46th International Workshop on High-Energy-Density Physics with Intense Ion and Laser Beams

January 25th – 30th, 2026

Darmstädter Haus

Hirschegg, Austria

Programme

Monday (January 26th)

Start	Duration	Speaker	Title
Session 1: Introduction (Chair: S. Le Pape)			
08:30	0:10	BAGNOUD, Vincent	Welcome + Opening
08:40	0:30	SCHOENBERG, Kurt	The HED@FAIR Collaboration Status Report
09:10	0:30	SPILLER, Peter	Longitudinal and transverse beam focusing at SIS18 and SIS100
09:40	0:30	TAVANA, Parysatis	Ultra-high Flux of Direct Laser Accelerated Electrons, MeV Photons and Neutrons using Overdense Foams
10:10		**Coffee break**	
Session 2: Inertial Confinement Fusion 1 (Chair: K. Schoenberg)			
10:40	0:30	LEE, Jordan	Measurements of the equation of state of foam targets for inertial fusion energy
11:10	0:30	PIRIZ, Antonio Roberto	Rayleigh-Taylor instability in non-ideal media: a quasi-irrotational approximation
11:30	0:20	MURAKAMI, Masakatsu	Self-similar multishock implosions for ultrahigh compression of matter
11:50	0:20	GLENZER, Siegfried	Advancing inertial fusion energy using ultra-high peak power X-rays
12:10		**Lunch break**	
Session 3: Short Pulse 1 (Chair: V. Bagnoud)			
17:00	0:30	KENNEDY, Jonathan	Ultrashort proton beams from all optical phase-space control
17:30	0:20	PAUW, Viktoria	Simulation of Particle Acceleration off Laser Irradiated Micro-Plasma
17:50	0:30	KARSCH, Stefan	Hybrid Wakefield Acceleration with 16% Beam-to-Beam Efficiency: Experimental Results and Infrastructure Advances
18:20	0:20	PUKHOV, Alexander	Galilean Electromagnetic PIC Code for Efficient Simulation of LWFA
18:40	0:20	HORNUNG, Johannes	High-charge electron acceleration in the self-modulated laser-wakefield acceleration regime at PHELIX
19:15		**Dinner**	**(only for house guests)**

Tuesday (January 27th)

Start	Duration	Speaker	Title
Session 4: Laser (Chair: Z. Major)			
08:30	0:30	SCHÖNLEIN, Andreas	High-LIDT Coatings for Laser Applications
09:00	0:20	DAUERER, Leon	A millijoule-level q-switched Nd:YLF laser pumped by high-power LEDs
09:20	0:20	COURJAUD, Antoine	Versatile Joule-class OPA as front-end laser for inertial fusion research
09:40	0:20	VON GRAFENSTEIN, Katinka	Ultra-high intensity laser pulses at 400 nm produced via Second Harmonic Generation
10:00		**Coffee break**	
Session 5: Inertial Confinement Fusion 2 (Chair: J. Lee)			
10:30	0:20	RUHL, Hartmut	High Gain Fusion Targets
10:50	0:30	LIENERT, Matthias	Systematic assessment of the hotspot ignition condition over a range of non-standard fuels
11:20	0:20	OPTOŁOWICZ, Filip	Investigating Magnetized Inertial Confinement Fusion Dynamics in Laser-Driven DT Fuel using PIConGPU
11:40	0:20	HONRUBIA, Javier	Hot electron transport in magnetized targets
12:00		**Lunch break**	
Session 6: Short Pulse+ and other (Chair: D. Hoffmann)			
17:00	0:30	GALBIATI, Marta	Ultra-high intensity laser interaction with nanostructured near-critical foams: numerical modelling and experimental challenges
17:30	0:20	SCHOLLMEIER, Marius	Experimental evaluation of Nano Accelerators driven at relativistic intensities
17:50	0:20	BILD, Christian	General Solution of the Moments of the Boltzmann Collision Integrals
18:10	0:20	NÖTH, Markus	Stopping of Nanoaccelerated Ions
18:30	0:20	BLASCHKE, David	Cluster viral expansion and generalized Beth--Uhlenbeck formula from the Φ - derivable approach
19:00		**Dinner**	**(only for house guests)**

Wednesday (January 28th)

Start	Duration	Speaker	Title
		Session 7: Target Fabrication (Chair: J. Hornung)	
08:30	0:20	HAMEL, Elias	Advancing Projection Two-Photon Polymerization for High-Repetition-Rate IFE Target Fabrication: Predictive Modeling and High-Sensitivity Materials
08:50	0:20	SEIP, Joschka	A Cryogenic Platform for Investigating Wetting Dynamics in Deterministic 2PP Foams for IFE
09:10	0:20	**Poster Slam**	
10:10		**Coffee break**	
10:50	**1:30**	**Poster Session 1**	
12:20		**Lunch break**	
17:00	**1:30**	**Poster Session 2**	
18:40	**0:50**	**Conference Board Meeting**	
20:00		**Conference Dinner at Birkenhöhe**	

Thursday (January 29th)

Start	Duration	Speaker	Title
Session 8: Astrophysics (Chair: P. Neumayer)			
08:30	0:30	SCHUMACHER, Samuel	Direct Measurement of Hydrogen Opacity at Conditions Prevailing in the Interior of Small Stars
09:00	0:20	KRAUS, Dominik	The High Energy Density Initiative (HEDI) in Rostock
09:20	0:20	HE, Zhiyu	Ultrafast multiscale response dynamics of materials under high energy density conditions
09:40	0:40	ZHAO, Yongtao	Observation of stopping power suppression in non-linear ion-plasma coupling regime
10:00		**Coffee break**	
Session 9: Short Pulse 2 (Chair: S. Karsch)			
10:30	0:30	FITZPATRICK, Colm	Relativistic harmonics in the efficiency limit
11:00	0:20	TIMMIS, Robin	Experimental observation of anomalous instability-driven relativistic surface emission
11:20	0:20	YEUNG, Mark	Impact of Near-time Contrast on Coherent Synchrotron Emission from Thin Foils
11:40	0:20	MATHERON, Aimé	Vacuum Birefringence Measurements Using the Dark-Field Concept at the European XFEL
12:00		**Lunch break**	
Session 10: Inertial Confinement Fusion 3 (Chair: J. Honrubia)			
17:00	0:30	WANG, Peipei	Investigation of Broadband-laser-induced Plasma Interaction and ablation properties
17:30	0:20	KANSTEIN, Christopher	Experimentally modulated laser plasma instabilities by using low coherence lasers
17:50	0:20	SHVETS, Gennady	Heavy Ion Fusion: Ready for Reassessment?
18:10	0:20	MATEO, Alfonso	Probabilistic Model of Laser Drive Asymmetries for an IFE Reactor design
19:15		**Dinner**	**(only for house guests)**

Friday (January 30th)

Start	Duration	Speaker	Title
		Session 11: Short Pulse 3 (Chair: A. Pukhov)	
08:30	0:30	YOUNG, Jordan	Control of Laser Contrast for Harmonic Generation from Relativistic Plasma Surfaces
09:00	0:20	ZEIL, Karl	Single-event fast neutron time-of-flight spectrometry with a petawatt-laser-driven neutron source
09:20	0:20	PAN, Diya	Simultaneous high-efficiency and high-energy proton acceleration via a dual-pulse micronozzle scheme
09:40	0:20	WEISER, Maximilian J.	Optimization and results of proton induced 238U fission at CALA
10:00		**Coffee break**	
		Session 12: Warm Dense Matter (Chair: S. Neff)	
10:30	0:30	SCHANZ, Martin	PRIOR-II – The first proton and heavy-ion particle radiography facility for probing ultra-fast ns-scale HED physics and beyond
11:00	0:20	HESSELBACH, Philipp	High-precision measurement of the K-edge shift in heavy-ion heated aluminum
11:20	0:20	LÜTGERT, Julian	A platform for observing phase-transitions and measuring temperature of ion-heated samples
11:40	0:20	RIPS, Johannes	Investigating the onset of carbon K-shell ionization from imploding CH and HDC capsules measured at the National Ignition Facility
12:00		**Conclusion and End of Workshop**	

Poster Session 1 (Wednesday, 10:50-12:20)

1	BONIFER, Markus	Studies of laser ablation of band-gap materials
2	BOOS, Carl Gerog	Increasing the electron charge in Laser Wakefield Acceleration with Orbital Angular Momentum beams
3	FISCHER, Marvin	Ion stopping power experiments with the laser-driven LIGHT beam-line
4	KRASIK, Yakov	Recent Results of the Research of Underwater Electrical Explosion of Wires/Wires Arrays
5	McDONALD, Cara	Relativistic Attosecond Sources from Intense Multi-colour Laser Pulses
6	OHLAND, Jonas B.	Adaptive Laser Architecture Development and INtegration (ALADIN) - Towards Inertial-Fusion Ready Beam Control
7	RODEN, Stephanie	Thermalization of optically excited Fermi systems: electron-electron collisions in solid metals
8	SCHNELL, Sebastian	Design of a Yb:CALGO regenerative Amplifier for the PHELIX Laser System
9	SEIBEL, Christopher	Nonequilibrium phonon dynamics after laser-excitation
10	TEPLICKY, Tibor	Target Development at ELI Beamlines - Two-Photon Polymerization
11	WINTER, Victor	Simulation Studies of High-Charge Electron Generation in the Self-Modulated Laser Wakefield Acceleration Regime
12	ZOBUS, Yannik	From Concept to Digital Twin: Holistic Modelling of High-Energy Laser Facilities with OPOSSUM

Poster Session 2 (Wednesday, 17:00-18:30)

1	CIKHARDT, Jakub	Characterization of Electron, EMP and Ion Emission at the kilojoule Laser System PALS
2	GRIMM, Sarah J.	Spectral Shaping in Laser-Ion Acceleration by Multispecies Effects
3	KOZAN, Alperen	Damage Threshold Tests for Project FOR2783
4	LINDQVIST, Björn	In-situ X-ray analysis of diamond formation in dynamically compressed glassy carbon
5	LÖFFELMANN, Jiří	Hybrid Modeling of Fast Electron Transport and EMP Generation in Nanosecond Laser-Target Interactions
6	MAJOR, Zsuzsanna	Update on the THRILL project: Towards High-Energy Lasers at High Repetition Rates
7	MARGRAF, Marcel	Plasma-Assisted Methane Decomposition for Hydrogen Production Using Micro Hollow Cathode and Dielectric Barrier Discharges
8	MARTIN, Jed	High-Repetition-Rate X-ray Diffraction of Shock-Compressed PET at the EuXFEL
9	MAY, Philipp	Investigating the DC conductivity of compressed C-H and C-H-O mixtures using ultrafast terahertz pulses
10	NEFF, Stephan	HED@FAIR - High Energy Density Science at FAIR
11	SÄVERT, Alexander	Active beamstabilization for JETi200 and TAF
12	WEGERT, Leonard M.	Experimental Study of Shock Interaction with a Dense Obstacle embedded in Foam Target

Monday 26 January

08:30

Session 1 - Introduction: Session 1 - Introduction

Session | **Location:** Darmstädter Haus, Oberseitestr. 38 D- 87568 Hirschegg | **Convener:** Sebastien Le Pape

08:30–08:40 (10m) **Welcome + Opening**

Speaker
Vincent Bagnoud

08:40–09:10 (30m) **The HED@FAIR Collaboration Status Report**

Speaker
Kurt Schoenberg

09:10–09:40 (30m) **Longitudinal and transverse beam focusing at SIS18 and SIS100**

Speaker
Peter Spiller

09:40–10:10 (30m)

Ultra-high Flux of Direct Laser Accelerated Electrons, MeV Photons and Neutrons using Overdense Foams

Speaker
Parysatis Tavana

Description

Ultra-bright, well-collimated MeV bremsstrahlung radiation was generated through the interaction of high-current electron beams produced via Direct Laser Acceleration (DLA) with a high-Z converter. The DLA mechanism was initiated by a 200 TW, sub-picosecond PHELIX laser pulse at a moderately relativistic intensity of approximately 10^{19} W/cm2, delivering about 60 J into pre-ionized, overcritical-density foam targets [1].

The electron spectrum measured along the laser axis exhibited an effective temperature of approximately 30 MeV and energies exceeding 100 MeV, with a total charge of about 300 nC for electrons with energies above 1.5 MeV (the ponderomotive potential). Of these, roughly 100 nC were directed along the laser axis within a half-angle cone of 12°. The directed fraction of DLA electrons with energies above 7.5 MeV carried a charge of 20–30 nC, corresponding to a flux of up to 2×10^{24} electrons sr^{-1} s^{-1} [2].

These high-current, relativistic electron beams [3] efficiently generate MeV X-rays, enabling the subsequent production of isotopes, positrons, and neutrons with exceptional yield and application potential [4-7]. In laser shots employing overcritical-density foam targets positioned in front of a high-Z converter, bremsstrahlung photons with energies up to 70 MeV were generated and analyzed via nuclear activation of tantalum and gold. The formation of the isotopes ^{174}Ta and ^{190}Au, whose photonuclear cross-section peaks occur near 65 MeV, confirmed the presence of high-energy photons. In contrast, no activation was observed in control shots where the laser was directed onto the converter without foam, demonstrating that high-energy photon generation is intrinsically linked to the DLA process in pre-ionized foam targets [2].

Autoradiographic measurements revealed a bremsstrahlung beam divergence of approximately 22° (half-angle) in the 14–21 MeV energy range. These diagnostics indicate an unprecedented photon flux of approximately 2×10^{22} photons sr^{-1} s^{-1}., corresponding to about 10^{11} photons per shot with energies exceeding 7.5 MeV. The conversion efficiency of focused laser energy into bremsstrahlung photons exceeds 1% within the (FWHM) of the X-ray beam. More than 2×10^9 photoneutrons per shot were emitted isotropically, corresponding to a peak flux of 2×10^{20} cm^{-2} s^{-1}, or 4×10^{18} cm^{-2} s^{-1} J^{-1} [2].

This approach demonstrates a robust and scalable method for generating ultra-intense MeV photon beams at kilojoule, petawatt-class laser facilities operating at moderately relativistic intensities, with strong implications for high-energy-density physics and nuclear astrophysics research.

[1] Rosmej, Olga N., et al. "Advanced plasma target from pre-ionized low-density foam for effective and robust direct laser acceleration of electrons." High Power Laser Science and Engineering 13 (2025): e3.

[2] Tavana, P., et al. “Ultrahigh Flux of Direct Laser-accelerated Electrons, MeV Photons, and Neutrons from Overdense Foams.” Physical Review Applied, Jan. 2026, https://doi.org/10.1103/5mpy-2jw5

[3] Rosmej, O. N., et al. "High-current laser-driven beams of relativistic electrons for high energy density research." Plasma Physics and Controlled Fusion 62.11 (2020): 115024.

[4] Günther, Marc M., et al. "Forward-looking insights in laser-generated ultra-intense γ-ray and neutron sources for nuclear application and science." Nature Communications 13.1 (2022): 170.

[5] Tavana, P., et al. "Ultra-high efficiency bremsstrahlung production in the interaction of direct laser-accelerated electrons with high-Z material." Frontiers in Physics 11 (2023): 1178967.

[6] Cikhardt, Jakub, et al. "Characterization of bright betatron radiation generated by direct laser acceleration of electrons in plasma of near critical density." Matter and radiation at extremes 9.2 (2024).

[7] Gyrdymov, Mikhail, et al. "High-brightness betatron emission from the interaction of a sub picosecond laser pulse with pre-ionized low-density polymer foam for ICF research." Scientific Reports 14.1 (2024): 14785.

10:10

10:40

Session 2 - Inertial Confinement Fusion 1: Session 2 - Inertial Confinement Fusion 1

Session | **Location:** Darmstädter Haus, Oberseitestr. 38 D- 87568 Hirschegg | **Convener:** Kurt Schoenberg

10:40–11:10 (30m)

Measurements of the equation of state of foam targets for inertial fusion energy

Speaker

Jordan Lee

Description

The recent progress at the National Ignition Facility (NIF) has sparked fresh excitement around the topic of inertial fusion energy (IFE) [1–5]. However, significant advances are still required before the goal of practical fusion energy can be realised. In particular, while the recently achieved gain of 4 represents an unprecedented milestone [5], it is still short of the minimum value of > 50 likely to be required for a viable fusion reactor [6]. In addition, current target designs are expensive and time-consuming to produce [7], while cost estimates for future fusion reactors require low cost and high repetition rates [8, 9]. Wetted-foam capsules are seen as a promising target solution for future IFE reactors, with the potential to enable high gain performance at low cost. The CH foams used to contain the DT liquid fuel can potentially be 3D printed, which could significantly improve the production rate and cost of such targets compared to conventional DT-ice targets. A variety of designs based on this technology have been proposed, ranging from more conventional designs (where the wetted-foam layer replaces a DT ice layer [10, 11]) to novel dynamic-shell approaches [7, 12]. Despite their potential, the shock response of low-density foams remains poorly characterised, limiting the accuracy of hydrodynamic simulations. Here, I will report experimental measurements of the equation of state (EOS) for silica (SiO_2) aerogel and TMPTA plastic foams under laser-driven shock compression, conducted recently at the Vulcan, GEKKO XII and LULI2000 laser facilities [13-15]. Shock pressures between 50 and 160 GPa were achieved, and the corresponding states were determined using standard impedance matching techniques with a quartz reference material.

[1] H Abu-Shawareb et al., Physical Review Letters 129, 075001 (2022).
[2] A. L. Kritcher et al., Physical Review E 106, 025201 (2022).
[3] A. B. Zylstra et al., Physical Review E 106, 025202 (2022).
[4] A. B. Zylstra et al., Nature 601, 542–548 (2022).
[5] https://lasers.llnl.gov/news/llnl-experts-foster-national-fusion-energy-ecosystem-ife-star-conference
[6] E. M. Campbell et al., "Laser-direct-drive program: Promise, challenge, and path forward", Matter and Radiation at Extremes 2, 37–54 (2017).
[7] V. N. Goncharov et al., Physical Review Letters 125, 065001 (2020).
[8] G. R. Tynan et al., Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences 378, 20200009 (2020).
[9] K. Gi et al., Energy Strategy Reviews 27, 100432 (2020).
[10] R. E. Olson et al., Physics of Plasmas 28, 122704 (2021).
[11] R. E. Olson et al., Physical Review Letters 117, 245001 (2016).
[12] I. V. Igumenshchev et al., Physical Review Letters 131, 015102 (2023).
[13] R. Paddock et al., Physical Review E 107, 025206 (2023).
[14] J.J. Lee et al., Physical Review E (under review 2025).

11:10–11:30 (20m)

Rayleigh-Taylor instability in non-ideal media: a quasi-irrotational approximation

Speaker

Antonio Roberto Piriz

Description

We present the results of the quasi-irrotational approximation developed to deal with the problem of the linear Rayleigh-Taylor instability in incompressible and immiscible non-ideal finite thickness media when the top surface of the layer is attached to a rigid wall, and extend them to the cases in which it is a free surface. These constitute two families of problems that allow for considering a wide variety of problems.The approximate results are compared with the exact ones finding an excellent agreement, which shows that the mathematical complexities introduced by the vorticity do not correspond with its physical relevance for the instability dynamics.

11:30–11:50 (20m)

Self-similar multishock implosions for ultrahigh compression of matter

Speaker

Masakatsu Murakami

Description

We present a unified theoretical and numerical framework for self-similar multi-shock implosions achieving ultra-high compression in a uniform solid spherical target. Extending the classical Guderley model to N-stacked, spherically converging shocks,we derive self-similar solutions and the scaling law for the final density. One-dimensional Lagrangian hydrodynamic simulations confirm this relation over a broad range of parameters, from the weakly to the strongly non- linear regime. The results show that cumulative compression increases systematically with the number of stacked shocks while entropy generation is strongly suppressed, asymptotically approaching a quasi-isentropic limit as $N \to \infty$. This volumetric scheme inherently eliminates the Rayleigh–Taylor instability that plagues shell-based implosions and thus provides a robust, instability-free compression path-way applicable to inertial confinement fusion (ICF) and other high-energy-density systems. The framework bridges similarity theory with realistic multi-shock dynamics, guiding the design of advanced laser-driven compression schemes.

11:50–12:10 (20m)

Advancing inertial fusion energy using ultra-high peak power X-rays

Speaker

Siegfried H. Glenzer

Description

The demonstration of energy gain by nuclear fusion in the laboratory and its industrial utilization as an unlimited energy source has been a grand challenge for physicists and engineers for 70 years. This vision has shifted closer to reality after the successful demonstration of multi-megajoule energy yield from deuterium-tritium plasmas in indirectly driven inertial confinement fusion implosions on the National Ignition Facility (NIF) at Lawrence Livermore National Laboratory. These experiments exceed fusion powers of 100 PW in a single event, vastly exceeding human's total annual power capability by a factor of 5,000. This achievement came after increasing the fusion energy yield by a factor of 3,000 since the first experiments on the NIF about a decade ago. Currently, several avenues towards power generation by fusion ignition and high fusion yield are beginning to emerge where efforts towards laser and target technology developments have been launched recently through the U.S. DOE's IFE-STAR and FIRE programs.

A leading target design for delivering high fusion yield at repetition rates of seconds uses laser-driven polymer foam capsules wetted with liquid nuclear fuels. Current target and fusion power plant design studies urgently need data on the Equation of State (EoS) and validation of simulations of the adiabat and hydrodynamic stability at megabar to gigabar pressures. For this purpose, we have launched a new program at SLAC to deliver these data by performing high precision experiments with powerful X-ray sources. Precision data are required because the fusion capsule design must be robust to thepresence of radiation cooling from polymer ions. Further, plastic capsules were abandoned earlier on the NIF and replaced by diamond ablators due to stability issues that will need to be overcome in future fusion power applications.

In this talk, I will present new elements of the U.S. IFE program and discuss recent results that provide critical experimental tests of our ability to model IFE implosions.

12:10

17:00

Session 3 - Short Pulse 1: Session 3 - Short Pulse 1

Session | **Location:** Darmstädter Haus, Oberseitestr. 38 D- 87568 Hirschegg | **Convener:** Vincent Bagnoud

17:00–17:30 (30m) **Ultrashort proton beams from all optical phase-space control**

Speaker

Jonathan Kennedy

Description

We demonstrate an all-optical method for generating ultrashort, spectrally narrow proton beams using an intense laser interaction with a helical target structure. Direct measurements reveal proton pulse durations of only tens of picoseconds, substantially shorter than those obtained from conventional targets at comparable energies. This temporal compression observed is as a result of a controlled multidimensional phase-space rotation from the coil. Numerical modelling confirms the underlying dynamics and shows that the scheme is scalable to petawatt laser intensities, where monoenergetic proton beams with sub picosecond-scale durations and energies of approaching 100 MeV are predicted. This approach enables the delivery of highly collimated proton bursts on ultrafast timescales inaccessible to conventional accelerators, opening new opportunities in ultrafast science and applied nuclear and medical research.

17:30–17:50 (20m)

Simulation of Particle Acceleration off Laser Irradiated Micro-Plasma

Speaker

Viktoria Pauw

Description

We report on updates on the comprehensive processing of PIC simulations on HPC systems at LRZ using tools for the data management of large parameter studies of physics simulations. Our example study uses a Particle-In-Cell code by Prof. Ruhl et al (LMU) to explore the laser plasma interaction and ensuing particle acceleration of polysterene or hydrogen micro-targets in the micrometer range. The related experiments (Hilz, Ostermayr et al) use a Paul trap to levitate the targets in a vacuum (or controlled gas filled surroundings) and irradiate them by an ultra-short relativistically strong laser pulse. The atoms in the targets are ionized completely by the electric fields of the pre-pulse and they act as so-called mass limited targets (MLT) for acceleration of ions (predominantly protons) to energies up to hundreds of MeV.. We explore the optimization of the near critical relativistic density targets, by examining the interplay between RPA and Coulomb explosion. We examine the possibility of different regimes of accelerated protons when using higher laser pulse energies, as available now at ELI-NP and different pulse parameters

17:50–18:20 (30m)

Hybrid Wakefield Acceleration with 16% Beam-to-Beam Efficiency: Experimental Results and Infrastructure Advances

Speaker

Stefan Karsch

Description

In this talk, we report on several novel aspects of laser-driven electron acceleration at CALA. The main highlight is the demonstration of energy doubling and a record absolute energy-transfer efficiency from the LWFA to the PWFA stages in hybrid laser–plasma wakefield acceleration (LPWFA). The motivation behind this scheme is to overcome the emittance limits inherent to classical laser-wakefield acceleration (LWFA), which arise from strong plasma-electron heating by the transverse laser fields. By using a high-charge, low-quality LWFA electron beam and exploiting its unipolar fields to drive a strong wake in a second plasma-wakefield-acceleration (PWFA) stage, the scheme enables cold-injection concepts in an initially cold plasma to achieve ultralow-emittance beams. The experimental demonstration of a 16% beam-to-beam transfer efficiency, energy doubling in the PWFA stage, and reduced beam bandwidth and divergence provides strong evidence for the practical feasibility of this approach. In addition, I will present a new, highly flexible, length-scalable gas-jet design currently being commissioned at CALA. Finally, I will comment on new insights into the sources of shot-to-shot instabilities at the ATLAS-3000 PW laser facility.

18:20–18:40 (20m)

Galilean Electromagnetic PIC Code for Efficient Simulation of LWFA

Speaker

Alexander Pukhov

Description

A Galilean electromagnetic particle-in-cell (GEM-PIC) algorithm that reformulates the complete Maxwell and Vlasov equations in a Galilean-boosted coordinate frame s developed. This transformation preserves the full electro-magnetic dynamics of the interaction while leveraging scale separation to improve computational efficiency. In contrast to quasistatic approaches, GEM-PIC does not require distinguishing between “beam” and “streaming” particles, enabling a fully self-consistent description of particle trapping. This method provides an efficient and accurate framework for simulating plasma-based wakefield acceleration.

18:40–19:00 (20m)

High-charge electron acceleration in the self-modulated laser-wakefield acceleration regime at PHELIX

Speaker

Johannes Hornung

Description

Laser–plasma accelerators promise a compact alternative to conventional radio-frequency accelerators, but achieving simultaneously high charge, high stability, and scalability at high repetition rates remains a major challenge. Here, we demonstrate that self-modulated laser wakefield acceleration (SM-LWFA) driven by picosecond laser pulses provides a robust pathway to generate electron bunch-charges of 100s of nanocoulomb. These experiments at the PHELIX facility, supported by three-dimensional particle-in-cell simulations, reveal that the acceleration dynamics are governed primarily by the laser power relative to the plasma density, rather than by the initial focal intensity. Once the relativistic self-focusing threshold is exceeded, the laser self-organizes to a smaller spot size dependent on the density, making the process largely insensitive to the focusing geometry. This finding overturns the conventional view that tight focusing is essential for efficient acceleration and provides a simple scaling law linking beam charge and cutoff energy mainly to the laser power and plasma density. We report on the results of the commissioning experiment, with beam charges up to (500+-160) nC and cutoff energies beyond 300 MeV. Extrapolating our scaling-results to upcoming lower-energetic 20 J, 100 Hz picosecond-class laser systems allow for average beam currents above 25 µA, which approach the capabilities of conventional accelerators. These results could establish SM-LWFA as a powerful and experimentally accessible regime for generating high-charge electron beams, enabling high-brightness x-ray, gamma-ray sources for fundamental research and applications.

19:00

Tuesday 27 January

08:30

Session 4 - Laser: Session 4 - Laser

Session | **Location:** Darmstädter Haus, Oberseitestr. 38 D- 87568 Hirschegg | **Convener:** Zsuzsanna Slattery-Major

08:30–09:00 (30m) **High-LIDT Coatings for Laser Applications**

Speaker

Andreas Schönlein

Description

The continuous advancement of high-power laser systems, including those driving inertial confinement fusion experiments, demands optical coatings with exceptionally high laser-induced damage thresholds (LIDT) and precise control over optical and mechanical properties.

This work presents recent developments in the deposition of high-LIDT coatings optimized for pulsed laser applications. Various deposition techniques—ion beam sputtering (IBS), plasma-assisted reactive magnetron sputtering (PARMS), plasma ion-assisted deposition (PIAD), and atomic layer deposition (ALD)—are compared in terms of LIDT, optical performance, and conformality. We discuss the role of optical parameters such as absorption and scattering, as well as the influence of substrate surface quality.

The results indicate that, by tailoring process parameters, it is possible to achieve dielectric coatings with LIDT values exceeding 120 J/cm^2 (10 ns, 1064 nm) while maintaining excellent environmental stability. These findings pave the way for next-generation optical components in high-energy lasers, CPA systems, precision optics, and ultrafast photonics.

The results also show that short-pulse laser damage mechanisms are strongly influenced by coating defect levels and substrate surface quality. Improving both is therefore essential for increasing the LIDT. While defect levels can be continuously optimized through further development of hardware and process parameters, state-of-the-art surface processing technologies—such as ion beam figuring (IBF)—play an important role in providing high-quality surfaces and will be presented as well.

09:00–09:20 (20m)

A millijoule-level q-switched Nd:YLF laser pumped by high-power LEDs

Speaker

Leon Dauerer

Description

A Nd:YLF laser pumped by high-power LEDs

Leon Dauerer1, Ralph Wirth4, Dennis Schumacher2, Florian Wasser3, Markus Roth3,2, and Vincent Bagnoud1,2

(1) GSI Helmholtzzentrum fur Schwerionenforschung GmbH, Planckstraße 1, 64291 Darmstadt, Germany,
(2) Technische Universität Darmstadt, Schlossgartenstrasse 7, 64289 Darmstadt, Germany
(3) Focused Energy GmbH, Im Tiefen See 45, 64293 Darmstadt, Germany
(4) ams-OSRAM International GmbH, Leibnizstr. 4, 93055 Regensburg, Germany

Right now, high-intensity and high-energy laser systems are pumped by flash lamps or laser diodes. The flash lamps have a very large emission bandwidth (>2000 nm), which makes them inefficient and limits the repetition rate of the laser, while the narrow-bandwidth laser diodes (2-6 nm) remain very expensive (30-50$/W). These characteristics are problematic for the application for laser-driven fusion, because a commercially-functioning power plant would require high repetition rates, high efficiency and low costs. In this contribution, we focus on the question if LEDs can serve as a good compromise between flash lamps and laser diodes.
In the past years, LEDs have developed tremendously as well as in cost as in performance. For example, the price for light (per kilolumen) dropped by a factor of 15 over the course of the last decade, driven by the lighting industry. In addition, the performance/efficiency increased over time. They have an acceptable bandwidth (20-60 nm), so there is significantly less unnecessary energy deposited in the amplifier material compared to flash lamps. In comparison to the laser diodes, they are a lot cheaper (20-40 ct/W). However, LEDs still exhibit low emission power densities, which has been regarded as a challenge for laser applications. A work around is the possibility to overdrive LEDs in pulsed operation mode, which has received little attention so far.
In this contribution, we report, to the best of our knowledge, on the first millijoule level Nd:YLF laser directly pumped by high-power LEDs. The laser works in cavity dumped q-switch mode. It exhibits near diffraction limited operation (Mx=1.08 and My=1.15) with a maximum pulse energy of 3.6 mJ (maximum small signal gain of 1.223). The pulse fluctuations are 2.3 % (standard deviation over mean) at a repetition rate of 0.5 Hz.
In addition, we developed a first generation of pulsed LEDs together with OSRAM, which were tailored for our application. The new LEDs have an emission wavelength centered around 800 nm and they exhibit a significantly increase in power density, reaching up to 120 W/cm2 in a 600 ms pulse. This should improve the laser performance dramatically. In total, we have three different LEDs with 3 different wavelengths to match absorption peaks of the gain medium.
Future plans include to implement the new asm-OSRAM LEDs to enhance the overall performance of the laser. It is also planned to change the design to enable cooling to enhance the repetition rate. It is also desirable to implement index matching to couple the LED light better into the gain medium. We also want to use the setup to pump Nd:Glass, to show that the method of direct pumping is now feasible for Nd:Glass.

09:20–09:40 (20m)

Versatile Joule-class OPA as front-end laser for inertial fusion research

Speaker

Antoine Courjaud

Description

The strategy to achieve high gain in Inertial Confinement Fusion (ICF) necessitates flexible laser beamlines capable of delivering diverse temporal characteristics at the kJ energy level. While direct drive target compression demands broad-bandwidth nanosecond pulses, specific ignition schemes require short pulses to generate penetrating particles. Consequently, advanced spectral management is critical in both regimes.
In this work, we present a versatile, multi-Joule front-end solution based on Optical Parametric Amplification (OPA). This system leverages two proprietary pump lasers specifically optimized for OPA applications: a high-repetition-rate unit (3J at 5–10Hz, 532nm) and a high-energy unit (>30J at 1 shot/min, 527nm). Both lasers deliver top-hat beam profiles with a high Strehl ratio, ensuring ideal conditions for OPA pumping. Furthermore, they feature adjustable temporal shaping (3–20ns) and are available in circular or square beam formats. We will demonstrate how this modular OPA architecture offers the necessary parameter flexibility for both short- and long-pulse operations in next-generation research facilities

09:40–10:00 (20m)

Ultra-high intensity laser pulses at 400 nm produced via Second Harmonic Generation

Speaker

Katinka von Grafenstein

Description

The interaction between ultra-short, high-power laser pulses and solid-density targets is frequently utilized to accelerate protons [1-3] and heavier ion species [4]. Since then, it has been shown that structuring the surface leads to enhanced absorption of the laser and enhanced conversion to secondary radiation. Ruhl and Korn [5] have proposed using nanowire arrays with average density near the critical density as efficient converters from laser energy to ion energy.
Simulations predict improved laser absorption and energy conversion from laser energy to accelerated particles and radiation for shorter laser wavelengths. Furthermore, for an ideal interaction between a short laser pulse and a solid target, high temporal contrast is needed such that the solid target is still intact when interacting with the peak of the pulse. A conversion of the laser pulses via second harmonic generation (SHG) is a good way to achieve both these goals at the same time: the wavelength is shortened and the temporal contrast is improved by the highly non-linear process.
We will present recent results of laser pulses with 0.75 PW from the Ti:Sa laser system ATLAS-3000 that have been converted via SHG to high energy pulses with a wavelength of 400 nm at the Centre for Advanced Laser Applications (CALA). For the conversion, a non-linear KDP crystal (800 μm thick, 300 mm diameter, type I) has been used and a conversion efficiency of over 50$\%$ has been reached. The converted pulses contain up to 10 J of energy and the beam is focused with an f/3.2 focusing geometry, reaching intensities of $\sim 10^{21}$ W/cm^2 in the second harmonic. These pulses will be used for highly relativistic laser-solid interaction studies, leading the way to highly efficient laser-driven accelerators for secondary sources and novel fusion schemes.

[1] R. A. Snavely et al., Phys. Rev. Lett. 85, 2945 (2000)
[2] E. L. Clark et al., Phys. Rev. Lett. 84, 670 (2000)
[3] A. Maksimchuk et al., Phys. Rev. Lett. 84, 4108 (2000)
[4] M. Hegelich et al., Phys. Rev. Lett. 89, 085002 (2002)
[5] Ruhl and G. Korn, arXiv, 2212.1294 (2022), H. Ruhl and G. Korn, arXiv, 2302.06562 (2023)

10:00

10:30

Session 5 - Inertial Confinement Fusion 2: Session 5 - Inertial Confinement Fusion 2

Session | **Location:** Darmstädter Haus, Oberseitestr. 38 D- 87568 Hirschegg | **Convener:** Jordan Lee

10:30–10:50 (20m) **High Gain Fusion Targets**

Speaker

Hartmut Ruhl

Description

The purpose of the presentation is to introduce Marvel Fusion's high-gain fusion target philosophy. The company's high-gain target concept incorporates a novel fast-ignition element capable of delivering up to multiple megajoules of fast-ignition energy into dense fuel. In addition, the concept includes a mild compression element that can be validated at existing implosion facilities. Combined, these elements are designed to exceed the required fusion triple product for hotspot igition and enable, in principle, unlimited fusion gain. The target design promises to be robust and simple.

10:50–11:20 (30m)

Systematic assessment of the hotspot ignition condition over a range of non-standard fuels

Speaker

Matthias Lienert

Description

Here, we discuss the hotspot ignition condition for scenarios relevant for applications in the field of inertial fusion energy. Different tradeoffs of compression and hotspot energy are considered. Special attention is paid to the necessary modifications of the condition for a novel class of fusion fuels, so-called "non-cryogenic DTs". These fuels, recently proposed by Ruhl et al. (2025), consist of DT bound in solid form by the addition of low to medium Z elements.

11:20–11:40 (20m)

Investigating Magnetized Inertial Confinement Fusion Dynamics in Laser-Driven DT Fuel using PIConGPU

Speaker

Filip Optołowicz

Description

Inertial Confinement Fusion (ICF) remains a promising pathway for high-gain energy production, yet achieving ignition conditions requires precise control over fuel compression and thermal transport. A promising avenue to relax these stringent requirements is the application of strong external magnetic fields. In this work, we investigate the viability of magnetically assisted heating, where the magnetic field is utilized to confine electrons within the fuel target, thereby inhibiting thermal losses and significantly increasing local heating rates.

We present a numerical study utilizing PIConGPU, a fully relativistic, open-source Particle-in-Cell code, enhanced with a newly developed fusion extension. This extension enables the self-consistent treatment of fusion reaction dynamics alongside the kinetic evolution of the plasma.

11:40–12:00 (20m) **Hot electron transport in magnetized targets**

Speaker

Javier Honrubia

Description

We report on further simulations for an experiment studying hot-electron transport in a magnetized planar target conducted on the OMEGA-EP laser system [1]. The magnetic field strength was set at 20 Tesla, which is sufficient to divert hot electrons and hinder their propagation toward a copper fluor layer. By analysing the heating of that layer by hot electrons both with and without the applied magnetic field, we intended to differentiate between radiative and hot-electron preheating. However, the experimental results were unexpected, as the K yields were similar with and without the applied magnetic field. In addition, broadening of the copper Kα lines was observed with the magnetic field.
To understand the experimental results, we have conducted 2-D MHD simulations with the FLASH code [2] and hot-electron transport simulations in a magnetized target with the 3D hybrid code PETRA [3]. One possible explanation that aligns with the findings of Enright and Burnett [4] is that the magnetic field increases the average energy of hot electrons, which are primarily gen-erated via SRS. With higher energy, these electrons can reach the fluor layer and produce increased Kα emission, like that achieved in the absence of the magnetic field. The broadening of the K emission from the copper layer when an external magnetic field is applied may be attributed to several effects that are still under investigation. These findings could help in managing hot-electron preheating in direct-drive central hot-spot ignition and shock-ignition targets.
References
[1] A. Tentori et al. Experimental characterization of hot electron emission and shock dynamics in the context of the shock ignition approach to inertial confinement fusion, Phys. Plasmas 28, 103302 (2021).
[2] B. Fryxell et al., FLASH: An Adaptive Mesh Hydrodynamics Code for Modeling Astrophysical Thermonuclear Flashes, ApJS 131, 273 (2000).
[3] J.J. Honrubia and J. Meyer-ter-Vehn, Three-dimensional fast electron transport for igni-tion-scale inertial fusion capsules. Nuclear Fusion 46, L25 (2006).
[4] G.D. Enright and N.H. Burnett, Effect of external magnetic field on the generation and transport of hot electrons in laser-target irradiation, The Physics of Fluids 29, 3456 (1986).

12:00

17:00

Session 6 - Short Pulse+ and other: Session 6 - Short Pulse+ and other

Session | **Location:** Darmstädter Haus, Oberseitestr. 38 D- 87568 Hirschegg | **Convener:** Dieter H.H. Hoffmann

17:00–17:30 (30m)

Ultra-high intensity laser interaction with nanostructured near-critical foams: numerical modelling and experimental challenges

Speaker

Marta Galbiati

Description

Foam-based targets are appealing for driving high-efficiency radiation-matter coupling in high-energy-density and high-intensity physics experiments [1-4]. In particular, low-density foams enable the generation of a near-critical plasma in which laser pulses with relativistic field strength, $a_0 \gg 1$, propagate. In this plasma, the laser delivers its energy to a large number of electrons and ions, possibly creating efficient radiation sources from the acceleration of these species [5-6], and from the generation of secondaries such as gamma rays and positrons through processes mediated by laser or matter fields [7-12]. Such low-density foams can be produced with pulsed-laser deposition, a physical deposition technique that provides the material with a fractal nanostructured morphology [13], which affects the laser-foam interaction [7,10].
The present contribution discusses kinetic simulations on the efficient super-ponderomotive acceleration of electrons and generation of gammas and positrons with energies of hundreds of MeV that can happen in nanostructured foams [10]. The impact of foam morphology is taken into account and discussed considering how the multiple length and density scales of these targets, ranging from nanometric to micrometric scales, can affect the interaction. Indeed, foam morphology can suppress the highest energy tail of particle spectra compared to homogeneous targets and at the same time induce additional processes related to local inhomogeneities.
The discussion on laser-foam interaction is also extended to the preparation of experimental campaigns. At high-energy, high-power laser facilities, several non-idealities must be considered to achieve the results predicted with foam targets. The difficulties range from controlling crucial laser parameters, such as polarisation and the temporal and spatial contrast of the pulse, to designing and handling foam targets and diagnostics. By combining numerical studies with experience at PW-level laser facilities such as Apollon [14], we discuss solutions at the target and setup levels to the challenges mentioned above, which will help the preparation of the next experimental campaigns.
Our contribution aims to build all the theoretical and practical knowledge needed to use nanostructured foam targets in experiments relevant to the design of radiation sources, the study of laser-driven fusion, the creation of dense, relativistic pair bunches, and the exploration of strong-field quantum electrodynamics.

[1] Delorme et al. 2016 Phys. Plasmas 23 042701
[2] Nagai et al. 2018 Phys. Plasmas 25, 030501
[3] Prencipe et al. 2021 New J. Phys. 23 093015
[4] Tikhonchuk et al. 2021 Matter Radiat. Extremes 6 025902
[5] Willingale et al. 2011 Phys. Plasmas 18 056706
[6] Rosmej et al. 2025 High Power Laser Sci. Eng. 13 e3
[7] Fedeli et al. 2018 Scientific Reports 8 3834
[8] Galbiati et al. 2023 Front. Phys. 11 1117543
[9] Formenti et al. 2024 Phys. Rev. E 109 035206
[10] Galbiati et al. 2025 preprint 10.21203/rs.3.rs-7808232/v1
[11] Pouyez et al. 2025 Phys. Rev. Lett. 134 135001
[12] Pouyez et al. 2025 preprint 10.48550/arXiv.2505.18843
[13] Maffini et al. 2022 Appl Surf Sci 599 153859
[14] Burdonov et al. 2021 Matter Radiat. Extrem. 6 0644

17:30–17:50 (20m)

Experimental evaluation of Nano Accelerators driven at relativistic intensities

Speaker

Marius Schollmeier

Description

Highly ordered nanowire arrays with sub-wavelength diameter can be engineered to absorb multi-PW laser pulses with ultra-high-contrast (<10^{-12} on ps timescales), sub-100-fs pulse duration at intensities above 10^{20} W/cm^2 with efficiency nearing 100%. A large fraction of the absorbed energy is converted to high-current ion and electron flows in a controlled manner by this Nano Accelerator [1].
We will present an experimental evaluation of the Nano Accelerator driven by 10 PW laser pulses of the HPLS laser at the Extreme Light Infrastructure for Nuclear Physics (ELI-NP), which was operated at approximately 200 J of energy on target at a pulse duration of 23 fs. The original focusing geometry was modified from F/60 to F/20 leading to intensities of 8×10^{20} W/cm^2 with a uniform focal spot volume of 16 µm FWHM and >200 µm Rayleigh length [2]. The intense laser pulse was used to irradiate highly aligned, high-aspect-ratio nanowires within a patch of 100×100 µm^2 and average electron density of ~$5\,n_c$, where n_c is the critical density. Monitoring the specularly reflected laser light and detecting ion emission via multiple Thomson parabola & CR-39 spectrometers, we demonstrate increased ion emission from 20 µm long wires compared to 10 µm wires, with conversion to high energy ions nearing 20-30% efficiency in line with theoretical expectations [1,3].
In a second experiment, conducted at HZDR with the DRACO laser using an optical pump-probe setup to study pre-plasma dynamics in the interaction of an ultrashort high-power laser with nanostructured targets, we investigated pre-ionization and pre-expansion of the nanowires from laser pre-pulses, modifying the nanostructure and degrading performance, making these dynamics critical to resolve for reliable modeling and target optimization. Using combined scattering and Doppler spectrometry, we measure target expansion and particle dynamics under different laser contrast conditions, providing insight into how nanostructure modification influences laser-plasma coupling and ion acceleration.

[1] Ruhl and G. Korn, arXiv, 2212.1294 (2022), H. Ruhl and G. Korn, arXiv, 2302.06562 (2023)
[2] V. Scutelnic. et al., accepted for publication in High Power Laser Science and Engineering
[3] D.E. Rivas et al., in preparation

17:50–18:10 (20m)

General Solution of the Moments of the Boltzmann Collision Integrals

Speaker

CHRISTIAN BILD

Description

We present a novel, more general analytic solution for the moments of the Boltzmann collision operator. Such moments are essential for deriving hydro equations and their nonthermal extensions. To the best of our knowledge, they have so far only been evaluated for specific models, cross-sections, small nonthermal contributions, and small relative velocities. We overcome these limitations by allowing for arbitrary models, arbitrary cross-section, and using a closed form solution containing all nonlinear terms. As an application, we discuss the nonlinear extension of the 21-moment model of Braginskii.

18:10–18:30 (20m) **Stopping of Nanoaccelerated Ions**

Speaker

Markus Nöth

Description

A brief description of the five moment model of Hydrodynamics for Coulomb collisions is given. The model includes large angle collisions. The corresponding integrals are evaluated to logarithmic and constant order in the maximum impact parameter. The Bethe formula is recovered in the appropriate limit.
This model is then self-consistently coupled to a deuterium-tritium plasma of a given initial temperature to model the process of heating such a plasma by fast moving ions generated from nano-rods irradiated by femtosecond lasers.

18:30–18:50 (20m)

Cluster viral expansion and generalized Beth--Uhlenbeck formula from the $\Phi-$derivable approach

Speaker

David Blaschke

Description

We derive a generalized Beth-Uhlenbeck formula for the entropy as well as the density, of a dense fermion system with strong two-particle correlations, including scattering states and bound states. We work within the $\Phi-$derivable approach to the thermodynamic potential. The formula takes the form of an energy-momentum integral over a statistical distribution function times a unique spectral density. In the near mass-shell limit, the spectral density reduces, contrary to na\"{i}ve expectations, not to a Lorentzian but rather to a "squared Lorentzian" shape. The relation of the Beth-Uhlenbeck formula to the Φ-derivable approach is exact at the two-loop level for Φ.
The formalism we develop, which extends the Beth-Uhlenbeck approach beyond the low-density limit, includes Mott dissociation of bound states, in accordance with Levinson's theorem, and the self-consistent back reaction of correlations in the fermion propagation. We develop the extension of the found relationship to a cluster viral expansion and discuss applications to further systems, such as quark matter and nuclear matter, with numerical examples for effective models.

18:50

Wednesday 28 January

08:30

Session 7 - Target Fabrication: Session 7 - Target Fabrication

Session | **Location:** Darmstädter Haus, Oberseitestr. 38 D- 87568 Hirschegg | **Convener:** Johannes Hornung

08:30–08:50 (20m)

Advancing Projection Two-Photon Polymerization for High-Repetition-Rate IFE Target Fabrication: Predictive Modeling and High-Sensitivity Materials

Speaker

Elias Hamel

Description

The transition of Inertial Fusion Energy (IFE) from scientific ignition to a viable power source depends on the ability to mass-produce complex, high-precision targets — specifically low-density polymer foams and shells — at repetition rates exceeding 10 Hz.
While Two-Photon Polymerization (2PP) offers the necessary sub-micron resolution for controlling foam morphology, standard point-scanning approaches are prohibited by low throughput and excessive energy consumption.

Projection Two-Photon Polymerization (P2PP) offers a parallelized solution, yet faces challenges in optical confinement and material sensitivity required for industrial scale-up.
We present a dual-pronged approach to optimizing P2PP for IFE target fabrication, combining a comprehensive wave-optics simulation with novel resin chemistry. First, we developed a numerical model based on Fourier optics to characterize the spatio-temporal focusing dynamics of the printing process.
The simulation quantifies critical fabrication artifacts, identifying a ≈ 36% axial elongation of voxels induced by the diffraction grating of the Digital Micromirror Device (DMD). Furthermore, we demonstrate that maximizing the spectral bandwidth of the laser source significantly improves axial confinement, a key parameter for defining the pore structure of low-density foams.

Second, to address the printing speed and energy efficiency bottleneck, we developed and characterized custom high-sensitivity photoresists. By utilizing the 4-methylcyclohexanone derivative (BBK) photoinitiator, we achieved a > 40-fold increase in photosensitivity compared to commercial standards (IP-S). This sensitivity gain reduces the projected laser power consumption and increases the printing speed by a factor of 40. It enables the microsecond-scale exposure times required for advanced linescanning strategies. We further demonstrate that the process stability of these highly reactive resins can be precisely tuned using inhibitors (MEHQ) without compromising sensitivity. Finally, we present preliminary results on the synthesis of oxygen-free, vinyl-based liquid polystyrene resists, outlining a pathway to pure hydrocarbon (C-H) targets essential for minimizing Bremsstrahlung losses in fusion experiments.

08:50–09:10 (20m)

A Cryogenic Platform for Investigating Wetting Dynamics in Deterministic 2PP Foams for IFE

Speaker

Joschka Seip

Description

The realization of Inertial Fusion Energy (IFE) requires target injection rates of approximately 10$\,$Hz. Furthermore, a perfectly homogeneous Deuterium-Tritium (DT) layer inside the target is strictly required, as even minor asymmetries in the fuel distribution will amplify during implosion, preventing ignition. To meet this demand while minimizing the active Tritium inventory, wetted foams are essential, as they facilitate rapid fuel distribution via capillary forces.

However, implementing this presents significant physical and modelling challenges. The fuel must wick evenly throughout the entire foam volume, even against gravity. Additionally, the subsequent liquid-to-solid phase transition often generates unwanted voids due to density changes. Validating predictive fluid simulations for these processes is hindered by the stochastic nature of conventional chemical foams and the lack of specific wetting data for novel materials.

To address these issues, we report on the commissioning of a cryogenic apparatus dedicated to investigating wetting properties and filling behavior in deterministic foams. These foams are fabricated via Two-Photon Polymerization (2PP), providing the reproducible geometry essential for benchmarking simulations. The setup achieves temperatures down to 11.0$\,$K with high stability, permitting the study of wetting and freezing using hydrogen as well as deuterium. Utilizing a custom optical diagnostic with a spatial resolution better than 5$\,$µm, the system allows for the visualization of liquid-gas phase boundaries relative to the pore geometry. Finally, we discuss strategies for applying controlled thermal gradients to drive directional solidification to counteract void formation during the freezing process.

09:10

09:10
10:10

Poster Slam: Poster Slam

Session | **Location:** Darmstädter Haus, Oberseitestr. 38 D- 87568 Hirschegg | **Convener:** Johannes Hornung

10:50

Poster Session 1: Poster Session 1

Session | **Location:** Darmstädter Haus, Oberseitestr. 38 D- 87568 Hirschegg

10:50–12:20 (1h 30m)

Increasing the electron charge in Laser Wakefield Acceleration with Orbital Angular Momentum beams

Speaker

Carl Georg Boos

Description

High-energy electrons have many applications, ranging from medical physics to fundamental research. Laser wakefield acceleration (LWFA) is a new method of accelerating electrons to high energies in mere centimeters, as opposed to hundreds of meters using classic linear accelerators. Electrons accelerated with LWFA can also be used to drive Laser-Driven Neutron Sources (LDNS). In this process, the electrons produce neutrons in a two-step process involving bremsstrahlung and photonuclear reactions, rather than ions accelerated by target normal sheath acceleration. Up to 25% of 350MeV electrons can be converted into neutrons.

However, the electron charge is typically limited to several hundred pC due to beam loading effects in the plasma wake. We are investigating if a beam with orbital angular momentum, which causes a ring focus and thus a ring wakefield, can increase the accelerated charge before beam loading occurs.

10:50–12:20 (1h 30m)

From Concept to Digital Twin: Holistic Modelling of High-Energy Laser Facilities with OPOSSUM

Speaker

Yannik Zobus

Description

In the worldwide pursuit of achieving energy production via inertial confinement fusion, the development of large laser infrastructures has experienced a renaissance. Advances in laser technology are being driven not only by the need to enhance laser performance and efficiency but also by the stringent requirements imposed by modern approaches to improve the overall efficiency of the fusion process. Given these increasing demands—and the sheer scale of laser facilities comprising hundreds to thousands of kilojoule beamlines—rigorous, holistic planning and design have become essential. Ideally, a digital twin of such a facility enables comprehensive analysis and optimization before significant resources are committed.

A tool whose development was initiated within the THRILL project (Technology for High-Repetition-Rate Intense Laser Laboratories) to support, guide, and evaluate designs for upcoming laser facilities at Eu-XFEL and FAIR addresses these challenges. This tool, called OPOSSUM (Open-Source Optics Simulation System and Unified Modeler), aims to provide a common software platform for the holistic modelling of large-scale laser facilities.

Following a flow-graph–based optical-design approach that mirrors laboratory build processes, OPOSSUM facilitates intuitive creation of digital optical setups and enables diverse analyses without the need to redefine configurations for each evaluation.

In this contribution, we present the latest developments, highlighting OPOSSUM's current modelling capabilities as well as ongoing and future enhancements.

10:50–12:20 (1h 30m)

Relativistic Attosecond Sources from Intense Multi-colour Laser Pulses

Speaker

Cara McDonald

Description

The generation of coherent attosecond pulses of radiation in the extreme ultraviolet (XUV) range provides the required spatial and temporal resolution to study a wide range of phenomena involving fast electron dynamics. [1]

Single sub-femtosecond XUV pulses as well as near-PHz repetition rate trains of such pulses have been demonstrated from gas targets however these are far too weak for XUV-pump/probe spectroscopy to be fully implemented. [1]
Coherent high order harmonic X-ray generation can be achieved however through the interaction of an initially solid target with an ultra short, intense laser pulse to create a near discontinuous plasma–vacuum boundary. [2] The interaction of light with solid-density plasmas offers the opportunity to reach much higher attosecond pulse intensities and generation efficiencies.

Using a two colour field (fundamental frequency and second harmonic) has been demonstrated experimentally [3] and in simulations [4] to be a route to achieve an optimal high harmonic yield in laser-matter interactions. By tuning the relative phase between the two frequency components of the incident beam, the driving electric field waveform and the resultant electron motion can be controlled. Strong attosecond pulses are associated with sharp transitions in the driving electric field with potential generation efficiencies that are significantly higher than for a typical single colour laser.[4]

The effect of tuning the relative phase of the second colour on the resulting high harmonic spectral shape is studied for a range of parameters and the link between this and the plasma surface dynamics is investigated and discussed.

10:50–12:20 (1h 30m)

Simulation Studies of High-Charge Electron Generation in the Self-Modulated Laser Wakefield Acceleration Regime

Speaker

Victor Winter

Description

X-ray sources are of growing importance as a diagnostic tool for fundamental research in High Energy Density (HED) physics and Inertial Confinement Fusion (ICF) studies. These applications deploy so-called x-ray backlighters to probe the interior of the plasma, which should ideally have a low divergence, small source size, to achieve a sufficient imaging resolution, and high brightness to overcome x-ray self-emission from the plasma itself. X-ray sources from laser-driven electrons from the regime of self-modulated laser wakefield acceleration (SM-LWFA) show promising parameters to meet these requirements, which can be achieved by using gas targets and picosecond laser pulses.
To develop such an x-ray source for experiments at the GSI Helmholtzzentrum für Schwerionenforschung, first experiments were conducted in March 2025 using laser pulse durations of 500 fs and intensities up to 1.5e19 W/cm^2. As the gas density distribution plays a crucial role in electron acceleration, the helium profile was characterized using a Mach-Zehnder interferometer.
Based on the experimentally obtained parameters, PIC simulations were performed with WarpX to study electron charge and divergence and to compare the results with the experimental data. These simulations will be further extended to include betatron radiation using PIConGPU. Additionally, the influence of the target density distribution on achieving high charge and low divergence will be investigated by varying the density profiles and gradients.

10:50–12:20 (1h 30m)

Design of a Yb:CALGO regenerative Amplifier for the PHELIX Laser System

Speaker

Sebastian Schnell

Description

Modern high-intensity laser systems are required to provide higher repetition rate, greater stability and higher output energy with increased wall-plug efficiency. In recent years, diode pumping has become a central theme in the development of new laser systems. With narrowband emission and precise current control, laser diodes offer higher efficiency and more stable output than flashlamp-pumped solid-state lasers, making them an attractive choice. Novel laser gain media and advancements in laser diode technology set the stage for the development of these new amplifier systems [1, 2].
The Petawatt High-Energy Laser for Heavy Ion EXperiments (PHELIX) located at GSI Helmholtz Centre for Heavy Ion Research is actively exploring pathways for future capability upgrades, such as transitioning to diode-pumped architectures in the early amplification chain. Serving as the initial stage of the high-intensity beam line, the femtosecond frontend delivers a pre-amplified seed pulse in the mJ range. Currently, it relies on a Ti:Sapphire based ring regenerative amplifier, exploiting the ultra broadband emission up to the central wavelength of the Nd:Glass main-amplifier at 1053 nm [3, 4]. This gain medium, while effective, requires expensive, bulky, frequency doubled pump lasers and is unfeasible for diode pumping [5].
A promising material that allows both, diode pumping and emission in the relevant spectral range of PHELIX is $\mathrm{Yb}{:} \mathrm{CaGdAlO_4}$ (Yb:CALGO) [2]. It is worth noting that the choice of material for broadband emission at 1053 nm is quite limited. To the best of our knowledge, Yb:CALGO shows the best compromise, justifying the move towards an experimental demonstration. As a precursor to this, we numerically modeled the pumping and amplification processes for three distinct cavity layouts to evaluate the feasibility of a Yb:CALGO-based amplifier for PHELIX. Our results indicate that achieving 20 mJ output energy is feasible, satisfying the requirements to replace the current amplifier.
Here, we present the theoretical design and simulation of a Yb:CALGO regenerative amplifier proposed as the successor to the Ti:sapphire-based stage and discuss its output characteristics.

[1] M. F. Kling et al., Roadmap on basic research needs for laser technology, J. Opt., 27(1):013002 (2025), DOI: 10.1088/2040-8986/ad8458.
[2] H. Wang et al., Advances of Yb:CALGO Laser Crystals, Crystals, 11(9):1131 (2021), DOI: 10.3390/cryst11091131.
[3] Z. Major et al., High-energy laser facility PHELIX at GSI: latest advances and extended capabilities, High Power Laser Science and Engineering, 12:e39 (2024), DOI: 10.1017/hpl.2024.17.
[4] Y. Zobus, Design and implementation of a high-contrast, millijoule-level ultrafast optical parametric amplifier for high-intensity lasers, PhD thesis, Technische Universität Darmstadt (2023), DOI: 10.26083/tuprints-00024200.
[5] P. F. Moulton, A. R. Fry, and P. Fendel, Ti:sapphire: Material, Lasers and Amplifiers, in Handbook of Laser Technology and Applications, CRC Press (2021), DOI: 10.1201/9781003127130.

10:50–12:20 (1h 30m)

Recent Results of the Research of Underwater Electrical Explosion of Wires/Wires Arrays

Speaker
Yakov Krasik

Description

Experimental and numerical results regarding underwater electrical explosion of single wires, cylindrical and spherical wire arrays and strong shock waves generation will be presented. Application of this approach for studies of high energy density matter, supersonic water jet generation, shock generation in a target and will be discussed as well.

10:50–12:20 (1h 30m)

Ion stopping power experiments with the laser-driven LIGHT beam-line

Speaker
Marvin Fischer

Description

The Laser Ion Generation, Handling and Transport (LIGHT) beamline at GSI Helmholtzzentrum für Schwerionenforschung GmbH enables advanced phase-space manipulations of laser-generated ion beams. In recent years, the LIGHT collaboration has successfully generated and focused intense proton and ion bunches with sub-nanosecond durations, opening pathways to applications such as probing ion-stopping power in plasmas. This process of energy deposition in dense plasmas, essential for inertial confinement fusion, is particularly challenging in the velocity-matching regime (vi ≈ ve,th), where theoretical predictions diverge and experimental data remain scarce.
To provide high-resolution experimental insight, LIGHT has been developed to deliver ion bunches synchronized to the nanosecond-scale dynamics of laser-generated plasmas. Earlier studies achieved temporal compression of carbon ions (1.2 ns FWHM at 0.6 MeV/u) and protons (0.8 ns FWHM at 0.6 MeV), which were applied to cold target energy-loss measurements.
In 2025, the first experiment combining the LIGHT beamline with a laser-ignited plasma target was performed using C^{4+} ions at 0.6 MeV/u. A pulse compression down to 0.74 ns (FWHM) was achieved. These results will represent an important step toward systematic studies of ion-stopping power in plasmas at temporal resolutions previously inaccessible.

10:50–12:20 (1h 30m)

Adaptive Laser Architecture Development and INtegration (ALADIN) - Towards Inertial-Fusion Ready Beam Control

Speaker

Jonas Benjamin Ohland

Description

Achieving inertial fusion energy (IFE) requires laser systems capable of delivering hundreds of high-power, high-repetition-rate beams with exceptional stability. The ALADIN project (Adaptive Laser Architecture for Dynamic INertial fusion) addresses this challenge by developing adaptive laser control technologies that enable reliable, repeatable fuel compression in direct-drive IFE schemes. ALADIN focuses on three key objectives: (1) the integration and automation of adaptive laser architectures (ALA) to coordinate thousands of active components across large facilities through an open-source control framework; (2) the advancement of real-time adaptive optics and beamline control to ensure stable laser performance at 10 Hz operation; and (3) the expansion of spatiotemporal pulse-shaping capabilities to optimize fuel compression. By combining hardware innovation, control software development, and real-time diagnostics, ALADIN aims to raise the technology readiness of ALA systems and establish a long-term European competence network in laser stabilization for IFE.
On this poster, we present the goals, the structure and the status quo of ALADIN.

10:50–12:20 (1h 30m)

Nonequilibrium phonon dynamics after laser-excitation

Speaker

Christopher Seibel

Description

Electron-phonon coupling is a fundamental process governing the energy relaxation dynamics of solids excited by ultrashort laser pulses. While this coupling is often described in terms of an effective electron temperature, recent works have highlighted the important roles of both nonequilibrium electronic distributions and detailed phononic properties.

In this study, we investigate how nonequilibrium electron occupations, phonon stiffness, and wavenumber-resolved coupling collectively shape the energy exchange between electrons and the lattice in metals. We find that deviations from thermal electronic distributions can substantially modify the coupling parameter, challenging the conventional assumption that electron temperature alone determines the coupling strength. We further identify a roughly quadratic scaling of the coupling parameter with phonon stiffness, with high-wavenumber phonon modes consistently dominating the interaction. Finally, we demonstrate that this preferential coupling leads to the emergence of hot phonons near the Brillouin-zone boundary, which in turn induces a collapse of the overall energy transfer rate and significantly delays electron-phonon equilibration.

10:50–12:20 (1h 30m)

Target Development at ELI Beamlines - Two-Photon Polymerization

Speaker

Tibor Teplicky

Description

Advances in high-energy-density physics increasingly require well-defined, targets that can shape the interaction of intense laser and ion beams. Traditional target fabrication methods, particularly for low-density foams, often produce stochastic microstructures with limited control over geometry, uniformity, and feature size.
In this work, we demonstrate the use of two-photon polymerization (2PP) as a flexible and precise technique for producing engineered micro- and nano-structured targets designed specifically for high-intensity laser experiments. Using a 2PP system, we fabricated solid foam targets with controlled internal architecture. This additive-manufacturing approach enables deterministic structuring in three dimensions, allowing not only tailored fabrication of targets but also functional geometries such as coils for magnetic field generation and composite assemblies that cannot be reliably produced using conventional methods. The ability to tailor the internal foam morphology and integrate custom-designed features offers new opportunities to systematically influence plasma formation and evolution during laser matter interaction.
These results highlight the potential of 2PP as a versatile platform for next-generation target development in experiments employing high-power laser or ion beams. In this poster, we present our current 3D-printing capabilities and workflow from target design through 2PP fabrication and post-processing to alignment and irradiation with high-power lasers.

10:50–12:20 (1h 30m)

Studies of laser ablation of band-gap materials

Speaker

Markus Bonifer

Description

We aim to explore laser ablation as a possible approach for creating clean, well-defined microholes in polymers used for lase fusion targets where symmetry and control of surface roughness are important. Because polymers differ widely in their properties, general insights into laser–material interaction are sought through modeling of density-dependent excitation in band-gap materials.
The theoretical models used are based on the density-dependent two-temperature model (nTTM) and extended multiple rate equations (EMRE). These calculations are intended to guide experimental studies carried out in collaboration with Focused Energy to identify suitable processing conditions and improve overall feature quality.

10:50–12:20 (1h 30m)

Thermalization of optically excited Fermi systems: electron-electron collisions in solid metals

Speaker
Stephanie Roden

Description

Ultrafast optical excitation of metals induces a non-equilibrium energy distribution in the electronic system, with a characteristic step-structure determined by Pauli blocking. On a femtosecond timescale, electron-electron scattering drives the electrons towards a hot Fermi distribution.
In this work, we present a derivation of the full electron-electron Boltzmann collision integral within the random-k approximation. Building on this approach, we trace the temporal evolution of the electron energy distribution towards equilibrium, for an excited but strongly degenerate Fermi system. Furthermore, we examine to which extent the resulting dynamics can be captured by the numerically simpler relaxation time approach, applying a constant and an energy-dependent relaxation time derived from Fermi-liquid theory. We find a better agreement with the latter, while specific features caused by the balance of scattering and reoccupation can only be captured with a full collision integral.

12:20

17:00

Poster Session 2: Poster Session 2

Session | **Location:** Darmstädter Haus, Oberseitestr. 38 D- 87568 Hirschegg

17:00–18:30 (1h 30m)

Hybrid Modeling of Fast Electron Transport and EMP Generation in Nanosecond Laser-Target Interactions

Speaker
Jiří Löffelmann

Description

High-intensity laser interactions with solid targets generate powerful radiofrequency and microwave electromagnetic pulses (EMP) that scale with laser energy and intensity. The fundamental origins and underlying physical mechanisms of laser-induced EMP emission remain an unresolved challenge in high-energy-density physics, necessitating more sophisticated diagnostic and modeling approaches. These pulses are presumed to be created by large electrical currents that arise in the target during the interaction. In laser plasmas, electrical currents are carried mainly by fast electrons. This study employs a multi-physics hybrid framework to simulate laser-plasma interactions on a nanosecond timescale, aiming to bridge the gap between microscopic particle dynamics and macroscopic evolution. Firstly, the fast electron distribution is obtained using approximate theoretical relations for the current plasma state. Secondly, the fast electron transport is simulated via the Geant4 Monte Carlo toolkit. Finally, the ion motion is captured by the FLASH radiation-MHD code. This hybrid approach facilitates a deeper understanding of the time evolution of fast electron transport during laser-target interaction, which is crucial for understanding the origin of the intense EMP field. The numerical results are compared to the experimental measurements obtained at the Prague Asterix Laser System facility.

17:00–18:30 (1h 30m)

Active beamstabilization for JETi200 and TAF

Speaker
Alexander Sävert

Description

A new target area is set up at the Helmholtz Institute Jena. One central aspect are combined experiments with the laser systems JETi200 and POLARIS. Additionally, a new dedicated probe laser system, JETi ONE, was installed giving the opportunity to investigate laser-plasma interactions with few-cycle laser pulse ranging from the visible to the mid infrared spectrum. In a first step, we synchronized the oscillators with a temporal jitter below 20 fs. Now, the spatial overlap with a precision below 3 µrad is in focus. A combined approach using continuous online pointing measurement and predictive beam steering will be presented.

17:00–18:30 (1h 30m)

HED@FAIR - High Energy Density Science at FAIR

Speaker

Stephan Neff

Description

The Facility for Antiproton and Ion Research (FAIR) is currently under construction and will start operations with first nuclear physics experiments in 2027. FAIR will offer unique high-intensity heavy ion beams and proton beams that will also be used by the HED@FAIR collaboration for warm dense matter (WDM) experiments. Three main experimental setups will be used by HED@FAIR for experiments: Isochoric heating and expansion (HIHEX), laboratory planetary science (LAPLAS) and proton microscopy (PRIOR).

HIHEX and LAPLAS will be used for equation of state studies of WDM. In the case of HIHEX, mm^{3}-sized samples will be heated with heavy ion beams to eV temperatures, making it possible to study the properties of WDM near the critical point and phase boundaries. In the case of LAPLAS, heavy ion beams will be used to isentropically compress samples to Mbar pressures at sub-eV temperatures, conditions which are typical for many planetary interiors. In the case of PRIOR, high energy protons are used for imaging samples generated with secondary drivers, for example to study shock wave dynamics.

The HED@FAIR experiments will take place at a dedicated beamline in the APPA cave. The beamline setup is flexible and can be used with heavy ions (U^{28+}, up to 2.7 GeV/u, $5\cdot 10^{11}$ ions, 50 ns bunch) for the HIHEX, LAPLAS experiments and with protons (up to 10 GeV, $2.5\cdot 10^{13}$ protons/bunch) for PRIOR experiments.

A diagnostic laser will be used to drive x-ray diagnostics.We are also investigating the possibility to install a high-power laser facility next to the APPA cave, which would not only drive the x-ray diagnostics for HIHEX and LAPLAS, but could also be used for fusion science experiments, for example to study laser-plasma instabilities. Until the APPA cave becomes available, HED@FAIR experiments are being carried out at the existing GSI facilities at reduced beam intensities with beams from the SIS-18 synchrotron and the PHELIX laser.

17:00–18:30 (1h 30m)

In-situ X-ray analysis of diamond formation in dynamically compressed glassy carbon

Speaker

Björn Lindqvist

Description

The structure of liquid carbon[1] and the formation of nanodiamonds under dynamic compression[2, 3] sparked scientific interest. The extreme conditions required were generated for a few nanoseconds using the HED-HIBEF instrument at EuXFEL[4] by the DiPOLE-100X laser. Laser-induced shock compression was utilised to compress glassy carbon, reaching Mbar pressures. For probing, X-ray Thomson scattering (XRTS) in forward direction achieved a resolution of ~1 eV, sufficient to observe changes of the plasmon shift. This observable depends on the plasmon frequency and information about the band gap[5, 6]. Complementary diagnostics, including X-ray diffraction (XRD) and a velocity interferometer system of any reflector (VISAR), infer a compressed diamond density of ~3.8 $\frac{\text{g}}{\text{cm}^3}$. This provides constraints for future plasmon-shift analysis which could offer insight into the electronic structure of diamonds at Mbar pressures.

[1] Kraus, D. et. al. (2025). In. Nature 642. pp. 351-355.
[2] Kraus, D. et al. (2017). In: Nat. Astron. 1. pp. 606-611.
[3] He, Z. et al. (2022). In: Sci. Adv. 8. eabo0617.
[4] Zastrau, U. et. al. (2021). In: J. Synchr. Rad. 28. pp.1393-1416.
[5] Penn, D. R. (1962). In: Phys. Rev. 128, pp. 2093–2097.
[6] Gamboa, E. J. (2016). In: IAEA. SLAC-Report.

17:00–18:30 (1h 30m)

High-Repetition-Rate X-ray Diffraction of Shock-Compressed PET at the EuXFEL

Speaker

Jed Martin

Description

Dynamic compression of carbon-rich materials provides a pathway to nanodiamond formation [1-3] under extreme pressure–temperature conditions comparable to those of ice-giant interiors, where diamond precipitation has been proposed to influence planetary structure and evolution. Laser-driven shock experiments at x-ray free-electron lasers enable in situ, time-resolved characterisation of high-energy-density states. Such experiments are often limited by the need to accumulate large numbers of shots, particularly for photon-hungry techniques such as meV inelastic x-ray scattering. To address this limitation, the newly commissioned high-repetition-rate tape target system at the European X-ray Free-Electron Laser (EuXFEL) can be operated at $1~ \mathrm{Hz}$, enabling unprecedented data acquisition. Beyond fundamental studies, high-repetition-rate dynamic compression represents a critical step towards scalable nanodiamond production schemes.

Using this platform, we present results on the characterisation of the shocked state of polyethylene terephthalate (PET), a readily available and easy-to-handle carbon-rich planetary-ice analogue, compressed via single-shock laser drive. Simultaneous x-ray diffraction (XRD) and Doppler velocimetry (VISAR) diagnostics were employed to characterise atomic-scale structural changes alongside macroscopic shock properties on the same experimental shots. A method based on the Rankine–Hugoniot relations, together with PET Hugoniot data, was used to determine the bulk pressure, density, and temperature directly from the measured shock velocity. The results provide evidence for diamond formation at pressures on the order of $60\,\mathrm{GPa}$ and corresponding temperatures of a few thousand kelvin, potentially extending the diamond formation regime reported by He et al. [2].

References:
[1] Kraus, D. et al.: Formation of diamonds in laser-compressed hydrocarbons at planetary interior conditions, Nat. Astron. 1, 606–611 (2017).
[2] He, Z. et al.: Diamond formation kinetics in shock-compressed C–H–O samples recorded by small-angle X-ray scattering and X-ray diffraction, Sci. Adv. 8(35), eabo0617 (2022).
[3] Heuser, B.: Synthesis of Nanodiamonds via
Laser-Driven Shock Compression of Plastic
Precursors, PhD Thesis, University of Rostock (2025).

17:00–18:30 (1h 30m) **Damage Threshold Tests for Project FOR2783**

Speaker

Alperen Kozan

Description

The Breit-Wheeler pair production experiment, under the project FOR2783[1], requires laser operation near the damage threshold of the turning mirror. Due to the experiment's inherently low cross section, a high number of laser shots is essential. Consequently, the selection of the mirrors and the geometry must be optimized to maximize shot count without exceeding damage limits. To support this, a laser-induced damage threshold (LIDT) test was performed using the JETi200 laser system on candidate mirrors intended for use in the final setup.

[1] F. C. Salgado et al., New J. Phys. 23, 105002 (2021)

17:00–18:30 (1h 30m)

Spectral Shaping in Laser-Ion Acceleration by Multispecies Effects

Speaker

Sarah Jane Grimm

Description

Laser-accelerated ions typically exhibit an exponential energy spectrum up to a characteristic cut-off energy, which is a signature of target normal sheath acceleration (TNSA) [1]. This broad energy distribution inherent to TNSA poses a significant limitation for applications requiring well-defined ion energies, such as proton therapy [2] and the fast ignition concept in inertial confinement fusion [3].

By introducing multiple ion species into the target material, modulations in the TNSA-driven ion spectrum can be achieved. During the acceleration, the differing charge-to-mass ratios of these species can result in a separation in space and energy [4]. This enables enhanced control over the energy spectrum and particle numbers for the light as well as the heavy ions. Simulations indicate that energy transfer between species may contribute to these effects, further emphasizing the potential for precise control of both ion populations.

I will introduce the concept of laser-ion acceleration using multi-species targets, discuss the potential advantages of such target compositions based on results from multidimensional particle-in-cell (PIC) simulations, present the current status of target fabrication, and outline planned experiments to further investigate this approach.

[1] P. Mora, Phys. Rev. Lett. 90, 185002 (2003).
[2] V. Malka et al., Med. Phys., 31: 1587-1592 (2004).
[3] J.J. Honrubia et al., J. Phys.: Conf. Ser. 244 022038 (2010).
[4] V.T. Tikhonchuk et al., Plasma Phys. Control. Fusion 47 B869–B877 (2005).

17:00–18:30 (1h 30m)

Investigating the DC conductivity of compressed C-H and C-H-O mixtures using ultrafast terahertz pulses

Speaker

P. May

Description

Dynamically shock compressing plastics like polystyrene [PS, (C$_{8}$H$_{8}$)$_{\text{n}}$] or polyethylene terephthalate [PET, (C$_{10}$H$_{8}$O$_{4}$)$_{\text{n}}$] to Mbar pressures accesses a regime with peculiar phenomena, like carbon de-mixing and subsequent formation of diamond crystallites $^{[1,2]}$ or the predicted appearance of metallic hydrogen $^{[3]}$, that are expected to impact conductivity. An accurate understanding of DC conductivity for materials at warm dense matter conditions is widely relevant to planetary modelling $^{[4,5,6]}$ and inertial confinement fusion efforts $^{[5,7]}$. Previous studies used visible or x-ray probes, which measure the high-frequency response, and extrapolated to the DC value $^{[5,8,9]}$. This extrapolation is model-dependent and prone to inaccuracies $^{[5]}$. In contrast, THz spectroscopy directly probes the electrical conductivity without relying on models $^{[5]}$. THz pulses are sufficiently low frequency to measure DC-like transport properties, while still being short enough to act as an ultrafast probe $^{[5]}$. This work, carried out at the Jupiter Laser Facility at the Lawrence Livermore National Laboratory, uses THz spectroscopy to measure the electrical conductivity of shocked PS and PET. Paired with established Doppler velocimetry and the published equations of state for PS $^{[10]}$ and PET $^{[11]}$, various pressure-temperature states in and around the diamond formation region $^{[2]}$, as well as the proposed hydrogen insulator-to-metal transition region $^{[12]}$, were studied and resulting conductivities will be presented.

[1]: Kraus et al., Nat Astron 1, 606–611 (2017).
[2]: He et al., Sci. Adv. 8, eabo0617 (2022).
[3]: Kraus, et al., Phys. Rev. Research 5, L022023 (2023).
[4]: Helled et al., Philos Trans A Math Phys Eng Sci 378, 20190474 (2020).
[5]: Ofori-Okai et al., Phys. Plasmas 31, 042711 (2024).
[6]: French et al., ApJS 202, 5 (2012).
[7]: Lindl, Phys. Plasmas 2, 3933–4024 (1995).
[8]: Millot et al., Science 347, 418-420 (2015).
[9]: Sperling et al., Phys. Rev. Lett. 115, 115001 (2015).
[10]: Barrios et al., Phys. Plasmas 17, 056307 (2010).
[11]: Lütgert et al., Sci Rep 11, 12883 (2021).
[12]: McWilliams et al., Phys. Rev. Lett. 116, 255501 (2016).

17:00–18:30 (1h 30m)

Experimental Study of Shock Interaction with a Dense Obstacle embedded in Foam Target

Speaker

Leonard Maximilian Wegert

Description

Shock–cloud interactions are a fundamental process in astrophysics, governing whether interstellar clouds collapse to form stars or are disrupted and dispersed into the surrounding medium. Laboratory astrophysics experiments provide a controlled platform to investigate the complex hydrodynamics involved in these interactions. In a experiment at the LULI2000 laser facility, we generated a strong shock wave in a low-density plastic foam containing an embedded aluminum-oxide sphere, designed to represent a dense interstellar cloud embedded in the diffuse interstellar medium. Time-resolved, high-resolution X-ray radiography was employed to track the shock propagation and the subsequent deformation and destruction of the sphere. Experimental results are then quantitatively compared with radiation-hydrodynamic simulations performed with FLASH and discussed in the astrophysical context.

17:00–18:30 (1h 30m)

Update on the THRILL project: Towards High-Energy Lasers at High Repetition Rates

Speaker

Zsuzsanna Slattery-Major

Description

The EU-funded THRILL project (Technology for High-Repetition-Rate Intense Laser Laboratories) has the goal to identify the most appropriate architecture of the next generation high-energy (kJ-class) lasers to be used in combination with the large-scale European research facilities Eu-XFEL and FAIR. Here the increase of the repetition rate from few shots per day the one shot per few minutes would represent a game changer in the applications of this type of laser system in a number of research fields, such as the investigation of shock-driven warm-dense matter, dynamic compression of materials, or laboratory astrophysics.

While THRILL is entering its final year, we will review the progress within the project achieved by the consortium, in particular on the topics of actively cooled high-energy laser amplification, high-energy beam-quality-conserving beam transport and optical coatings for large optics. First considerations towards the concept of a high-energy laser at FAIR will also be discussed.

17:00–18:30 (1h 30m)

Plasma-Assisted Methane Decomposition for Hydrogen Production Using Micro Hollow Cathode and Dielectric Barrier Discharges

Speaker

Marcel Margraf

Description

Hydrogen is becoming an increasingly important energy carrier in the context of sustainable energy systems. Consequently, there is strong interest in developing methods for hydrogen production that are both environmentally benign and energy efficient. Established production routes either rely on fossil fuels with significant CO_2 emissions or suffer from comparatively low overall efficiencies.
One promising alternative is methane plasmalysis, in which methane is decomposed into hydrogen and solid carbon using a plasma. In previous work, methane plasmalysis using micro hollow cathode (MHC) discharges was investigated over a range of pressures, yielding promising peak energy efficiencies of up to approximately 9%.
Building on these results, the present work aims to further optimize hydrogen production using micro hollow cathodes and to extend the investigation to additional plasma sources. In particular, dielectric barrier discharge (DBD) plasmas and hollow cathode discharges at lower pressures are studied to enable a systematic comparison of different plasma configurations with respect to their suitability for efficient hydrogen generation.

17:00–18:30 (1h 30m)

Characterization of Electron, EMP and Ion Emission at the kilojoule Laser System PALS

Speaker

Jakub Cikhardt

Description

In this contribution, we present results from a long-term experimental study of electron, electromagnetic, and ion emission at the iodine laser system PALS (wavelength 1315 nm, pulse duration 0.3 ns, up to 700 J on target). Charged-particle emission was investigated using a comprehensive set of diagnostics, including magnetic spectrometers and differential absorption spectrometers deployed at multiple angles.
Electromagnetic pulse (EMP) emission was measured using an array of broadband B-dot and D-dot probes as well as horn antennas, with a bandwidth extending up to 18 GHz. The signals were recorded by a 33 GHz / 100 GSps oscilloscope via ultra-low-loss cables. The experiments were performed using both metallic foil targets and low-density foam targets. With a help of novel focusing and target positioning system, the focal effective area was minimized and relativistic on-target laser intensities were reached.
Using the above-mentioned diagnostics, we observed target polarization currents of up to 10 kA, escaping electrons with energies exceeding 9 MeV, proton energies up to 5 MeV, and EMP spectral components extending to 18 GHz at an on-target laser power of 2 TW.

18:30

18:40

Conference Board Meeting: Conference Board Meeting

Session | **Location:** Darmstädter Haus, Oberseitestr. 38 D- 87568 Hirschegg

19:30

Thursday 29 January

08:30

Session 8 - Astrophysics: Session 8 - Astrophysics

Session | **Location:** Darmstädter Haus, Oberseitestr. 38 D- 87568 Hirschegg | **Convener:** Paul Neumayer

08:30–09:00 (30m)

Direct Measurement of Hydrogen Opacity at Conditions Prevailing in the Interior of Small Stars

Speaker

Samuel Schumacher

Description

Understanding radiative energy transport in stellar interiors requires accurate knowledge of the opacity of dense hydrogen plasmas, yet direct experimental constraints in the relevant regime have been absent. We report measurements of hydrogen opacity at extreme densities—up to ~800× solid density—and temperatures of a few million kelvin, achieved through a tailored low-velocity capsule implosion at the National Ignition Facility. This approach produces conditions comparable to those in red dwarf stellar cores while suppressing background emission sufficiently to enable time-resolved X-ray radiography. By tracking X-ray transmission during stagnation, we extract the density evolution and opacity of the transient plasma. The measured opacities show significant deviations from commonly used stellar opacity models (e.g., OPLIB) and instead align with modern atomistic simulations such as average atom models. These results provide the first experimental benchmark of hydrogen opacity in the dense-plasma regime that dominates low-mass stellar interiors. Beyond astrophysics, the implosion design and diagnostics developed here are applicable to advanced concepts for inertial fusion energy, where accurate radiation transport models are likewise essential.

09:00–09:20 (20m)

The High Energy Density Initiative (HEDI) in Rostock

Speaker

Dominik Kraus

Description

States of extreme energy density – i.e., matter under high pressures and extremely high temperatures – are found in the interiors of planets (megabar pressures, several thousand kelvins) or stars (gigabar pressures, several million kelvins) and are highly relevant for the ultimate application of clean and reliable energy production by inertial fusion. A deep understanding of the complicated physical conditions along the compression path to inertial fusion plasmas and the dynamics on short timescales is essential for the eventual realization of an energy source based on this concept.

The physics of these extreme states is highly complex and the combined experimental and theoretical investigation of them has only recently been channeled into the new field of high energy density physics. The Helmholtz Association has initiated the development of world-leading research infrastructures to reproducibly create conditions of comparable energy density in a controlled laboratory environment and to enable highly precise in situ measurements of the microphysics in these exotic states of matter. One such initiative is the Helmholtz International Beamline for Extreme Fields (HIBEF) at the European XFEL, which was initiated and is operated by the Helmholtz-Zentrum Dresden-Rossendorf (HZDR) and has started to produce first breakthrough results.

To further establish and advance groundbreaking research with these unique capabilities in Germany, a university partnership within an interdisciplinary environment is required to efficiently utilize and develop the new facilities. Therefore, the HZDR together with the University of Rostock has established the High Energy Density Initiative (HEDI) as a Helmholtz Flagship Initiative and the State of Mecklenburg-Vorpommern has committed to finance the construction of a research building on the University of Rostock campus.

Based on a showcase of recent scientific results of the HEDI team, this presentation will discuss the planned research program of HEDI in the areas of theoretical and experimental high energy density physics and potential applications in the areas of inertial confinement fusion, astrophysics, planetary physics and materials science.

09:20–09:40 (20m)

Ultrafast multiscale response dynamics of materials under high energy density conditions

Speaker

Zhiyu He

Description

The investigation of equations of state, physical properties, and phase transitions of materials under extreme high-pressure conditions is a fundamental challenge in condensed matter physics and planetary science. Recent advancements in laser-driven compression techniques allow us to replicate these extreme states in laboratory settings, achieving terapascal (TPa) pressures, temperatures exceeding tens of thousands of Kelvin, and time scales from femtoseconds to microseconds. This capability provides a unique platform for exploring material properties under high-pressure and high-strain-rate conditions.
The rapid development of next-generation large-scale laser facilities and advanced X-ray sources, coupled with innovative diagnostic techniques, enhances our understanding of warm dense matter and has significant implications in fields such as astrophysics, inertial confinement fusion, national defense technology, and materials science. The integration of multi-scale (macro-meso-micro) in situ diagnostic techniques with multi-method detection is crucial for constructing a comprehensive understanding of matter under extreme conditions.
This report presents multi-scale diagnostic techniques based on laser-driven platforms and their applications in studying extreme warm dense matter. We have established precise measurement methods for key physical quantities like velocity, temperature, and pressure at the macroscopic scale. Mesoscopically, we achieved in situ characterization of microcrystal sizes and pore structures, while at the microscopic scale, we made strides in real-time detection of lattice structure evolution. By employing various loading methods—including shock loading, quasi-isentropic loading, and static-dynamic combined loading—we have advanced issues such as high-pressure equations of state, superionic water properties, and phase transition mechanisms of high-pressure carbon-based compounds. Furthermore, the report evaluates the feasibility of developing multiple in situ diagnostic techniques on large-scale laser facilities, offering a novel paradigm for analyzing physical processes under dynamic loading.
References:
[1] Zhiyu He#, Qili Zhang#, Haifeng Liu, et al., Physical Review B 103, 134107, 2021
[2] Zhiyu He, Melanie Rödel, J. Lütgert, et al., Science Advances, 8(35), 2022
[3] Zhiyu He, J. Lütgert, M. G. Stevenson, et al., High Power Laser Science and Engineering, 12, e46, 2024
[4] Zhiyu He, Xiuguang Huang, Hua Shu, et al., Chinese Journal of High Pressure Physics, 37(5), 2023

09:40–10:00 (20m)

Observation of stopping power suppression in non-linear ion-plasma coupling regime

Speaker

Yongtao Zhao

Description

Ion stopping in dense plasmas is fundamental for understanding the plasma transport properties with direct implications for inertial confinement fusion, high-energy-density physics and laboratory astrophysics. This process remains poorly understood when the ion-plasma coupling parameter exceeds unity - a nonlinear regime where non-perturbative screening play an important role. We report a controlled experimental study of stopping power in this nonlinear regime using laser-accelerated quasi-monoenergetic highly charged carbon ions near Bragg peak and a well-characterized dense plasma (Te = 17 eV, ne = 4×10^{20} cm^{-3}) target. Through simultaneously tracking the charge-state distributions and energies of ions traversing plasma, the prevailing stopping models are tested eliminating the uncertainties associated with the effective charge states predictions. All the perturbative models, including BPS, Li–Petrasso, Bethe, T-matrix, and Vlasov formulas, overestimate the measured energy loss. In contrast, classical molecular dynamics simulations, which can self-consistently capture the nonlinear screening effects, closely reproduce the data when augmented by a quantum-diffraction correction that suppresses the small-angle scattering. Our results demonstrate the failure of linear-response treatments under non-linear ion-plasma coupling regime and validate a hybrid framework of classical MD theory with quantum correction. This work established a platform to probe the complex collisional dynamics in plasma, offering insight into the accuracy of energy and particle flow models.

10:00

10:30

Session 9 - Short Pulse 2: Session 9 - Short Pulse 2

Session | **Location:** Darmstädter Haus, Oberseitestr. 38 D- 87568 Hirschegg | **Convener:** Stefan Karsch

10:30–11:00 (30m) **Relativistic harmonics in the efficiency limit**

Speaker

Colm Fitzpatrick

Description

Relativistic oscillating plasma mirrors provide a promising platform for generating bright high-harmonic radiation and, ultimately, extreme electromagnetic fields. Theory predicts that, under optimized conditions, these systems can strongly compress laser energy in space and time, forming a Coherent Harmonic Focus (CHF) with intensities orders of magnitude beyond those of the driving pulse. While previous experiments have demonstrated diffraction-limited harmonic emission and attosecond phase locking, efficiently coupling highly relativistic laser energy into the emitted harmonic cone has remained an outstanding challenge.

Here we present the first conclusive experimental evidence that this coupling can be optimized to reach the conversion efficiencies predicted by simulations. By precisely shaping the driving laser's temporal profile on femtosecond timescales, we obtain >9 mJ of harmonic energy between the 12th and 47th orders (18–73 eV). The measured harmonic yields follow the theoretically expected efficiency scaling with harmonic order, indicating that the underlying plasma dynamics have been tuned to optimal conditions.

These results complete the final missing step toward realizing CHF-level intensity boosts in the laboratory. Although simultaneous spatial and temporal compression at peak efficiency remains a challenge, this work establishes a clear pathway to generating optical field strengths approaching the quantum-electrodynamic critical field, opening new opportunities for all-optical studies of vacuum physics and extreme attosecond science.

11:00–11:20 (20m)

Experimental observation of anomalous instability-driven relativistic surface emission

Speaker

Robin Timmis

Description

Efficiency limit relativistic harmonic generation from solid targets (ROM) has recently been demonstrated experimentally. Multi-petawatt laser facilities will soon be able to harness this mechanism to generate intense coherent attosecond harmonic foci suitable for probing the quantum vacuum via fully optical means. However, experiment has demonstrated that efficiency scaling with harmonic order falls faster than ROM theory or 1D PIC simulations predict, a significant limitation for X-ray ROM applications. Simulations have revealed that this surprising deviation of XUV ROM harmonic generation efficiency is correlated with the emergence of a second anomalously propagating instability-driven harmonic beam. Here we show experimental evidence of this novel beam simultaneously with observation of the specularly emitted ROM beam, identify their qualitative differences and demonstrate that each mechanism can be finely controlled. In contrast with the ROM beam, the anomalous beam has a remarkably shallow efficiency scaling making it a promising candidate for water-window harmonic generation and biological imaging, while its strongly modulated lower orders could yield new information on the plasma conditions at the interaction region.

11:20–11:40 (20m)

Impact of Near-time Contrast on Coherent Synchrotron Emission from Thin Foils

Speaker

Mark Yeung

Description

Precise control over the temporal profile of the incident laser radiation in ultra-relativistic plasma interactions is crucial for many applications. While the effects of laser contrast on longer timescales have been studied and methods of control are well known, here we investigate the impact of the rising edge within a few picoseconds of the peak intensity of the pulse. As laser powers enter the multi-petawatt regime, contrast ratios of even 10^{-4} on the leading shoulder will be at relativistic intensities and can have a significant impact on the plasma conditions.
Here we present an experimental study of the generation of coherent, attosecond scale extreme ultraviolet (XUV) radiation from short dense bunches of electrons generated during interactions with thin foils. This Coherent Synchrotron Emission [1,2] is observed in the transmitted direction as high order harmonics in the spectral domain. Here, they serve as a witness to the evolving plasma conditions as the few-ps contrast is varied on the 80J, 500fs TRIDENT laser. A single-shot frequency resolved optical gating (FROG) diagnostic [3] recorded the pulse shape corresponding to each measured XUV spectrum. Particle-in-cell simulations link the observed degradation in the harmonic structure and efficiency to the impact of the pulse shoulder on the plasma surface conditions.

1. B. Dromey et al. Nature Physics, 8, 804 (2012)
2. D. an der Brügge and A. Pukhov, Physics of Plasmas 17, 033110 (2010)
3. S. Palaniyappan et al. Review of Scientific Instruments, 81, 10 (2010)

11:40–12:00 (20m)

Vacuum Birefringence Measurements Using the Dark-Field Concept at the European XFEL

Speaker

Aimé Matheron

Description

Quantum field theory predicts that the vacuum exhibits a nonlinear response to strong electromagnetic fields, giving rise to phenomena such as vacuum birefringence. Despite its fundamental significance, this effect has remained experimentally inaccessible and has yet to be observed in the laboratory. Detecting it would provide a distinct signature of the optical activity of the quantum vacuum and enable a precision test of nonlinear quantum electrodynamics in an unexplored regime.

A central difficulty in such experiments is isolating the weak signal from the photon background of the probe beam. In the strong-field region created by a tightly focused IR pump pulse, the X-ray probe acquires a tiny vacuum-induced polarization rotation and an angular deflection. Conventional approaches rely on ultra-high-contrast polarimetry to suppress the background and reveal the signal.

We introduce here the dark-field concept, a promising alternative that creates a controlled shadow in the probe’s near field, enabling a clean angular separation between the vacuum-induced signal and the background. We report on recent experimental campaigns at the European XFEL’s High Energy Density (HED) instrument, where this technique was implemented using the X-ray beam as the probe and the ReLaX IR laser as the pump. The dark-field configuration reduced the background by roughly 15 orders of magnitude. This design not only increases the sensitivity of the measurement, but also gives access to both the polarization-flipped and non-flipped components of the probe, enabling a direct determination of the fundamental QED parameters that can be confronted with theoretical predictions. We present an overview of the setup, the experimental results from the last campaings, the expected measurable signal for the upcoming campaign, and the current status of the advanced simulation framework that models both the vacuum birefringent signal and its background.

12:00

17:00

Session 10 - Inertial Confinement Fusion 3: Session 10 - Inertial Confinement Fusion 3

Session | **Location:** Darmstädter Haus, Oberseitestr. 38 D- 87568 Hirschegg | **Convener:** Javier Honrubia

17:00–17:30 (30m)

Investigation of Broadband-laser-induced Plasma Interaction and ablation properties

Speaker

Peipei Wang

Description

Inertial Confinement Fusion (ICF) is one of the critical technical approaches to achieving controlled fusion energy. The successful achievement of ignition at the National Ignition Facility (NIF) has further confirmed the technical feasibility of ICF. However, although the ignition has been achieved, research into higher gains and lower driving conditions remains an important next step. Laser plasma interaction (LPI) and laser ablation properties are the key issues in laser-driven inertial confinement fusion ignition (ICF), as it may affect target compression and fusion energy gain. Broadband laser technology is one novel option that may inhibit the related processes of LPI and thus enhance the absorption efficiency.
One broadband double-frequency laser facility (named as Kunwu) with an output energy of hundreds of joules (532nm, Δω/ω: 0.6%, 700J) by using the superluminescent diode (SLD) technology has now been built by the researchers from Shanghai Institute of Laser Plasma. Based on kunwu facility, several preliminary experiments into broadband-laser-driven laser plasma instabilities were carried out by our group. Through direct comparison with the LPI results for the traditional narrowband laser, the actual LPI-suppression effect of the broadband laser was shown. The former work shows that broadband laser had a clear suppression effect on both the back-stimulated Raman scattering and the back-stimulated Brillouin scattering at laser intensities below 1 ×1015 Wcm-2. Furthermore, The results also show that the target coupling absorption efficiency of broadband laser is higher than that of narrowband laser.
In a follow-up experiment, we observed a new phenomenon. We tested the laser transmission energy with target of different thickness driven by broadband laser or narrowband laser. we've found that it has significantly higher transmission energy for the target driven by broadband laser than narrowband laser. Also, it can be clearly seen that the broadband laser burns through targets faster.
The plasma generated and coupled by laser incident on target can be such important. As it directly determines the efficiency and quality of the energy conversion. Higher transmission energy may indicate less energy loss during the laser interact with the plasma corona of the imploding capsule. Furthermore, tn our experiment, the ablation pressure of aluminum was also measured under narrowband and broadband laser condition. The results show that, compared with traditional narrowband laser, broadband laser effectively enhanced the ablation pressure.
Thus, this interesting and valuable experimental phenomenon may have influence on the fundamental understanding of the related processes of laser plasma interaction of novel broadband low- coherence laser facility.

17:30–17:50 (20m)

Experimentally modulated laser plasma instabilities by using low coherence lasers

Speaker

Christoph Kanstein

Description

In the interaction of ns laser pulses with plasma, a large amount of highly energetic electrons stems from laser plasma instabilities (LPIs). These describe the scattering of a large percentage of laser photons on ion acoustic or electron plasma waves, with unbound electrons being accelerated in the resulting fields of the latter.
By adjusting the incident laser light, LPIs can be modulated to fit the intended application. Increasing the spectral bandwidth is a newly studied approach to do so without adjusting its overall temporal and spatial profile. From theoretical studies, an appreciable effect is expected for a FWHM of $\Delta\lambda/\lambda \approx 1\%$, with lower coherence length denying LPI the time to fully develop [1,2]. But due to the complexity of realistic laser systems and plasmas, such as the interaction between different types of LPI [3], careful experimental studies are required to fully resolve all effects in play. So far, the number of studies is limited due to the small number of laser systems equipped with the necessary broadband capabilities. The PHELIX laser is one of them, newly capable of providing tunable bandwidths up to about 0.5%.
We present a study of LPI with 2-ns laser pulses at a central wavelength of 527 nm, including comparison of different types of LPI under monochromatic and broad-bandwidth laser conditions at PHELIX [4]. With the latter, two plasmon decay and stimulated Brillouin scattering were reduced in back- and side-scatter directions, but side stimulated Raman scattering was strongly increased. In conjunction, the number and temperature of “hot” electrons and of the x-ray photons they produce was increased. This is in agreement with experiments performed at the other operational high-bandwidth laser facility [5]. Going forward, this discrepancy between expected and observed modulation of LPI should be investigated by more detailed analysis of on-shot plasma conditions and of the focal region of the laser pulse.

17:50–18:10 (20m)

Heavy Ion Fusion: Ready for Reassessment?

Speaker

Gennady Shvets

Description

Research activities on heavy-ion fusion (HIF) were abandoned over a decade ago, and brought down to a crawl even earlier. It is easy to forget that in the 90's HIF was considered to be the top contender for developing inertial fusion energy (IFE). This is not surprising: accelerator technology is well-established, and the conversion efficiency from a wall plug to accelerated particles is hard to match, especially at the repetition rates required for IFE powerplants. Moreover, unlike most laser fusion schemes, HIF does not require any damageable optics. One of the often-cited reasons for abandoning HIF is its non-modular nature: testing even the most basic IFE components requires multi-km long induction accelerators. Compact high-gradient collective ion acceleration has the potential for drastic reduction of the driver size -- an important step towards modularity and compactness. I will describe the historical context for such schemes and describe the latest efforts in my group to improve them. In addition to driving future fusion power-plants, compact ion accelerators have many other exciting applications that I will describe. Those range from promising carbon ion radiation therapy in the short-bunch (FLASH) regime to testing space-bound electronics for deleterious effects from impinging high-energy ions.

18:10–18:30 (20m)

Probabilistic Model of Laser Drive Asymmetries for an IFE Reactor design

Speaker

Alfonso Mateo

Description

In the pursuit of the realization of an Inertial Fusion Energy (IFE) reactor, directly driving the fuel capsules with laser beams is a compelling design choice due to the more efficient energy coupling compared to indirect drive. However, the laser illumination symmetry necessary for achieving ignition and gain imposes stringent accuracy requirements on the laser system.
We present a reactor beam port configuration derived from the charged particle repulsion heuristic from [1]. Multiple beams per port are used to dynamically shift power between different beam spot sizes as the capsule implodes, reducing the laser light blowby while maintaining a uniform illumination. A probabilistic model has been developed to directly propagate the laser drive modes from stochastic system errors (target injection, beam pointing and power imbalance) without the need for Monte Carlo simulations. This model constitutes a useful tool for the broad optimization of the laser beam geometrical configuration of future facilities.
[1] M. Murakami and D. Nishi, “Optimization of laser illumination configuration for directly driven inertial confinement fusion”. Matter and Radiation at Extremes **2**, 2 (2017).

18:30

Friday 30 January

08:30

Session 11 - Short Pulse 3: Session 11 - Short Pulse 3

Session | **Location:** Darmstädter Haus, Oberseitestr. 38 D- 87568 Hirschegg | **Convener:** Alexander Pukhov

08:30–09:00 (30m)

Control of Laser Contrast for Harmonic Generation from Relativistic Plasma Surfaces

Speaker

Jordan Young

Description

High power laser systems driving relativistic plasmas have applications in the generation of high energy, short duration particle and photon secondary sources. These mechanisms are typically extremely sensitive to laser contrast - pre-pulses and amplified spontaneous emission (ASE) that can trigger an expanding plasma long before the peak intensity is reached. As we enter the multi-petawatt regime, the requirements on laser contrast will become more stringent as peak intensity rises.

One commonly used method of improving a laser's contrast is using plasma mirrors. These optical systems take advantage of the fast switch on time of an initially transparent medium as it is turned to plasma by the intense laser pulse itself. This has the effect that any light impinging before the peak of the pulse will not be reflected and is removed prior to the main interaction. Using a chain of two such optics, Double Plasma Mirror (DPM) systems have been effectively demonstrated to improve the contrast of laser pulses by 4-5 orders of magnitude, well before the rising edge at a few picoseconds before the peak of the pulse [1,2]. However, the impact very close to the peak as the intensity rises rapidly is less clear despite these timescales still being very impactful on the final plasma conditions.

Surface high harmonic generation (SHHG) from overdense plasmas is one application of high-power lasers that is extremely sensitive to laser pulse contrast [3]. Not only is SHHG a powerful source of extreme ultraviolet (XUV) and attosecond duration radiation, but it can also provide an effective benchmark of laser pulse contrast. Here we present characterisations of a DPM system currently in operation on the Gemini laser and its impact on the observed SHHG signal when a controlled pre-pulse is added. Furthermore, we discuss planned developments on the JETI-200 laser and the expected performance for SHHG experiments.

[1] A. Lévy et al., "Double plasma mirror for ultrahigh temporal contrast ultraintense laser pulses," Optics Letters, vol. 32, no. 3, p. 310, Jan. 2007, doi: https://doi.org/10.1364/ol.32.000310.
[2] I. W. Choi et al., "Highly efficient double plasma mirror producing ultrahigh-contrast multi-petawatt laser pulses," Optics Letters, vol. 45, no. 23, pp. 6342–6342, Oct. 2020, doi: https://doi.org/10.1364/ol.409749.
[3] S. Kahaly et al., "Direct Observation of Density-Gradient Effects in Harmonic Generation from Plasma Mirrors," Physical review letters, vol. 110, no. 17, Apr. 2013, doi: https://doi.org/10.1103/physrevlett.110.175001

09:00–09:20 (20m)

Single-event fast neutron time-of-flight spectrometry with a petawatt-laser-driven neutron source

Speaker

Karl Zeil

Description

Fast neutron-induced nuclear reactions are crucial for advancing our understanding of fundamental nuclear processes, stellar nucleosynthesis, and applications, including reactor safety, medical isotope production, and materials research. As many research reactors are being phased out, compact accelerator-based neutron sources are becoming increasingly important. Laser-driven neutron sources (LDNSs) offer unique advantages: ultrashort neutron pulses providing superior energy resolution, high flux per pulse, and a drastically reduced footprint. While single-event neutron spectroscopy has been demonstrated with epithermal neutrons, its application to fast neutron spectrometry is more challenging and remains unproven. This capability demands stable multi-shot operation and detectors resilient to the extreme environment of petawatt-class laser-plasma interactions. Here, a proof-of-concept experiment at the DRACO PW laser in a pitcher-catcher configuration is presented. This setup stably produced ≈108 neutrons/shot with energies above 1MeV, sustained over more than 200 shots delivered at a shot-per-minute rate. Neutron time-of-flight measurements were performed using a single-crystal diamond detector positioned at 1.5m from the source, capable of resolving individual neutron-induced reactions. Observed reaction rates are consistent with Monte Carlo simulations informed by real-time diagnostics of accompanying gamma, ion, and electron fluxes. With recent advances in repetition rate, targetry, and ion acceleration efficiency, this work establishes LDNSs as a promising, scalable platform for future fast neutron-induced reaction studies, particularly those involving short-lived isotopes or requiring a high instantaneous neutron flux.

09:20–09:40 (20m)

Simultaneous high-efficiency and high-energy proton acceleration via a dual-pulse micronozzle scheme

Speaker

Diya Pan

Description

Institute of Laser Engineering, Osaka University, Suita, Osaka 565-0871, Japan

Laser-driven proton acceleration has long been limited by an apparent trade-off between laser-to-ion conversion efficiency and maximum particle energy. While target-normal-sheath acceleration (TNSA) remains robust, it typically suffers from low efficiency and thermal-like spectra at the multi-MeV level. Here we propose and numerically demonstrate a dual-pulse micronozzle acceleration (DP--MNA) scheme that decouples source generation from accelerating-field formation and thereby substantially relaxes this longstanding constraint at intensities around $10^{21}\,\mathrm{W\,cm^{-2}}$.

In DP--MNA, a structured target comprising a hydrogen rod (source) inside an aluminum nozzle (field generator) is driven by a precisely timed dual-pulse sequence. Two-dimensional particle-in-cell simulations (EPOCH) show that a tightly focused prepulse acts as an injector, extracting a compact proton bunch and seeding return currents, while a delayed main pulse drives a long-lived (hundreds of femtoseconds), gigavolt-per-meter axial electric field in the nozzle cavity. By tuning the delay into a robust synchronization window ($\Delta t \approx 0\text{--}40\,\mathrm{fs}$), the proton front becomes spatiotemporally ``phase-locked'' to the advected cavity field, forming a directed acceleration channel that suppresses transverse electron loss compared with unconfined targets.

Within this regime, the DP--MNA scheme sustains laser-to-proton conversion efficiencies exceeding 15% (peaking near 20%) while simultaneously maintaining cutoff energies above $0.5\,\mathrm{GeV}$ (up to $\approx 0.8\,\mathrm{GeV}$) for $\sim 100\,\mathrm{fs}$ pulses. These results identify source--field synchronization and geometric confinement as powerful design principles for compact, potentially high-repetition-rate proton sources for high-energy-density applications, including neutron generation, fusion-relevant target driving, and nuclear photonics at next-generation laser facilities.

09:40–10:00 (20m)

Optimization and results of proton induced 238U fission at CALA

Speaker

Maximilian Julius Weiser

Description

With the goal of investigating the creation of extremely neutron rich isotopes around the waiting point of the rapid neutron capture process (r-process) at N=126, Habs et al. [1] proposed the so-called fission-fusion reaction mechanism. This mechanism exploits the inherently nearly solid-state bunch density of laser ion accelerated ions, resulting high cross-sections for the creation of exotic nuclei close to the magic neutron number N=126.

One necessary prerequisite for the realization of the fission-fusion reaction mechanism is gaining a better understanding how laser accelerated protons induce fission in a high-Z material, e.g., Uranium-238. For this purpose, we implemented, based on the previous designs at other facilities [2,3], a gas-based fission-fragment transportation system and developed an aerosol transport system for the transfer of non-volatile fission products generated by irradiating Uranium-238 targets with laser accelerated protons ca. 15 meter away from the EMP-contaminated target area to a well-shielded HPGe detector for y spectroscopy.

In our latest experimental campaigns conducted at the Centre for Advanced Laser Applications (CALA) using the ATLAS-3000 laser system (central wavelength 800 nm, pulse length 25 fs, energy per pulse <60 J) we successfully detected volatile and non-volatile fission products employing our transportation system. Currently, we are focusing on improving the yield of the generated fission products by varying parameters such as laser energy and transport medium.

Funded by the BMFTR under Grant No. 05P24WM2. We acknowledge the GSI target lab (Dr. Bettina Lommel) for providing the Uranium targets.

[1] D. Habs et al., Appl. Phys. B 103, 471-484 (2011)
[2] P. Boller et al., Sci. Rep. 10, 17183 (2020)
[3] J. Burggraf et al., Nuc. Inst. 1053, 168369 (2023)

10:00

10:30

Session 12 - Warm Dense Matter: Session 12 - Warm Dense Matter

Session | **Location:** Darmstädter Haus, Oberseitestr. 38 D- 87568 Hirschegg | **Convener:** Stephan Neff

10:30–11:00 (30m)

PRIOR-II – The first proton and heavy-ion particle radiography facility for probing ultra-fast ns-scale HED physics and beyond

Speaker

Martin Schanz

Description

Magnetic lens-based proton radiography is a unique and powerful diagnostics technique capable of resolving ultra-fast processes on the ns-scale in dense matter with unprecedented micrometer spatial resolution.
Recently, the PRIOR-II proton radiography facility has been designed, constructed and commissioned at the GSI Helmholtz Centre for Heavy Ion Research, pushing the technical boundaries of charged particle radiography with normal conducting magnets to the limits [1]. It is specifically designed for imaging ultra-fast processes in dense matter with up to 4.5 GeV protons from the SIS-18 synchrotron, its primary use case is the diagnostics of ultra-fast shock-wave experiments for HED fundamental physics applications or materials science.
PRIOR-II has the unique capability of imaging using heavier ions (tested with up to 975MeV/u 12C6+ and up to 1.5GeV/u 14N7+) which led to improvements of the underlying scattering theory used for radiographic density reconstruction. Furthermore, experiments can benefit from heavy ions due to an increased areal density contrast compared to proton imaging.
The PRIOR-II facility is currently undergoing a transition to enable HE driven HED physics and material science experiments on shock compressed matter at extreme densities above 100 GPa and to serve as a new user facility to the HED community. With the certification of key components completed, efforts are focusing on developing HE-driven planar shockwave generators to enable the first set of experiments in early 2027. These experiments will study shock compaction as an approach to large-scale,
high-pressure material synthesis, as well as planetary defense applications. The facility is also suited for characterizing new functional materials for use as first contact barriers in magnetic confinement fusion reactors, as well as for EOS measurements of
inhomogeneous and porous matter under extreme conditions.

[1] M. Schanz, D. Varentsov, et. al.; Design and commissioning of the PRIOR-II “proton microscope for FAIR”. Rev. Sci. Instrum. 1 December 2024; 95 (12): 123704. https://doi.org/10.1063/5.0220086

11:00–11:20 (20m)

High-precision measurement of the K-edge shift in heavy-ion heated aluminum

Speaker

Philipp Hesselbach

Description

The HHT experiment area at GSI offers the unique capability to heat matter by intense bunches of high-energy heavy-ions from the SIS-18 heavy-ion synchrotron and to probe the generated short-lived states with X-rays created by the PHELIX laser facility. Focusing ~300-ns-long bunches of up to 4×10^9 U^{73+} ions down to sub-millimeter spot-sizes, aluminum samples were heated to around $1700\,\text{K}$. We detected X-ray absorption spectra around the K-edge ($1560\,\text{eV}$) under these conditions.

High-precision measurements of the K-edge shift were achieved using characteristic emission lines of the X-ray backlighter for on-shot spectral calibration of the X-ray absorption near edge structure. The extracted red shifts, on the order of $0.2\,\text{eV}$ at $1700\,\text{K}$, are compared with predictions from density-functional-theory molecular dynamics (DFT-MD) simulations. The hydrodynamic evolution of the target was investigated by 2D simulations with the code BIG2, to account for the thermal expansion during the heating phase. The DFT-MD results reveal a competition between the reduction of the Fermi energy in the conduction band and the lowering of the 1s binding energy (indicating stronger binding) upon heating.

In this contribution, we present the experimental setup combining heavy-ion heating with laser-driven X-ray diagnostics, discuss the measured K-edge shifts in aluminum, and compare the results with DFT-MD predictions. Finally, we give an outlook on future absorption spectroscopy studies on heavy-ion heated iron which will provide complementary diagnostics to previous X-ray diffraction studies on the phase transition and melting dynamics. The demonstrated techniques are directly applicable to experiments at the future FAIR facility, where unprecedented ion beam intensities will enable studies of continuum lowering at warm-dense-matter conditions.

11:20–11:40 (20m)

A platform for observing phase-transitions and measuring temperature of ion-heated samples

Speaker

Julian Lütgert

Description

The graphitization-threshold of diamond is of significant interest for nanodiamond synthesis from laser-shocked plastics, for particle detectors, and for the application in diamond anvil cells.
We report on experiments conducted at the HHT facility (GSI), in which a monocrystalline diamond target was volumetrically heated using a uranium ion beam. The PHELIX laser enabled measurements of X-ray Thomson scattering (XRTS) and X-ray diffraction (XRD) from the heated sample.

By comparison to density functional theory molecular dynamics simulations, the increase of diffuse elastic scattering can be leveraged to asses the sample's bulk temperature. We show that this method provides good agreement with the expected heating up to $\sim 2000\mathrm{K}$. Above this threshold, a rapid increase in the elastic scattering intensity is observed, which cannot be attributed to increased lattice movement alone. Instead, the data suggest a fundamental change in the target's integrity. Although macroscopic fracture is clearly evident, we argue that it is not sufficient to account for the observed signal. Rather, a thermally driven graphitization process provides the best explanation for the measurement.

Building on these findings, we outline the next steps in the experimental campaign, substituting the carbon targets by silicon. As heating is increased for comparable ion numbers while the temperature of the phase transition is reduced, we do not rely on the Bragg peak for triggering the phase transition, resulting in a more homogeneous probing area. This allows constraining temperature not only by XRTS, but also from the thermal expansion visible in the spatially resolved XRD. By varying probing time and heating, we seek to obtain insight into the super-heating dynamics of the material.

11:40–12:00 (20m)

Investigating the onset of carbon K-shell ionization from imploding CH and HDC capsules measured at the National Ignition Facility

Speaker

Johannes Rips

Description

Accurately determining the ionization state of warm dense carbon is critical for predictive modeling in high-energy-density physics, particularly for inertial confinement fusion experiments and for advancing the understanding of astrophysical systems such as white dwarf envelopes [1,2]. However, obtaining direct measurements under the relevant extreme conditions remains challenging. To address this, X-ray Thomson scattering (XRTS) provides a powerful diagnostic capable of simultaneously characterizing temperature, density, and ionization state in warm dense matter [3-6]. Here, we report the current status of analyzing XRTS spectra from imploding CH and HDC capsule experiments at the National Ignition Facility (NIF). Utilizing the capsule implosion platform in 120-degree backscatter geometry, this work enables in situ probing of the carbon K-shell ionization state and inferring prevailing plasma conditions during the dynamic implosion. In the probed regime of 0.1 Gbar to 1 Gbar in pressure and up to 100 eV in temperature, our results show significantly higher carbon ionization compared to state-of-the-art ionization models and simulations

[1] A. Kritcher et al., Nature **584**, 51–54 (2020).
[2] O. A. Hurricane et al., Nature **506**, 343–348 (2014).
[3] S. Glenzer & R. Redmer RMP **81**,1625 (2009).
[4] T. Döppner et al., Nature **618**, 270–275 (2023).
[5] T. Dornheim et al., Phys. Plasmas **30**, 032705 (2023).
[6] D. Kraus et al., Phys. Rev. E **94**, 011202 (2016).

12:00