by means of the singularities in the probe beam, can be extended to EVBs transmitted through light.

References: M.R. Dennis and J.B. Götte, Phys. Rev. Lett. 109, 183903 (2012).

A 33.2 Thu 14:45 C/kHS

Linear polarization of x-ray transitions due to dielectronic recombination in highly charged ions — •Holger Jörg[1], Zhimin Hu[1], Hendrik Bekker[2], Michael Andres Blessenohl[2], Daniel Hollain[2], Stephan Fritzsche[3,4], Andrey Surzhykov[3], José Ramón Crespo López-Urrutia[2], and Stanislav Tashenov[1] — [1]Physikalisches Institut der Universität Heidelberg, 69120 Heidelberg, Germany — [2]Max-Plank-Institut für Kernphysik, Heidelberg, 69117 Heidelberg, Germany — [3]Helmholtz-Institut Jena, 07743 Jena, Germany — [4]Theoretisch-Physikalisches Institut, Friedrich-Schiller-Universität Jena, 07743 Jena, Germany

Linear polarization of x-rays produced in the process of dielectronic recombination in highly charged xenon ions was studied at an electron beam ion trap by means of the Compton polarimetry technique. The experimental results are in all cases in good agreement with the theoretical predictions. In the specific case of the dielectronic recombination resonance exciting the [1s2s22p1/2]1 state, the Breit interaction between bound electrons strongly influences the polarization of the emitted x-rays. The results agree with the predictions which include the Breit interaction and by 5σ rule out the theory taking into account only the Coulomb electron-electron repulsion. Apart from the fundamental importance, the experimental results open numerous possibilities for polarization diagnostics of hot anisotropic plasmas. In particular the directions of the electrons in the plasmas, found e.g. in the accretion discs and jets of black holes, can be probed by measuring polarization of the satellite transitions in HCIs.

A 33.3 Thu 15:00 C/kHS

Influence of the laser field's turn-on duration and frequency detuning on Kapitza-Dirac scattering — •Matthias M. Dellweg and Carsten Müller — Institut für Theoretische Physik I, Heinrich-Heine-Universität Düsseldorf, Universitätsstraße 1, 40225 Düsseldorf

Diffractive scattering of an electron beam from a standing wave of light (Kapitza-Dirac effect) is studied theoretically. The corresponding Schrödinger equation is solved by combined analytical and numerical means. We examine the roles played by the nature of the field's turning-on phase and by a detuning of the light frequency. We demonstrate that the characteristic Rabi oscillations between the initial and scattered electron states are strongly suppressed when the turn-on of the field takes too long [1] or when the field frequency is largely detuned from the resonance (Bragg) condition. A mutual interplay between the detrimental effects of detuning and turn-on duration is revealed [2]. Also the case of very fast turn-on is considered where we show that the electron dynamics follow a scaling law with respect to an action variable.

[1] M. V. Fedorov, Opt. Commun. 12, 205 (1974)
[2] M. M. Dellweg and C. Müller, in preparation

A 33.4 Thu 15:15 C/kHS

Angle-resolved properties of characteristic x-rays as a tool for determining small level splittings in highly charged ions — •Zhongwen Wu[1,2], Nikolay Kabachnik[3,4], Andrey Surzhykov[1], Chenzhong Dong[2], and Stephan Fritzsche[1,5] — [1]Helmholtz Institute Jena, Germany — [2]Northwest Normal University, China — [3]European XFEL, Germany — [4]Lomonosov Moscow State University, Russia — [5]University of Jena, Germany

The angular distribution and the photon-photon angular correlation of x-ray emissions have been studied for two-step radiative cascades that proceed via overlapping intermediate resonances. Special attention was placed especially upon the questions of how the level splitting of the intermediate resonances affects the x-ray emissions and whether angle-resolved measurements can help determine small splittings in the level structure of highly charged ions. As an example, detailed computations within the multiconfiguration Dirac-Fock method were performed for the two-step cascade $1s2p^2\ J_i = 1/2, 3/2 \rightarrow 1s2s2p\ J = 1/2, 3/2 + \gamma_1 \rightarrow 1s^2 2s\ J_f = 1/2 + \gamma_1 + \gamma_2$ of lithium-like ions, for which a level crossing of the two $1s2s2p\ J = 1/2, 3/2$ intermediate resonances occurs in the range $74 \leq Z \leq 79$. A remarkably strong effect associated with finite lifetime and level splitting of these intermediate resonances was found for the angular distribution and the photon-photon angular correlation. We therefore suggest that accurate angle-resolved measurements of x-ray emissions may serve as a tool for determining small level splittings [1].

[1] Z. W. Wu *et al.*, Phys. Rev. A 90, 052515 (2014).

A 33.5 Thu 15:30 C/kHS

Observation of coherence in the time-reversed relativistic photoelectric effect — •Stanislav Tashenov[1], Holger Jörg[1], Darius Banas[2], Heinrich Beier[3], Carsten Brandau[3], Alexandre Gumberidze[3], Siegbert Hagmann[3], Pierre-Michel Hillenbrand[3], Ivan Kojouharov[3], Christophor Kozhuharov[3], Michael Lestinsky[3], Yury Litvinov[3], Anna Maiorova[4], Henning Schaffner[3], Uwe Spillmann[3], Thomas Stöhlker[5,6], Andrey Surzhykov[6], Stephan Fritzsche[5], Sergiy Trotsenko[3], and Vladimir Shabaev[4] — [1]Heidelberg University, Germany — [2]Jan Kochanowski University, Kielce, Poland — [3]GSI Helmholtzzentrum, Darmstadt, Germany — [4]St. Petersburg State University, Russia — [5]Friedrich-Schiller-Universität Jena, Germany — [6]Helmholtz-Institut Jena, Germany

The photoelectric effect has been studied in the regime of hard x-rays and strong Coulomb fields via its time-reversed process of radiative recombination (RR). In the experiment the relativistic electrons recombined into the $2p_{3/2}$ excited state of hydrogenlike uranium ions and both, the RR x-rays as well as the subsequently emitted characteristic x-rays were detected in coincidence. This allowed to observe and manipulate the coherence between the magnetic substates in a highly charged ion and to identify the contribution of the spin-orbit interaction to the RR process.

A 33.6 Thu 15:45 C/kHS

Atomic-scale imaging of molecular bonds with laser-induced electron diffraction — •Benjamin Wolter[1], Michael G. Pullen[1], Anh-Thu Le[2], Matthias Baudisch[1], Michele Sclafani[1], Hugo Pires[1], Arne Senftleben[3], Claus Dieter Schröter[4], Joachim Ullrich[4,5], Robert Moshammer[4], Chii-Dong Lin[2], and Jens Biegert[1,6] — [1]ICFO - Institut de Ciències Fotòniques, Mediterranean Technology Park, Castelldefels (Barcelona), Spain — [2]J. R. Macdonald Laboratory, Physics Department, Kansas State University, Manhattan, Kansas, USA — [3]Universität Kassel, Institut für Physik and CINSaT, Kassel, Germany — [4]Max - Planck - Institut für Kernphysik, Heidelberg, Germany — [5]Physikalisch - Technische Bundesanstalt, Braunschweig, Germany — [6]ICREA - Institució Catalana de Recerca i Estudis Avançats, Barcelona, Spain

Dynamic imaging of molecular dynamics is one of the grand challenges of science as it requires sub-Ångström spatial and few femtosecond temporal resolutions. These demands are fulfilled by laser-induced electron diffraction (LIED), where a molecule is structurally probed with its own returning electron after tunnel ionization induced by a strong mid-IR laser field. Here, we present the retrieval of multiple bond lengths from polyatomic molecules by simultaneously measuring the C-C and C-H bond lengths of aligned acetylene. Our approach is based on the combination of an ultrafast 160 kHz mid-IR source with full 3D electron-ion coincidence detection towards investigating ultrafast processes like e.g. dissociation or proton migration.

A 33.7 Thu 16:00 C/kHS

Pair creation with channeling ions — •Nikolay Belov and Zoltán Harman — Max Planck Institute for Nuclear Physics, Saupfercheckweg 1, 69126 Heidelberg

The creation of particle-antiparticle pairs plays a role in several physical enviroments. We suggest an alternative way to investigate this phenomenon by the channeling of accelerated heavy ions through a crystal. In the framework of the ion, the energy of virtual photons arising from the periodic crystal potential may exceed the thresold $2mc^2$. This scheme increases the pair production rate coherently and allows to provide a more precise investigation of nuclear pair conversion [1]. It also allows to depopulate nuclei in metastable states, and convert the nuclear energy stored to electron-positron pairs. Pair creation by channeling ions can be also regarded as an extension of the resonance coherent excitation of highly charged ions to higher frequencies and higher ion velocities, which has been investigated at the GSI before [2]. Therefore, this novel channel of pair creation can be examined at the upcoming FAIR facility in the nearest future.

[1] N. A. Belov, Z. Harman, arXiv:1411.5711(2014).
[2] Y. Nakano, Y. Takano, T. Ikeda, et al., Phys. Rev. A 87, 060501 (2013).

A 33.8 Thu 16:15 C/kHS

Dominante Korrelationseffekte in Atomspektren — •Hubert Klar — Duale Hochschule BW, FB Maschinenbau, Hangstr.46-50, 79539 Lörrach

Das Spektrum von Zwei-Elektronen-Atomen wird in hypersphärischen Koordinaten studiert. Wir finden eine Rydbergserie von instabilen Cooper-Paaren unterhalb der Schwelle für Doppelionisation. Die Bindung wird vermittelt durch eine neuartige Kraft resultierend aus der Beugung einer Welle an einem Potentialrücken. Infolge spontaner Symmetriebrechung gehorchen diese Paare nicht dem Pauliprinzip. Die Wannier'sche Schwellenionisation wird als Zerfall eines Cooper-Paars identifiziert.