P 4: Dichte Plasmen / Schwerionen- und Laserplasmen

Zeit: Dienstag 10:30–13:00 Raum: HS C

Hauptvortrag P 4.1 Di 10:30 HS C

Laser-matter and laser-vacuum interaction at extreme field strengths — •Hartmut Ruhl — Ludwig-Maximilians-Universität München, Lehrstuhl für Theoretische Physik, München

The projected ELI facility promises to make field strengths accessible for experiments that are orders of magnitude in excess of what is possible presently. It is believed that effects of radiation reaction and quantum vacuum stability become detectable on macroscopic scales. A model is presented that shows the onset of electron, positron and photon cascading in the presence of ELI-scale optical fields. The model is based on a set of transport equations in the context of strong electromagnetic fields. The latter are solved numerically. For circular polarized spatially constant external electric fields the grows rate of the cascade can also be obtained analytically. The analytical results will be compared with the numerical solution of the problem. In addition, more complex scenarios as they are relevant for ELI will be discussed.

Hauptvortrag P 4.2 Di 11:00 HS C

Eigenschaften Warmer, Dichter Materie - Physik auf dem Weg zur Laserfusion — •Dirk O. Gericke, David Chapman, Donald Edie, Jan Vorberger und Kathrin Wünsch — Centre for Fusion, Space and Astrophysics, Department of Physics, University of Warwick, Coventry CV4 7AL, United Kingdom

Die Fertigstellung der National Ignition Facility (NIF) in Livermore, USA ist ein wichtiger Meilenstein in der Trägheitfusion und erlaubt nun praktische Experimente auf der relevanten Energieskala. Warme, dichte Materie wird dabei als transitiver Zustand sowohl im Wasserstoff-Pellet als auch im umgebenden Material erzeugt. Ihre Eigenschaften sind somit wichtig, um Fusionstargets erfolgreich zu zünden. Wichtige Beispiele sind der Energieverlust von α-Teilchen in dichten Plasmen, Relaxationsvorgänge nach der Heizung, das Schmelzen des Ablators unter hohem Druck und die Zustandsgleichung für dichten Wasserstoff. Im Vortrag werden verschiedene theoretische Modelle für die Berechnung dieser Größen vorgestellt. Weiterhin werden auch experimentelle Tests der Theorien erläutert. Obwohl diese oft an viel kleineren Lasern vorgenommen werden zeigen sie doch die reiche Physik, die auf dem Weg zur Laserfusion zu verstehen ist.

P 4.3 Di 11:30 HS C

Radiation reaction effects on ion acceleration in laser-solid interaction — •Matteo Tamburini[1], Francesco Pegoraro[1], Antonino Di Piazza[2], Christoph H. Keitel[2], Tatyana V. Liseykina[3], and Andrea Macchi[1,4] — [1]Dipartimento di Fisica, Università di Pisa, Largo Bruno Pontecorvo 3, I-56127 Pisa, Italy — [2]Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, D-69117 Heidelberg, Germany — [3]Institute of Computer Technologies, SD-RAS, Novosibirsk, Russia and Institute of Physics, University of Rostock, Germany — [4]Istituto Nazionale di Ottica, CNR, Pisa, Italy

At the extremely high optical laser intensities expected in the near future, electrons become ultrarelativistic within a fraction of the wave period experiencing superstrong accelerations and therefore emitting relatively large amounts of electromagnetic radiation. At such extreme laser intensities it may be then necessary to include radiation reaction (RR) effects to describe the laser-plasma interaction.

In this contribution [1], we present the results of our PIC simulations with RR effects included in the radiation pressure-dominated regime, both for linear and circular polarization. Our approach is based on the Landau-Lifshitz (LL) equation of motion for electrons. Our results show that the RR force leads to a significant electron cooling and an increased spatial bunching of both electrons and ions with a beneficial effect on the quality of the ion spectrum.

[1] M. Tamburini, F. Pegoraro, A. Di Piazza, C. H. Keitel and A. Macchi, New J. Phys. vol. 12, 123005 (2010); M. Tamburini et al., Nucl. Instr. and Meth. Phys. Res. A, in press.

P 4.4 Di 11:45 HS C

Interplay between ionization, pulse propagation and particle acceleration in intense laser-matter interaction — •Tatyana Liseykina and Dieter Bauer — Universität Rostock, Institut für Physik, 18051 Rostock, Germany

One important application of intense lasers is the acceleration of particles. When intense, near infrared laser light interacts with matter, the electric field of the laser easily rips off outer electrons, and a plasma is formed. Both electrons and ions can then be accelerated up to hundreds of MeV. While laser-based particle acceleration shows an unprecedented efficiency as far as particle energy per acceleration length is concerned, the beam quality is not yet sufficient for many applications. Experimentalists in this field are guided by simulation results, mainly obtained using the PIC method. Standard PIC codes start with a preformed plasma of a certain density profile and temperature, which means that ionization, both by the electric field and by collisions, is neglected. However, as the laser field propagation is determined by the plasma density but the plasma is generated by ionization due to the laser, the charge state and density distributions have to be calculated self consistently. In fact, even the strongest present-day lasers cannot fully ionize heavier elements so that the assumption of a preformed plasma is often inadequate. In the present paper we show our recent results on the interplay between ionization, pulse propagation and particle acceleration in intense laser-matter interaction using three-dimensional, relativistic PIC simulations with ionization included.

P 4.5 Di 12:00 HS C

Are laser-induced beams spin polarized? — Markus Büscher[1], •Ilhan Engin[2,1], Paul Gibbon[3], Mohammad Aziz Hessan[2,1], Anupam Karmakar[3], Andreas Lehrach[1], Natascha Raab[1], Monika Toncian[4], Toma Toncian[4], and Oswald Willi[4] — [1]Institut für Kernphysik (IKP) and Jülich Center for hadron Physics (JCHP), Forschungszentrum Jülich — [2]RWTH Aachen — [3]Jülich Supercomputing Center (JSC), Forschungszentrum Jülich — [4]Institut für Laser-Plasma Physik (ILPP), Heinrich Heine Universität Düsseldorf

The physics of laser-plasma interactions has undergone dramatic developments in recent years, both experimentally and in the theoretical understanding of high-brightness light and particle sources. However, it is a yet untouched issue whether the laser-generated particle beams are or can be spin-polarized and, thus, whether laser-based polarized sources are conceivable.

The first measurement of the degree of polarization of laser-accelerated protons have recently been carried out at the Düsseldorf Arcturus Laser Facility where proton beams of typically 3 MeV were produced in foil targets. The results have been analysed with the help of particle-in-cell simulations to follow the generation of static magnetic field gradients ($\sim$ 100s of Megagauss per micron) in thin foil targets.

As a next step, measurements with unpolarized H_2 (for proton acceleration) and ^{3}He gas (for ^{3}He ions) are planned and, finally, prepolarized ^{3}He will be used.

P 4.6 Di 12:15 HS C

Kinetic equation approach to describe dynamics of irradiated samples — •Beata Ziaja[1], Christoph Bostedt[2], Tim Laarmann[3], Fenglin Wang[3], Edgar Weckert[3], and Thomas Möller[4] — [1]CFEL, DESY, D-22607 Hamburg, Germany — [2]SLAC, LCLS Exp Fac Instr Sci R&D, CA 94025, USA — [3]HASYLAB, DESY, D-22607 Hamburg, Germany — [4]TU Berlin, Institut für Optik und Atomare Physik, D-10623 Berlin, Germany

We describe the kinetic equation approach to follow the dynamics of irradiated samples. We introduce the kinetic Boltzmann equation and discuss its advantages and limitations, when comparing to other modelling methods. We then apply this equation to describe the experimental data on irradiated clusters and laser-created plasmas that were obtained at the free-electron laser facility FLASH at DESY. We show the good agreement between experimental results and our theoretical estimations.

P 4.7 Di 12:30 HS C

High-quality dense laser-accelerated proton beams for hadron cancer therapy — •Benjamin J. Galow, Zoltán Harman, and Christoph H. Keitel — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, D-69029 Heidelberg, Germany

Simulations based on the coupled relativistic equations of motion show that protons stemming from laser-plasma processes (e.g. target normal sheath acceleration) can be efficiently post-accelerated employing pulsed laser beams in different configurations focused to spot radii on the order of the laser wavelength. We demonstrate in [1] that the laser fields produce quasi-monoenergetic accelerated protons with kinetic energies exceeding 200 MeV, small energy spreads of about 1% and high densities as required for hadron cancer therapy. To our knowledge, this is the first scheme allowing for this important application based on a laser set-up.

[1] B. J. Galow, Z. Harman, and C. H. Keitel, Opt. Express **18**, 25950–25957 (2010)

P 4.8 Di 12:45 HS C

Bestimmung von Elektronenstoßionisationsquerschnitten hochgeladener Eisenionen über Ionenextraktionsmessungen an einer EBIS — •Robert Mertzig[1], Alexandra Thorn[1], Falk Ullmann[2] und Günter Zschornack[1] — [1]Institut für Festkörperphysik, Technische Universität Dresden, Germany — [2]Dreebit GmbH, Dresden, Germany

Experimente mit in Elektronenstrahlionenquellen erzeugten, hochgeladenen Ionen bieten hervorragende Möglichkeiten, Atomdaten für die Plasma- und Astrophysik präzise zu messen und theoretische Modelle zur Beschreibung der Struktur hochgeladener Ionen und dynamischer Prozesse mit involvierten hochgeladenen Ionen zu prüfen. Wir berichten über Ionenextraktionsexperimente an einer EBIS (Electron Beam Ion Source) - Ionenquelle mit dem Ziel, Elektronenstoßionisationsquerschnitte von hochgeladenen Eisenionen zu bestimmen. Untersucht wird die Einfachionisation von Fe^{16+} bis Fe^{23+} im Elektronenenergiebereich von 15 keV bis 20 keV. Dazu erfolgten Messungen an einer Ionenquelle des Typs Dresden EBIS - A, bei denen für unterschiedliche Ionisationszeiten die korrespondierenden Intensitäten der ladungszustandsseparierten, extrahierten Ionen vermessen wurden. Aus diesen Zusammenhängen kann der Elektronenstoßionisationsquerschnitt bestimmt werden. Experimentell gewonnene Ergebnisse werden vorgestellt und im Vergleich mit gängigen Theorien diskutiert. Darüber hinaus wird gezeigt, dass die beschriebene Methode Möglichkeiten zur Messung von Elektronenstoßionisationsquerschnitten für hochgeladene Ionen unterschiedlichster Elemente bietet.