A 10: Collisions, scattering and correlation phenomena

Time: Tuesday 14:00–16:15 Location: a320

Invited Talk A 10.1 Tue 14:00 a320

Scattering of twisted x-rays from a crystal — •Anton Peshkov[1,2], Stephan Fritzsche[3,4], and Andrey Surzhykov[1,2] — [1]Technische Universität Braunschweig, Germany — [2]Physikalisch-Technische Bundesanstalt, Braunschweig, Germany — [3]Helmholtz-Institut Jena, Germany — [4]Friedrich-Schiller-Universität Jena, Germany

The elastic scattering of x-rays by bound atomic electrons is known to be an excellent probe of the structure of matter. One of the most intriguing example here is x-ray crystallography used to determine the arrangement of atoms in a crystal. The essential physics of this process has been known and understood for many years for the incident plane-wave radiation. However, this is not the case for twisted light beams that carry a nonzero projection of the orbital angular momentum (OAM) onto their propagation direction and whose intensity pattern has an annular character. In order to understand how the scattering from crystals depends on the "twistedness" of incident x-rays, we present here a theoretical analysis of the elastic scattering of Bessel beams from a single crystal of lithium. Our numerical calculations show that the scattering cross section is sensitive to the OAM projection of twisted beams and differs from the standard plane-wave case when the size of the crystal is reduced to the nanometer scale.

[1] A. A. Peshkov *et al.*, Phys. Scr. 94, 105402 (2019).

A 10.2 Tue 14:30 a320

Two-center electron-impact ionization via collisional excitation-autoionization — •Fiona Grüll, Alexander B. Voitkiv, and Carsten Müller — Institut für Theoretische Physik I, Heinrich-Heine-Universität Düsseldorf

Electron-impact ionization of an atom can be strongly influenced by the presence of a neighbour atom. We study electron-impact ionization via excitation-autoionization in a two-center atomic system consisting of atoms A and B. First, collisional excitation of the neighbouring atom B occurs by high-energy electron impact. Afterwards, the excitation energy is transferred radiationlessly via a two-center Auger process to the other atom or ion, leading to its ionization, whereas atom B returns into its initial state. In contrast to other processes creating an autoionizing two-center state by electron impact [1,2], the incident electron in resonant two-center electron-impact ionization 2C(e,2e) leads to excitation – rather than ionization – of atom B. We show that, due to resonant 2C(e,2e), electron-impact ionization can be qualitatively modified and strongly enhanced by several orders of magnitude in a narrow range of emitted electron energies. As a consequence, resonant 2C(e,2e) can provide a substantial contribution to the total electron-impact ionization cross section of atom A and can also lead to changes in the angular distribution of ejected electrons [3].

[1] S. Yan et al., Phys. Rev. A 97, 010701(R) (2018).
[2] X. Ren et al., Nature Commun. 7, 11093 (2016).
[3] F. Grüll, A. B. Voitkiv and C. Müller, Phys. Rev. A 100, 032702 (2019)

A 10.3 Tue 14:45 a320

Calculation of Rayleigh scattering by highly charged heavy ions — •Dmitrii Samoilenko[1], Andrey Volotka[2,3], and Stefan Fritzsche[2,3,4] — [1]Friedrich-Schiller-Universität Jena, Jena, Germany — [2]Helmholtz-Institut Jena, Jena, Germany — [3]GSI Helmholtzzentrum für Schwerionenforschung, Darmstadt, Germany — [4]Theoretisch-Physikalisches Institut, Friedrich-Schiller-Universität Jena, Jena, Germany

Rayleigh scattering for photon energies close to core-core transitions resonances in highly charged lead ions is investigated theoretically. Angular distribution of cross section and polarization of the scattered light is obtained using rigorous quantum electrodynamics approach. The results are compared to those given by often used simple dipole approximation. It is shown that for certain scenarios a significant effect of higher multipoles on both angle-differential cross section and linear polarization of the scattered light can be indicated.

A 10.4 Tue 15:00 a320

Polarization transfer in Rayleigh scattering — •Sophia Strnat[1], Vladimir A. Yerokhin[2], and Andrey Surzhykov[1,3] — [1]Technische Universität Braunschweig, Germany — [2]Peter the Great St. Petersburg Polytechnic University, Russia — [3]Physikalisch Technische Bundesanstalt, Germany

In this work we present a theoretical study of Rayleigh scattering of hard x-rays by closed-shell atoms. In order to investigate this process we employed relativistic Dirac theory and second order perturbation approach. Special attention was paid to the polarization transfer between incident and outgoing light. In particular, we applied density matrix formalism to describe the polarization of the outgoing photons for arbitrary linear and/or circular polarization of the incident photons. We derived the Stokes parameters of the scattered light in terms of their counter-partners for incident light and of the transition amplitudes. Our study generalizes the previous work (reported in Ref [1]) which was restricted to only linear polarization. Detailed calculations were performed for helium-, neon-, argon- and krypton-like lead. Based on these calculations we show that Rayleigh scattering can be used not only to probe the polarization purity of synchrotron radiation but also as an alternative tool for measuring circular polarization in the x-ray domain.

[1] A. Surzhykov *et al.*, Physical Review A **98**, 053403 (2018)

A 10.5 Tue 15:15 a320

A New Super Current — •Hubert Klar — Universität Freiburg, Germany

We treat slow electron scsttering from a highly excited Rydberg atom. The electron-target interaction i nolonger controled by single particle Coulomb forces but by by a potential ridge between Coulomb valleys in the potential surface. We show that the diffraction fromthe ridge leads to adichromatic splitting of that surface. In the incoming channel the ridge becomes flat and allows to the electrons to jump onto the top of the ridge. That motion is unstable, but shows an electron-electron attraction. The pair moves towards the nucleus, and is reflected due to a new fictitious force relected. The outgoing wave on the ridge top is unstable. the pair decays into a bound Rydberg state of the target and one escaping electron. The latter is attracted by a neighbor atom, and the above described process may be repeated many times. In this way one electron is transported without any ineleastic collision through a multiatom material. In contrast to a Couper pair our pair formation works independent of the temperatur, and explains the high temperatur super conductivity.

A 10.6 Tue 15:30 a320

Stable longitudinal spin domains in a one-dimensional nondegenerate gas — •Sean D. Graham[1], Dorna Niroomand[1], Robert J. Ragan[2], and Jeffrey M. McGuirk[1] — [1]Simon Fraser University, Burnaby, Canada — [2]University of Wisconsin - La Crosse, La Crosse, USA

We demonstrate that linear spin-dependent potentials can stabilize longitudinal spin domains in a weakly-interacting gas of ^{87}Rb atoms above quantum degeneracy. Coherent spin-rotating interactions are modified by a small spin-dependent potential that varies the local Larmor precession. Stable domains are observed when the gradient of the linear spin-dependent potential opposes the initial spin gradient within the domain wall. Experimental results over a range of cloud temperatures, densities, and linear spin-dependent potentials are compared to solutions of the quantum Boltzmann equation in the hydrodynamic and collisionless regimes. In the hydrodynamic regime, the measured stabilizing gradients agree well with the quantum Boltzmann theory. However, the stabilizing gradients in the collisionless regime deviate from the quantum Boltzmann theory as the mean free path becomes comparable to the domain-wall width. We extend this domain stabilization technique by stabilizing one-dimensional dipolar, quadrupolar, and hexapolar spatial spin modes using spin-dependent potentials that are linear within every domain wall.

A 10.7 Tue 15:45 a320

From polarons to bipolarons in Bose-Einstein condensates. — •Luis Ardila — Institut für Theoretische Physik-Hannover Universität

Mobile impurities in a Bose-Einstein condensate can form quasi-particles termed Bose polarons. Here I show how these quasi-particles are originated when a single impurity is dressed by the excitations

of the quantum bosonic bath. The most striking advantage of these polarons is the huge degree of controllability of the coupling strength between the impurity and the bosonic bath. Thus, one can realize polarons from weak all the way up to the strong interacting regime. For strong interactions two polaron can bind together forming bound bipolarons states. They emerge due to the induced nonlocal interaction mediated by density oscillations of the bath. It turns out that exploring low-dimensions, polarons can form many-body bound states even at intermediate coupling. Here, we use exact QMC to study an impurity immersed in a 2D superfluid and to compute the polaron energy, the effective mass and the quasiparticle residue for arbitrary coupling strength. We find important deviations of the quasiparticle properties from perturbation theory even at very weak coupling strengths. In the strongly interacting regime, the ground-state polaron loses the quasiparticle nature characteristic of weak interactions and forms a many-body bound state featuring a large effective mass, a vanishing wavefunction residue and a size that extends over many healing lengths of the bath .

A 10.8 Tue 16:00 a320

Efficient double ionization by interatomic Coulombic decay — •Jacqueline Fedyk, Kirill Gokhberg, and Lorenz S. Cederbaum — Theoretical Chemistry, Heidelberg University, Heidelberg, Germany

Several processes, such as single-photon double-ionization and double Auger decay, are known, which result in correlated emissions of two electrons. The ratios of double to single-ionization in these processes usually amount only to a few percent. Recently, a new decay mechanism has been reported, which leads to double ionization of alkali dimers attached to helium droplets [1]. This double ionization proceeds via interatomic Coulombic decay and occurs with an efficiency comparable to single-ionization. Motivated by these experimental results, we investigated this new decay mechanism, which is called double interatomic Coulombic decay (dICD). In particular, we asked ourselves, if the observed efficiency of dICD was its general characteristic, or if these results were due to the specific choice of the experimental system. To answer this question, we analytically derived the decay width of dICD. First, we developed an asymptotic formula, based on the assumption that the two centers are spatially well-separated. Second, we derived a general analytical expression by using many-body perturbation theory. Finally, we investigated the efficiency of dICD for experimentally realizable small atomic and molecular clusters.

[1] A. C. LaForge, M. Shcherbinin, F. Stienkemeier,R. Richter, R. Moshammer, T. Pfeifer, and M. Mudrich, Nature Physics 15, 247 (2019)