K 7: Laser-Beam Matter Interaction - Laser Applications II

Time: Thursday 14:00–15:45 Location: K-H4

K 7.1 Thu 14:00 K-H4

The Three-Backlink experiment: A phase reference distribution system for LISA. Design, construction and first measurements. — •Jiang Ji Ho Zhang, Lea Bischof, Stefan Ast, Daniel Jestrabek, Krishnapriya Rajasree, and Melanie Ast — Max Planck Institute for Gravitational Physics, Callinstraße 38, 30167 Hannover, Germany

LISA (Laser Interferometer Space Antenna) will be the first gravitational wave detector in space, aiming to use laser interferometry to detect gravitational-wave signals in the 0.1 mHz to 1 Hz band. It consists of three satellites forming a near-equilateral triangle with 2.5 million km arms. Due to the orbital mechanics, the inter-satellite distances and angles vary by about 1% and $\pm 1.5°$ per year, respectively. Each satellite features two moving optical sub-assemblies (MOSAs) that are connected via a flexible optical link, the so-called backlink or phase reference distribution system (PRDS), which articulates the payload to compensate for the angular dynamics. The optical path-length difference between two counter-propagating beams along the PRDS is required to reach 1 pm/$\sqrt{\text{Hz}}$ stability. The Three-Backlink Experiment is a trade-off study between different designs of the PRDS: a direct fibre backlink, a frequency separated fibre backlink and a free beam backlink. To simulate the angular motion of the MOSAs, the experiment features two rotation stages, each containing a Zerodur plate to which fused silica optical components are bonded using UV glue. We report on the first measurements of the backlink non-reciprocity, a first step towards achieving the required performance for LISA.

K 7.2 Thu 14:15 K-H4

Update on the laser heavy ion acceleration at CALA — •Laura Desiree Geulig, Erin Grace Fitzpatrick, Maximilian Weiser, Florian H. Lindner, and Peter G. Thirolf — LMU Munich

We report on the current work on laser driven heavy ion acceleration at the Centre for Advanced Laser Applications (CALA), using the ATLAS 3000 laser with a central wavelength of 800 nm, a pulse length of about 25 fs and currently up to 8 J energy on target in the context of developing the novel 'fission-fusion' nuclear reaction mechanism [1]. First the efficient acceleration of gold ions with kinetic cutoff-energies above 7 MeV/u is targeted. For our experiments the laser is focused with an f/2 parabola on gold foils with thicknesses ranging from 100 nm to 500 nm. To analyze the accelerated ion bunch, a Thomson Parabola Spectrometer was designed that resolves the full proton and gold spectrum as well as the individual gold charge states [2]. A radiative heating system is integrated into the setup to enhance the acceleration of gold ions by removing hydro-carbon surface contaminations. An integrated IR spectrometer allows for in-situ measurement of the heated foil temperature, while enabling a simultaneous monitoring with a camera to detect possible thermal damage to the foil [3]. With the current setup, proton cutoff energies above 21 MeV have already been realized.

[1] D. Habs et al., Appl. Phys. B 103, 471-484 (2011) [2] F.H. Lindner et al., arXiv:2104.14520, submitted to Scientific Reports (2021) [3] M. Weiser, Master Thesis, LMU Munich, 2021

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K 7.3 Thu 14:30 K-H4

Effect of pre-excited charge carriers on high harmonic generation in silicon — •Pawan Suthar[1], František Trojánek[1], Petr Malý[1], Thibault Derrien[2], and Martin Kozák[1] — [1]Faculty of Mathematics and Physics, Charles University, Ke Karlovu 3, 12116 Prague 2, Czech Republic — [2]HiLASE Centre, Institute of Physics, Academy of Science of the Czech Republic, Za Radnicí 828/5, 25241 Dolní Břežany, Czech Republic

High harmonic generation (HHG) in solids is a highly nonlinear optical process, in which electron-hole pairs are created via quantum tunneling, coherently accelerated and then recombined by the strong electric field of a non-resonant laser pulse. Here we study how the HHG yield in crystalline silicon is influenced by scattering of coherent wave packets by charge carriers resonantly pre-excited to the conduction and valence bands using a pump-probe like setup. The HHG is driven by few-cycle mid-infrared probe pulses with central photon energy of 0.61 eV and its spectrum and yield are characterized as functions of the time delay after a pump pulse, which resonantly excites carriers in silicon via direct (photon energy of 3.8 eV) or indirect (1.9 eV) transitions. We find that the HHG yield changes differently for different orientations of linear polarization of the mid-infrared pulse with respect to crystallographic orientation of silicon, for different photon energies of the resonant pump and that the response of each harmonic order differs. These results emphasize the role of band structure and Coulomb interactions between carriers in the HHG process.

K 7.4 Thu 14:45 K-H4

Laboratory evidence for proton energization by collisionless shock surfing — •Alice Fazzini[1], Weipeng Yao[1,2], Sophia Chen[3], Konstantin Burdonov[1,2], Patrizio Antici[3], Jérôme Béard[3], Simon Bolanos[1], Andrea Ciardi[2], Raymond Diab[1], Stanimir Kisyov[3], Vincent Lelasseux[1], Marco Miceli[3], Salvatore Orlando[3], Sergey Pikuz[3], Evgeny Filippov[3], Dragos Popescu[3], Viorel Nastasa[3], Quentin Moreno[3], Guilhem Revet[1], Emmanuel d'Humières[3], Xavier Ribeyre[3], and Julien Fuchs[1] — [1]LULI - CNRS, CEA, Ecole Polytechnique - F-91128 Palaiseau, France — [2]Sorbonne Université, Observatoire de Paris, Université PSL, CNRS, LERMA, F-75005, Paris, France — [3]Refer to J. Fuchs for the complete list of addresses

Collisionless shocks are present in many astrophysical phenomena, such as supernovae remnants and the Earth's bow shock. In these events, collisionless electromagnetic processes mediate the transfer of momentum and energy from the flowing plasma to the ambient one. Using our platform, where we couple high-power lasers (JLF/Titan at LLNL, and LULI2000) with strong magnetic fields, we have generated astrophysically relevant super-critical magnetized collisionless shocks. Kinetic Particle-In-Cell simulations based on our experimental results reveal that shock surfing acceleration is responsible for the energization of the background protons up to 100 keV. Our observations not only provide evidence of early stage ion acceleration by collisionless shocks, but they also highlight the role this mechanism plays in energizing ions initially at rest, with capacity to feed further stages of acceleration.

K 7.5 Thu 15:00 K-H4

Ultrafast single-photon detection at high repetition rates based on optical Kerr gates under focusing — •Amr Farrag[1], Abdul-Hamid Fattah[1], Assegid Mengistu Flatae[1], and Mario Agio[1,2] — [1]Laboratory of Nano-Optics and Cμ, University of Siegen, 57072 Siegen, Germany — [2]National Institute of Optics (INO), National Research Council (CNR), 50125 Florence, Italy

Abstract:

The ultrafast single-photon detection of quantum emitters has become recently vital, as there are faster emission processes that the current techniques cannot resolve. To overcome this limitation, here we present a semi-analytical model using the Optical-Kerr-shutter (OKS) technique at GHz rate under focused illumination, showing a gate efficiency around 70%. The findings will form the basis for experimental demonstration of time-resolved ultrafast detection of single emitters. In addition, it will be beneficial for various fields for instance, quantum nanophotonics, quantum information science and quantum optics.

Reference: A.-H. Fattah, A. M. Flatae, A. Farrag, and M. Agio, Opt. Lett. 46, 560(2021).

K 7.6 Thu 15:15 K-H4

X-ray dose rate and spectral measurements generated from ultrafast laser machining and research-grade laser systems — •Philip Mosel[1], Pranitha Sankar[1], Jan Düsing[2], Elisa Appi[1], Günter Dittmar[3], Uwe Morgner[1], and Milutin Kovacev[1] — [1]Institute of Quantum Optics, Cluster of Excellence PhoenixD and Quantum Frontiers, Leibniz Universität Hannover, Hannover, 30167 — [2]Laser Zentrum Hannover e. V., Hannover, 30419 — [3]Engineering office Prof. Dr.-Ing. Günter Dittmar, Aalen, 73433

In ultrashort pulsed laser machining, process speeds are increased by scaling the average power and pulse repetition rate, which can lead to potentially dangerous X-ray emission [1]. We present measurements with a novel calibrated X-ray detector in the detection range from 2 keV to 20 keV and show the dependence of X-ray dose rate and spectral emission of commonly used metals, alloys, and ceramics for ultrafast laser processing [2]. Our studies include the dependence of dose rate on various laser parameters available in ultrafast laboratories

as well as on industrial laser systems. The results presented show that focused sub-picosecond pulses with intensity above $10^{13}\,\mathrm{W/cm^2}$ can exceed the annual irradiation limit even in just one hour, requiring adequate shielding for the safety of researchers.

[1] Legall, Herbert, et al., Applied Physics A 125.8 (2019): 1-8.
[2] Mosel, Philip, et al., Materials 14.16 (2021): 4397.

K 7.7 Thu 15:30 K-H4

Light-field control of electrons in graphene: approaching ultrafast electronics — •Tobias Boolakee[1], Christian Heide[1], Antonio Garzón-Ramírez[2], Heiko B. Weber[1], Ignacio Franco[2], and Peter Hommelhoff[1] — [1]Department Physik, Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU), 91058 Erlangen — [2]Department of Chemistry, University of Rochester, Rochester, New York 14627, USA

Controlling the motion of electrons in solids on the timescale of an optical cycle is key to advance electronics to unprecedented switching bandwidths. Importantly, for this aim, we can distinguish and take advantage of two types of charge carriers: Real carriers, persisting after their excitation, and virtual carriers, existing during the light-matter interaction only. We show that in a gold-graphene-gold heterostructure, real and virtual charge carriers can be disentangled in the photogeneration of electric currents based on the carrier-envelope phase of incident few-cycle laser pulses. Our experimental observations are well supported by simulations on atomistically detailed charge transport in the heterostructure. These insights now enable us to design and demonstrate a proof-of-concept of an ultrafast logic gate with a potential bandwidth limited fundamentally by the frequency of light.