Q 27: Ultrashort Laser Pulses: Applications I

Time: Wednesday 10:30–12:30 Location: F 342

Q 27.1 We 10:30 F 342

Ultra-short pulse laser proton acceleration — •Karl Zeil, Stephan Kraft, Michael Bussmann, Thomas Cowan, Thomas Kluge, Josefine Metzkes, Tom Richter, and Ulrich Schramm — Forschungszentrum Dresden-Rossendorf, Bautzner Landstrasse 400, 01328 Dresden

We present a systematic investigation of ultra-short pulse laser acceleration of protons yielding unprecedented maximum proton energies of 17 MeV using the Ti:Sapphire lased high power laser of 100 TW Draco at the Research Centre Dresden-Rossendorf. For plain few micron thick foil targets a linear scaling of the maximum proton energy with laser power is observed and attributed to the short acceleration period close to the target rear surface. Although excellent laser pulse contrast was available slight deformations of the target rear were found to lead to a predictable shift of the direction of the energetic proton emission away from target normal towards the laser direction. The change of the emission characteristics are compared to analytical modelling and 2D PIC simulations.

Q 27.2 We 10:45 F 342

High Intensity Laser-Driven Ion Acceleration — •Andreas Henig[1,2], Daniel Kiefer[1,2], Daniel Jung[1,2], Jörg Schreiber[1,2], Rainer Hörlein[1,2], Sven Steinke[3], Matthias Schnürer[3], Thomas Sokollik[3], Peter Nickles[3], Xueqing Yan[1], Toshi Tajima[2], Jürgen Meyer-ter-Vehn[1], Manuel Hegelich[2,4], Wolfgang Sandner[3], and Dietrich Habs[1,2] — [1]Max-Planck-Institut für Quantenoptik, D-85748 Garching — [2]Department für Physik, Ludwig-Maximilians-Universität München, D-85748 Garching — [3]Max-Born-Institut, D-12489 Berlin — [4]Los Alamos National Laboratory, New Mexico 87545, USA

Ion acceleration by intense laser-plasma interactions is a very active field of research whose development can be traced in a large number of publications over the last few years. Past studies were mostly performed irradiating thin foils where protons are predominantly accelerated to energies up to 60 MeV in an exponentially decaying spectrum by a mechanism named target normal sheath acceleration (TNSA). We present our latest experimental advances on acceleration schemes away from TNSA, such as shock acceleration [Henig *et al.*, PRL **102**, 095002 (2009)], ion beam generation from relativistically transparent targets [Henig *et al.*, PRL **103**, 045002 (2009)] and radiation-pressure acceleration [Henig *et al.*, PRL **103**, 245003 (2009)]. These results are a major step towards highly energetic, mono-chromatic ion beams generated at high conversion efficiencies as demanded by many potential applications. Those include fast ignition inertial confinement fusion (ICF) as well as oncology and radiation therapy of tumors.

Q 27.3 We 11:00 F 342

Low-Divergent, Energetic Electron Beams from Ultra-Thin Foils — •Thomas Kluge[1], Michael Bussmann[1], Sandrine Gaillard[1], Kirk Flippo[2], Cort Gautier[2], Thomas Lockard[4], M Lowenstern[5], Yasuhiko Sentoku[4], Karl Zeil[1], Stephan Kraft[1], Ulrich Schramm[1], Thomas Cowan[1], Roland Sauerbrey[1], J.E. Mucino[5], and Brady Gall[3] — [1]Forschungszentrum Dresden-Rossendorf e.V., Dresden, Germany — [2]Loas Alamos National Laboratory, Los Alamos, USA — [3]University of Missouri, Columbia, USA — [4]University of Nevada, Reno, USA — [5]University of Michigan, Ann Arbor, USA

We present recent experiments performed at the LANL Trident laser facility. A well collimated, energetic (up to ~90 MeV) electron beam has been observed in the laser direction following the short pulse (600 fs) high-intensity laser interaction with ASE-preheated ultra-thin solid foils. These results are in contrast to the typical low-energy divergent electrons accompanying ions in the target normal direction usually seen in solid targets. 2D particle-in-cell simulations suggest the excitation of a wakefield that can accelerate electrons to tens of MeV.

Q 27.4 We 11:15 F 342

Electron bunch length measurements from laser-accelerated electrons using single-shot THz time-domain interferometry — •Alexander Debus[1], Michael Bussmann[1], Ulrich Schramm[1], Roland Sauerbrey[1], and Stefan Karsch[2] — [1]Forschungszentrum Dresden-Rossendorf, Institute for Radiation Physics, 01328 Dresden, Germany — [2]Max-Planck-Institute für Quantenoptik, Hans-Kopfermann-Strasse 1, 85748 Garching, Germany

Laser-plasma wakefield based electron accelerators are expected to deliver ultrashort electron bunches with unprecedented peak currents. However, their actual pulse duration has never been directly measured in a single-shot experiment. We present measurements of the ultrashort duration of such electron bunches by means of THz time-domain interferometry. With data obtained using a 0.5J, 45fs, 800nm laser and a ZnTe-based electro-optical setup we demonstrate the duration of laser-accelerated, quasi-monoenergetic electron bunches at a best fit of 32fs (FWHM) with a 90% upper confidence level of 38fs.

Q 27.5 We 11:30 F 342

Simultaneous diagnostics of laser-accelerated protons and electrons — •Josefine Metzkes, Karl Zeil, Stephan Kraft, Tom Richter, Thomas Cowan, Roland Sauerbrey, and Ulrich Schramm — Forschungszentrum Dresden-Rossendorf, 01314 Dresden, Germany

Pulses of energetic protons with energies of several MeV can be produced by focusing an ultra-short intense laser pulse onto a solid target. The protons stem from the target rear side where they gain energy in an electric field that builds up due to charge separation effects triggered by electrons that are accelerated during the interaction of the laser with the target.

In order to investigate the acceleration of protons at solid targets which is expected to be strongly correlated to the properties of the electrons that set up the electric field at the target rear side we have set up a diagnostic which allows for the simultaneous online analysis of the accelerated protons as well as electrons. Here we are going to present first experimental results that have been measured at a table-top Ti:Sapphire laser with a pulse length of 30 fs and a peak intensity exceeding 10^{21} W/cm^2. From these data fundamental parameters can be derived that allow for a testing of theoretical scaling laws for the proton acceleration mechanism.

Q 27.6 We 11:45 F 342

Strong-field photoelectron emission from metal nanotips — Reiner Bormann, Max Gulde, Sergey Yalunin, Alexander Weismann, and •Claus Ropers — University of Göttingen, Courant Research Center Nano-Spectroscopy and X-Ray Imaging, Friedrich-Hund-Platz 1, 37077 Göttingen, Germany

The generation of ultrashort, localized electron pulses is of fundamental interest for future applications in time-resolved electron imaging and diffraction. Femtosecond electron sources of great spatial coherence make use of a combination of local field enhancement at metal nanotips and nonlinear photoelectric effects. Previous studies have resulted in a controversial debate about the underlying physical processes.

Here, we present our most recent theoretical and experimental results regarding ultrafast photoelectron emission from nanometric gold tips. For the first time, we conclusively show the transition between the multiphoton and the optical field emission (i.e. tunneling) regimes. Direct evidence for this transition is found from both the power dependence of the total current and the spatial characteristics of the resulting electron beam. The results are supported by theoretical modeling.

Q 27.7 We 12:00 F 342

Proton, Electron and K-Alpha Emission from Micro-Scale Copper Cone Targets — •Thomas Kluge[1], Sandrine Gaillard[1], Kirk Flippo[2], Michael Bussmann[1], Yasuhiko Sentoku[5], Eduardo Mucino[6], Mariano Lowenstern[6], Cort Gautier[2], John Kline[2], Dustin Offermann[2], Jonathan Workman[2], Fred Archuleta[2], Raymond Gonzales[2], Thomas Hurry[2], Randall Johnson[2], Samuel Letzring[2], David Montgomery[2], Sha-Marie Reid[2], Tsutomu Shimada[2], Brady Gall[3], Thomas Lockard[5], Emmanuel d'Humieres[4], Tomas Cowan[1], and Jenny Rassuchine[1] — [1]Forschungszentrum Dresden-Rossendorf e.V., Dresden, Sachsen — [2]Los Alamos National Laboratory, Los Alamos, USA — [3]University of Missouri, Columbia, USA — [4]CELIA, Université Bordeaux, France — [5]University of Nevada, Reno, USA — [6]AOSS, Ann Arbor, USA

We have conducted two sets of laser-ion acceleration experiments at the LANL 200 TW Trident short-pulse laser comparing regular size flat foils, reduced mass targets and new Cu micro-cone targets to elucidate the production of hot electrons and ions in these targets. Results from the latest experiment show proton energies in excess of ~65 MeV for the cones, compared to ~55 MeV for reduced mass targets and ~45 MeV for regular flat foils for high contrast. Data from a Cu Kα 2D imaging crystal, an X-ray single hit CCD, proton beam images on RCF film stacks, and an electron/proton spectrometer are presented.

Q 27.8 We 12:15 F 342

Design considerations for high-yield x-ray sources using travelling-wave Thomson scattering — •Alexander Debus, Matthias Siebold, Axel Jochmann, Michael Bussmann, Ulrich Schramm, and Roland Sauerbrey — Forschungzentrum Dresden-Rossendorf, Institute for Radiation Physics, 01328 Dresden, Germany

Our design of a high-yield Thomson source makes use of the compact electron bunches, as achievable from laser wakefield accelerators or advanced, low-emittance linear accelerators. We show that the restrictions on the x-ray photon yield by the Rayleigh limit can be avoided with an ultrashort laser pulse in an oblique angle scattering geometry using tilted pulse fronts, where electrons and laser remain overlapped while both beams travel over distances much longer than the Rayleigh length. For large scattering angles up to 75° the use of varied line-spacing (VLS) gratings is proposed for spatio-temporal beam shaping to achieve optimal overlap. Compared to head-on (180°) Thomson scattering the photon numbers for ultrashort and bright x-ray pulses could with this approach be improved by several orders of magnitude. For small interaction angles ($\leq 10°$) interaction distances can be scaled up into the meter range, which could make the SASE-FEL regime accessible using optical undulators driven by existing laser technology.