P 19: Poster II

Time: Thursday 16:00–17:30 Location: P

P 19.1 Thu 16:00 P

Validation of quasilinear transport models in the ASTRA framework — •Michael Bergmann, Rainer Fischer, Pedro Molina Cabrera, Klara Höfler, Frank Jenko, and The ASDEX Upgrade Team — Max-Planck-Institute für Plasmaphysik, Boltzmannstr. 2, 85748 Garching

By combining multiple heating and transport subroutines ASTRA is capable of simulating realistic temperature and density radial profiles of fusion plasmas. While these profiles match experimental data taken from e.g. the Integrated Data Analysis (IDA) code, the simulated gradients often differ from measured ones and are largely dependent on the turbulence subroutine chosen. The interest in correct plasma gradients is particularly high as these give rise to the turbulence which dominates the transport. Using two quasi-linear turbulence solvers (TGLF and Qualikiz) as well as their much faster neural-network versions we shall explore the validity and uncertainty of the models in different discharge scenarios via input-error propagation, as well as comparing the models to high-fidelity codes such as GENE and experimental measurements. This work feeds back into attempts of using ASTRA simulations as a theoretical prior for IDA, where the prior of the simulated profile is needed.

P 19.2 Thu 16:00 P

The Disruptive H-Mode Density Limit and MARFE Behaviour — •Felix Klossek, Anja Gude, Marc Maraschek, Bernhard Sieglin, Matthias Bernert, Hartmut Zohm, and the ASDEX Upgrade Team — Max-Planck-Institut für Plasmaphysik, Garching, Germany

The high confinement mode (H-mode) is an operational regime in tokamaks with suppressed turbulence near the edge, so that particles and energy are confined better. High densities, which are desirable in terms of fusion power, are prone to a density limit: a degradation of confinement and subsequent disruption.

When approaching a density limit disruption, a Multifaceted Asymmetric Radiation From the Edge (MARFE) forms as toroidal ring. It is strongly radiating and is therefore altering the power balance in the plasma and reducing the temperature in its vicinity. During the MARFE evolution, this effect becomes more pronounced. The MARFE starts near the X point, where it is also called X point radiator (XPR). It will subsequently move up on the high field side near the separatrix and stay some time at the top of the plasma, before approaching the low field side, entering the core and triggering MHD instabilities which finally lead to the disruption.

The MARFE position can be reconstructed using measurements from bolometer pinhole cameras. A robust and fast approach based on angular probability distributions for each camera is presented.

P 19.3 Thu 16:00 P

GPU Offloading of the Gyrokinetic Turbulence Code GENE-X — •Jordy Trilaksono[1], Dominik Michels[1], Andreas Stegmeir[1], and Frank Jenko[1,2] — [1]Max Planck Institute for Plasma Physics, Boltzmannstraße 2, 85748 Garching, Germany — [2]University of Texas at Austin, Austin, TX 78712, USA

Turbulence in magnetic confinement fusion devices is a non-linear phenomenon which involves multi-scale and multi-physics modeling. Simulating turbulence requires a large number of computing resources exploited in parallel which is provided by modern supercomputers. The recently developed gyrokinetic turbulence code `GENE-X` [1] extends the typical coverage of gyrokinetic turbulence simulations from the core to the edge and scrape-off layer of magnetic confinement fusion devices. Currently, `GENE-X` uses a heterogenous parallelization featuring OpenMP for intranode and MPI for internode parallelism respectively. To enable simulations of the edge and scrape-off layer of reactor relevant fusion devices, like ITER, the scalability of `GENE-X` needs to be improved. Therefore, we present progress towards GPU offloading in `GENE-X` in this work. This includes improving the current offloading approach of `GENE-X` by implementing a separate C++ layer to the code using modern Fortran's C interoperability and CUDA.

[1] D. Michels, et. al., Comput. Phys. Commun. 264, 107986 (2021)

P 19.4 Thu 16:00 P

Application of the Gyrokinetic Turbulence Code GENE-X on TCV — •Philipp Ulbl[1], Dominik Michels[1], and Frank Jenko[1,2] — [1]Max Planck Institute for Plasma Physics, Boltzmannstraße 2, 85748 Garching, Germany — [2]University of Texas at Austin, Austin, TX 78712, USA

Turbulence in the edge and scrape-off layer (SOL) of magnetic confinement fusion devices is a complicated phenomenon whose understanding remains a central task on the way to optimized fusion reactors. Recent progress along these lines has been made with the development of the novel gyrokinetic turbulence code `GENE-X` [1]. In this work, we apply `GENE-X` to the validation case "TCV-X21" [2], studying the evolution of plasma profiles such as density, electron- and ion temperature. Further we compare the results to collisional simulations assessing the effect of collisions on edge and SOL turbulence.

[1] D. Michels, et. al., Comput. Phys. Commun. 264, 107986 (2021)
[2] D. S. Oliveira, T. Body, et. al., arXiv:2109.01618 (2021)

P 19.5 Thu 16:00 P

Predictive simulations of Runaway Electron deconfinement by a helical coil — •Nina Schwarz, Javier Artola, Konsta Särkimäki, and Matthias Hölzl — Max Planck Institute for Plasma Physics, Boltzmannstrasse 2, 85748 Garching - Germany

Future tokamak fusion power plants are designed as high plasma current devices which comes with the risk of generating fast electrons during disruptions. Due to an avalanche mechanism a small seed can create so called Runaway Electrons (RE), which can carry more than 50% of the plasma current. The surrounding structures can be damaged seriously when the vertically unstable RE beam comes into contact with the wall. Current avoidance or mitigation concepts are based on active techniques like the injection of deuterium for plasma dilution. A passive mitigation system has been proposed consisting of a passive coil, in which current is induced during a current quench (CQ), that in turn generates a helical perturbation in the plasma. This triggers magnetic islands that grow and overlap and thus create a region of enhanced radial transport. When a large part of the plasma is stochastic, the complete formation of an RE beam can be mitigated or even be fully prevented. We show here a possible coil geometry based on the SPARC concept [1] in the ASDEX Upgrade configuration. The induction efficiency of the coil is investigated for different CQ times and the vacuum perturbation by different geometries are shown. Finally, 3D non-linear simulations of a disruption with the extended MHD code JOREK are presented with a fully self-consistent inclusion of the passive coil. [1] R.A. Tinguely et al 2021 Nucl. Fusion 61 124003

P 19.6 Thu 16:00 P

Analytical investigation of heat conduction of plasmas in a magnetic field with an island — •Gregor Pechstein and Per Helander — Max-Planck-Institut für Plasmaphysik, Wendelsteinstraße 1, 17491 Greifswald

In a hot plasma that is magnetically confined in a fusion device, heat is transported across flux–surfaces towards the plasma vessel. In the W7-X stellarator, the plasma edge consists of a magnetic island chain. The magnetic islands function as Scrape–Off Layer (SOL), directing the plasma to a divertor. Radiative cooling through collisions with impurities such as carbon can play an important role in reducing the heat loads on the plasma-facing components.

We investigate a heat conduction equation with a loss term describing radiation in and around a magnetic island. The full 2D heat conduction problem can be reduced to a 1D description in the limit of large parallel heat conduction. We focus our investigation on understanding heat transport in three regions: the island center (the “O-point”), the seperatrix, and the region far away from the island. Far away from the magnetic island, the heat conduction given by our model reduces to the perpendicular heat conduction across flux surfaces without an island. The effective heat conduction coefficient reaches a maximum at the seperatrix. The influence of this heat conduction coefficient on the position of the radiation front is also discussed.

P 19.7 Thu 16:00 P

Investigation of spontaneous transitions to high core-electron temperatures in W7-X low-iota plasmas — •Juan Fernando Guerrero Arnaiz[1,2], Andreas Dinklage[1,2], Axel Könies[2], Carolin Nührenberg[2], Bernd Pompe[1], Alessandro

Zocco[2], Matthias Hirsch[2], Udo Höfel[2], Christian Brandt[2], Joachim Geiger[2], Kian Rahbarnia[2], Jonathan Schilling[2], John Schmitt[3], Henning Thomsen[2], and the W7-X Team[2] — [1]Universität Greifswald, Greifswald Germany — [2]Max-Planck-Institut für Plasmaphysik, Greifswald Germany — [3]Auburn University

Spontaneous transitions to higher core-electron temperatures preserving the electron pressure were detected in the so-called low-iota configuration of W7-X. Data mining employing a large data set at different heating powers and densities was conducted. Permutation Entropy as a fast and robust novelty detection method was used to characterize the conditions for the occurrence of a core-localized spatio-temporal bifurcation. To investigate the transition mechanism in more detail, highly sampled electron cyclotron emission and soft-X ray data reveal low-coherent fluctuations which disappeared when higher electron temperatures were attained. First analysis of the effects due to the evolving bootstrap current indicates a change of the rotational transform (iota) profile temporarily crossing low-order rational values. The same neoclassical analysis indicates that a transition into the stellarator-specific core electron-root confinement regime would be consistent with the observed increase of the central electron temperature. The role of rational iota values is being assessed in MHD stability studies.

P 19.8 Thu 16:00 P

Modeling the beam emission Balmer-α spectrum in neutral beam heated plasmas at Wendelstein 7-X — •Sebastian Bannmann, Oliver Ford, Udo Höfel, and Robert Wolf — Max-Planck-Institut für Plasmaphysik, Greifswald, DE

The optimized stellarator Wendelstein 7-X (W7-X) is equipped with a neutral beam injection (NBI) system. Knowledge about the particle and heat deposition of the beam in NBI shots is essential for further plasma physics analysis. The deposition depends on the beam and plasma parameters and information can be provided by measuring the Balmer-α light emitted by excited beam and halo particles. As the whole spectrum is too complex to be unambiguously fitted, a modular Bayesian inference network called Minerva is used. This requires implementing a detailed forward model with which one can infer beam and plasma parameters from the measured spectra. Existing modeling tools deploy Monte-Carlo techniques which is not feasible to use in combination with a Bayesian inference framework. The presented work describes the implementation of an analytical neutral beam and halo model. The possibility of inferring ion temperature profiles from the halo Balmer-α emission and density profiles from the halo and beam emission is investigated.

P 19.9 Thu 16:00 P

Optimizing quasi-isodynamic stellarators — •Alan Goodman, Rogerio Jorge, Per Helander, and Sophia Henneberg — Max-Planck-Institut für Plasmaphysik, Wendelsteinstraße 1, 17491 Greifswald

Stellarators are a class of plasma confinement devices that, if designed properly, may be viable nuclear fusion reactors. The W7-X stellarator's successes indicate that stellarators designed to be "quasi-isodynamic" (QI) — which, amongst other things, have minimal plasma boostrap currents — may be a viable path forward for future stellarators. QI configurations have contours of constant magnetic field strength wrapping around the device poloidally (the short way around) with a special symmetry.

Experimental measurements from the W7-X and HSX stellarators have shown that optimization methods are powerful tools in finding configurations with desirable properties. W7-X's optimized QI configuration has proven effective in confining particles trapped in magnetic wells (which is essential for a viable fusion reactor), but further improvements are now possible.

Unfortunately, optimized QI configurations tend to have unintended undesirable properties, such as large elongations and high mirror ratios, so care must be taken to limit these values. We present several objective measures which have shown promise in generating optimized QI stellarators and the results thereof.

P 19.10 Thu 16:00 P

ECRH in early plasma formation — •Albert Johansson and Pavel Aleynikov — Max-Planck-Institut für Plasmaphysik, Wendelsteinstraße 1, 17491 Greifswald

Electron Cyclotron Resonant Heating (ECRH) is important for the operation of current and future fusion devices, and is the main plasma heating mechanism in the Wendelstein 7-X (W7-X) stellarator. Although ECRH at high plasma temperatures and densities is routinely used in experiments and understood theoretically, a complete theoretical description of ECRH at the early stages of plasma formation (breakdown) has yet to be derived. Among the critical questions is the possibility of using higher–harmonics during startup in W7-X and effect of the ECRH-assisted startup in ITER.

In current work we seek to determine the minimum microwave beam power necessary to achieve breakdown, i.e., plasma formation, in conditions similar to the W7-X stellarator. We aim to accurately describe the cyclotron–wave interaction in the early stages of plasma formation, including both beam parameters and magnetic field structure.

Here, a fully relativistic integratable Hamiltonian system for an obliquely propagating beam in a much larger homogeneous magnetic field is derived. It is used to find the non–linear particle trajectories, and thus their energy gain, for various beam parameters.

P 19.11 Thu 16:00 P

Model for collisional transport of impurities in tokamaks and the combined impact of rotation and collisionality — •Daniel Fajardo[1], Clemente Angioni[1], Francis Casson[2], Anthony Field[2], Patrick Maget[3], Pierre Manas[3], and JET Contributors[4] — [1]Max-Planck-Institut für Plasmaphysik, Garching, Germany — [2]UKAEA/CCFE, Abingdon, United Kingdom — [3]CEA/IRFM, Saint Paul-lez-Durance, France — [4]See author list of [E. Joffrin et al. 2019 Nucl. Fusion 59 112021]

The collisional transport of impurities in tokamak plasmas can be dominant over the turbulent transport, particularly for heavy impurities like tungsten (W). An analytical model for the Pfirsch-Schlüter (PS) and Banana-Plateau (BP) components of the neoclassical impurity flux has been developed. It is accurate with respect to the drift-kinetic solver NEO across a broad collisional parameter space and reproduces well the profiles of the transport coefficients with experimental ASDEX Upgrade and predicted ITER profiles. The model includes the impact of rotation on the PS transport only. The impact of rotation on the BP transport, relevant at low collisionalities, has received limited consideration so far. The combined effects of rotation, collisionality and trapped particle fraction are analyzed with NEO. It is found that at sufficiently low collisionality and high Mach number an operational window opens where the temperature screening of impurities is enhanced. It is shown that recent experiments at JET have managed to enter this regime. An analytical description of this effect, in particular for the BP flux, is developed for fast integrated modelling applications.

P 19.12 Thu 16:00 P

Analysis of ITER instabilities for a reduced transport model development — •Virgil-Alin Popa, Philipp Lauber, and Thomas Hayward-Schneider — Max Planck Institute for Plasma Physics, Garching, Germany

Previous work has suggested that Alfven Eigenmodes (AEs) such as the Toroidal AEs (TAEs) can be partially unstable in ITER: energetic particles (EPs), such as fusion-born alpha-particles or neutral beam ions are energetic enough to resonantly interact with these weakly damped plasma waves. Due to the sensitivity of the AEs* properties on the background kinetic profiles, an automated analysis method is required to study their stability that does not rely upon prior knowledge of the linear mode spectrum, as is the case for most reduced models for EP transport. In view of this, the first automated time-dependent workflow for energetic particle stability analysis was created. This is used as a main tool for various linear stability analysis. An ITER Deuterium-Tritium scenario given by a transport code (METIS) was investigated. From the analysis, one can determine the dependance of the instabilities on the background profiles and the alpha particle population, as needed for profile optimisation or reduced transport models.

P 19.13 Thu 16:00 P

Experimental impurity transport analysis for tokamak regimes without type-I ELMs — •Tabea Gleiter[1,2], Ralph Dux[1], Marco Cavedon[3], Rachael McDermott[1], Francesco Sciortino[1], Ulrike Plank[1], and the ASDEX Upgrade Team[1] — [1]Max-Planck-Institut für Plasmaphysik, Garching, Germany — [2]Physik-Department E28, Technische Universität München, Garching, Germany — [3]Dipartimento di Fisica "G. Occhialini", Università di Milano-Bicocca, Milano, Italy

A profound knowledge of the transport of impurities is inevitable when it comes to designing tokamak reactor scenarios. In particular, it is necessary to integrate sufficient radiative cooling by impurities near the plasma edge with small impurity concentrations in the core.

High confinement regimes with no or little ELM activity (QCE or EDA H-mode) are promising candidates for future reactor operation. Information about their impurity transport mechanisms is therefore of large interest. In the focus is specifically the pedestal region since an edge transport barrier provokes suppressed turbulence and neoclassical inward transport in the inter-ELM phases of the standard H-mode. However, as no impurity accumulation is observed in the QCE and EDA-H modes despite their negligible ELM activity, a modification of the transport in this area is expected.

In this contribution, first results from transport studies in such ELM-free regimes at ASDEX Upgrade are presented. We show the inverse inference of radially and temporally resolved diffusion and convection from charge exchange recombination spectroscopy (CXRS) data.

P 19.14 Thu 16:00 P

Microstructural evolution of a tungsten heavy alloy during extended heat-treatments — •Philipp Sand and Armin Manhard — Max-Planck-Institute for Plasma Physik, 85748 Garching, Germany

Tungsten heavy alloy (97W-2Ni-1Fe, %wt.) is a possible candidate as plasma-facing material in future nuclear fusion devices. It exhibits a similar heat conductance at high temperature and sputter yield as pure tungsten, whilst showing an improved ductility [1] and hydrogen retention behaviour [2]. These improved properties can be attributed to its heterogenous microstructure, in which, as a consequence of the manufacturer's liquid phase sintering process, tungsten grains are embedded in a perturbating matrix of nickel and iron. In fusion devices as well as in materials testing experiments (e.g. permeation experiments) elevated temperatures for extended times might lead to grain growth or formation of intermetallic phases. Since the grain structure and tungsten-matrix interface constitution can affect the hydrogen transport, the permeation and retention behaviour might change during long-term annealing. A systematic heat treatment study has been performed with a conventional tungsten heavy alloy. Additionally, two-dimensional model systems consisting of Fe-Ni layers on W foils with identical composition where investigated to deepen the understanding of the tungsten-matrix interface. Microstructural changes are tracked with scanning electron microscopy and ion beam analysis. [1] R. Neu, et al., Fusion Eng. Des. 124 (2017) 450-454 [2] H. Maier, et al., J. Nucl. Mater 18 (2019) 245-259

P 19.15 Thu 16:00 P

Off-axis confinement and pulse stacking in a multi-cell Penning-Malmberg trap — •Martin Singer[1,4], James R. Danielson[2], Matthew R. Stoneking[3], Lutz Schweikhard[4], and Thomas Sunn Pedersen[1,4] — [1]Max-Planck Institute for Plasma Physics, 17491 Greifswald, Germany — [2]University of California, San Diego, La Jolla, California 92093, USA — [3]Lawrence University, Appleton, Wisconsin 54911, USA — [4]University of Greifswald, 17489 Greifswald, Germany

For the operation of a multi-cell Penning-Malmberg trap (MCT) the transfer to the storage-cells and consistent stacking of pulses is an essential step. This becomes increasingly complex when many pulses needs to be added in each storage-cell to reach large particle numbers and high plasma space charges, and when the small diameter storage-cells are radially displaced with respect to the large diameter master-cell. If the plasma is displaced off-axis and expanded over both cells, its motion is dominated by competing diocotron drifts. Also, the transfer and pulse stacking into the off-axis cell can lead to halo formation and the loss of particles. Since the APEX collaboration aims to create and study the first magnetically confined, low energy pair plasma, the MCT is a crucial tool on the way to accumulate up to 10^{11} positrons with low heating and particle loss. We will present our new MCT and measurements where we already achieved the transfer and confinement in two off-axis cells simultaneously. This MCT will be used to address open questions such as concerning plasma transfer and stacking as well as off-axis ejection.

P 19.16 Thu 16:00 P

Experimental helium exhaust studies in the full-W ASDEX Upgrade — •Antonello Zito[1,2], Athina Kappatou[1], Marco Wischmeier[1], Volker Rohde[1], Edward Hinson[3], Oliver Schmitz[3], Marco Cavedon[4,1], Rachael McDermott[1], Ralph Dux[1], Michael Griener[1], Arne Kallenbach[1], Ulrich Stroth[1,2], and the ASDEX Upgrade team[1] — [1]Max-Planck-Institut für Plasmaphysik, Garching, Germany — [2]Physik-Department E28, Technische Universität München, Garching, Germany — [3]University of Wisconsin-Madison, USA — [4]Dipartimento di Fisica G. Occhialini, Università di Milano-Bicocca, Milano, Italy

An efficient removal of helium ash by active pumping in future fusion devices is mandatory, in order to avoid fuel dilution and not degrade confinement properties. Helium exhaust in reactor-relevant edge and divertor scenarios has been experimentally investigated at the ASDEX Upgrade tokamak. A small amount of helium was injected during otherwise steady-state deuterium plasma discharges, and the time evolution of the resulting helium content was measured in the plasma and in the exhaust gas. The dynamics of the helium decay following the injection was characterized in several different scenarios and interpreted by means of simple analytic models. In attached H-modes plasmas, the helium pumping efficiency was found to greatly improve with increasing divertor neutral pressures. This was shown to be mainly driven by a more efficient divertor retention of helium at higher pressures. On the other hand, an exhaust degradation was qualitatively observed with the divertor entering a detached regime in L-mode.

P 19.17 Thu 16:00 P

Ion mass ratio impact on the collisional closure in the SOLPS-ITER Scrape-off layer simulations — •Sergei Makarov[1], David Coster[1], and Vladimir Rozhansky[2] — [1]Max-Planck-Institut für Plasmaphysik, D-85748 Garching, Germany — [2]Peter the Great St.Petersburg Polytechnic University, 195251, St.Petersburg, Russia

Impurity transport in the Scrape-off layer of a tokamak is an important and challenging problem. For instance, noble gasses are seeded into the tokamak for additional radiation and divertor target protection. When the impurity mass is significantly larger than the mass of the main ions the multispecies extension of the single ion Braginskii approach can be applied. However, usually impurity/main ion mass ratio can not be assumed infinitely large, and the Grad-Zhdanov 21N-moment method should be used for the transport coefficients estimation. This approach takes into account realistic masses of ions are present in the plasma for coefficients calculation. It is the major improvement in comparison to the previous approach applied for the SOLPS-ITER code. New approach is implemented into the SOLPS-ITER code for multiple ion parallel transport description in collisional plasmas. Previously, the sufficient change in the impurity transport is found when the realistic mass ratio between different ion species is taken into account. Here we explore the origin of this impact. The mass ratio between different species is artificially increased in the collisional terms calculation. The improved approach turns into the standard SOLPS-ITER model, for artificially increased mass ratio.

P 19.18 Thu 16:00 P

Analysis of nonlinear dynamics of shear Alfven waves driven by energetic trapped particles — •farah atour — IPP Garching

In controlled fusion devices, shear-Alfven waves can be driven unstable by resonant interactions with energetic alpha particles. This results in many issues regarding the confinement of the particles and therefore can prevent thermalisation of the plasma core or increase the thermal load on the material's wall. The source of these particles is either from the nuclear fusion reaction produced by the background plasma and/or external heating systems. Due to the importance of these issues, there exists extensive literature on this topic. These studies mostly focus on the nonlinear dynamics of passing particles since they have more significant impacts. However, the nonlinear dynamics of shear-Alfven waves driven by energetic trapped particles deserves also depth analysis and will be the focus of this study. The overall goal of this work is to investigate on a deeper level the fundamental physics processes regarding both the linear stability properties and the nonlinear saturation mechanisms for a single and multi modes. For this reason, to keep the context of dynamical study simplified, these phenomena are investigated by HMGC code, which has a simple circular geometry and is based on the hybrid reduced MHD gyrokinetic model.

P 19.19 Thu 16:00 P

Non-local neoclassical PIC simulations for the self-consistent radial electric field in stellarators. — •Michał Kuczyński, Ralf Kleiber, and Håkan Smith — Wendelsteinstraße 1, 17491 Greifswald, Germany

Transport in fusion plasma devices can be classified as either turbulent or neoclassical. Since turbulent transport is predominantly ambipolar, the radial electric field that arises ensures ambipolarity of the neoclassical part of the transport. This fact allows us to perform neoclassical particle-in-cell (PIC) simulations to calculate the electric field self-consistently. We introduce non-linear and non-local terms into the equations of motion in order to investigate ion and electron root transitions.

P 19.20 Thu 16:00 P

Optimal Quasi-isodynamic Stellarator Magnetic Equilibria Using a Direct Construction Approach — •Katia Camacho Mata, Gabriel Plunk, Michael Drevlak, and Per Helander — Max-Planck-Institut für Plasmaphysik, Greifswald, Germany

Two important requirements for a viable stellarator reactor are easy-to-build-coils and good confinement. Omnigenous configurations, traditionally found through numerical optimization, fulfil the good confinement properties requirement but tend to need complex coils to be realised. However, it is unknown whether such complexity is fundamentally necessary.

To explore this question, we use a method developed for the direct construction of omnigenous MHD (Magnetohydrodynamic) equilibria [1], numerically, at first order from the magnetic axis. It avoids the computational cost of conventional optimization and allows a thorough survey of the space of omnigenous stellarators at large aspect ratio.

Omnigenous magnetic fields are necessarily non-analytical and can only be physically realised by a smooth approximation. In previous works this condition was met by introducing regions where omnigeneity was abandoned. A different approach, employing a smoother approximation, and higher number of field periods is analysed in this work aiming to identify configurations that can be realised with easy-to-build coils.

[1]Plunk, G. G., et. al. (2019). Direct construction of optimized stellarator shapes. Part 3. Omnigenity near the magnetic axis. Journal of Plasma Physics, 85(6).

P 19.21 Thu 16:00 P

Towards Simulations of Deuterium Shattered Pellet injection into an MHD active ITER plasma — •Fabian Wieschollek[1], Matthias Hoelzl[1], Eric Nardon[2], and The JOREK Team[3] — [1]Max Planck Institute for Plasma Physics, Boltzmannstr. 2, 85748 Garching b. M., Germany — [2]CEA, IRFM, F-13108 Saint-Paul-lez-Durance, France — [3]See the author list of M. Hoelzl et al 2021 NF 61, 065001

The foreseen disruption mitigation strategy for ITER is shattered pellet injection (SPI). In a realistic disruption scenario, the SPI is being triggered, when the plasma has already become MHD active; in particular 2/1 neoclassical tearing modes (NTM) are often present.

Previous theoretical studies on an ASDEX Upgrade equilibrium have shown, that a large pre-existing NTM may influence the thermal quench (TQ) significantly. According to these studies, the injection into the O-point delays TQ, while it occurs considerably earlier with X-point injection. Results indicate that pre-existing islands do not render the mitigation ineffective.

To further verify these findings, the studies are now being extended to an ITER L-mode plasma, into which Deuterium SPI is launched. Scans will be performed of the initial island width, the number of atoms injected, and the relative injection phase with respect to the island O-point and the concentration of background impurities. Also, different shard velocitiy distributions are considered. We are presenting here the detailed research plans, as well as the first preliminary results.

P 19.22 Thu 16:00 P

Validating soft X-ray tomograms via modeling of perturbative events — •Christian Brandt[1], Henning Thomsen[1], Charlotte Büschel[2], Edith V. Hausten[2], Jonathan Schilling[1], René Bussiahn[1], and and the W7-X Team[1] — [1]Max-Planck-Institute for Plasma Physics, Greifswald, Germany — [2]University Greifswald, Germany

The hot core of a fusion plasma is invisible in the visual part of the spectrum but it radiates strongly in the X-ray range. A soft X-ray (SX) tomography system detects the spatiotemporal structure of the core plasma in a poloidal cross-section at the stellarator experiment Wendelstein 7-X. Depending on the presence of localized structures on top of the background X-ray radiation profile, such as injected impurity pellets, injected cryogenic hydrogen pellets or MHD mode structures, the poloidal cross-sectional SX emissivity can be substantially structured. The validity of the tomograms obtained by tomographic inversion with respect to the real topology of the SX emissivity is benchmarked by forward calculations of different modeled perturbation scenarios (e.g. symmetric vs. asymmetric 2-D emissivity, local blobs, mode structures). More parameters sensitively influencing the quality of the tomographic inversion are investigated, i.e. the signal-to-noise ratio and the amplitude calibration.

P 19.23 Thu 16:00 P

Characterization and driving mechanisms of dominant Alfvén eigenmodes at the Wendelstein 7-X Stellarator — •S. Vaz Mendes, K. Rahbarnia, C. Slaby, H. Thomsen, J. Schilling, C. Brandt, M. Borchardt, R. Kleiber, A. Könies, and Wendelstein 7-X Team — Max-Planck-Institute for Plasma Physics, Wendelsteinstr. 1, 17491 Greifswald, Germany

Alfvén waves are often present in different scenarios of the Wendelstein 7-X stellarator plasmas. Magnetic fluctuations were observed during 727 discharges with different magnetic configurations, heating scenarios and variations of further plasma parameters. The measurements were performed using a system of 41 Mirnov coils, located in half-module 11 of W7-X. The correlation of the observed Alfvénic activity with different plasma parameters is investigated. With increasing heating power the fluctuation bands in the frequency spectra (between 100-450kHz) and associated mode spectra become broader with poloidal mode numbers $\|m\| \leq 5$. In addition, the overall amplitudes of the different Alfvénic fluctuations in this range increases with higher plasma energy. To better understand the conditions for enhanced Alfvénic activity at W7-X possible driving mechanisms are discussed. A possible candidate is plasma turbulence. Magnetic fluctuation levels are compared to turbulent activity, observed for e.g. in density fluctuations.

P 19.24 Thu 16:00 P

Assessment of NII line ratio method for analysis of nitrogen enrichment in the W7-X divertor — •F. Henke, M. Krychowiak, R. König, F. Reimold, D. Gradic, and T. Sunn Pedersen — Max Planck Institute for Plasma Physics, Wendelsteinstr. 1, 17491 Greifswald, Germany

Impurities are of great importance in fusion plasmas. At the plasma edge, their radiation provide an advantageous cooling and dissipation, whereas they can negatively impact the energy confinement and dilute the fusion fuel in the plasma core already at small concentrations. Because the divertor of Wendelstein 7-X consists of graphite, the intrinsic impurity carbon is utilized as the main radiator. As tritium retention rules out carbon for the choice of wall material in a future reactor, seeded gases will be crucial for successful divertor operation.
In order to study the impurity screening capabilities of the divertor of Wendelstein 7-X, we analyse nitrogen seeding experiments via a NII line ratio model in the plasma edge and Charge Exchange Recombination Spectroscopy (CXRS) in the plasma core with the goal of estimating an enrichment coefficient of nitrogen in the divertor $c_{N,divertor}/c_{N,core}$.
Due to the complexity of the W7-X divertor plasmas and geometry, the passive NII line ratio model is subject to considerable uncertainties. The assessment of this method as well as possible model and diagnostics upgrades for its application in future experiment campaigns are discussed in this work.

P 19.25 Thu 16:00 P

Determination of 2D Filament Temperatures and Densities at ASDEX Upgrade with the Thermal Helium Beam Diagnostic — •Daniel Wendler[1,2], Michael Griener[1], Gregor Birkenmeier[1,2], Rainer Fischer[1], Ralph Dux[1], Elisabeth Wolfrum[1], Ulrich Stroth[1,2], and the ASDEX Upgrade team[1] — [1]Max-Planck- Institut für Plasmaphysik, Garching, Germany — [2]Physik Department E28, TUM, Garching, Germany

In all plasma scenarios in magnetic confinement fusion, small filamentary structures appear in the scrape-off layer (SOL), called blobs, with a locally strongly enhanced density which propagate convectively outwards. Blobs contribute to reactor relevant phenomena like the density shoulder formation, large first wall particle and power fluxes close to the density limit and the broadening of the divertor heat flux fall-off length. To calculate the effective power flux which is carried by the filaments, temperature and density as well as the frequency and velocity of filaments have to be determined. While the measurements of mean filament velocities are routinely made with various diagnostics, the simultaneous non-invasive measurement of temperatures and densities of single filaments is now possible with the thermal helium beam diagnostic at ASDEX Upgrade. By means of a grid of 2D distributed lines of sight, the temperature, density and velocities as well as the filament shape can be determined in two dimensions. A dedicated numerical approach based on a collisional-radiative model for the determination of blob temperatures and densities is presented and first measurements of temperatures and densities of blobs in two dimensions are presented.

P 19.26 Thu 16:00 P

Simulations of the O-X mode conversion in MAST-U — •Alf Köhn-Seemann[1], Bengt E. Eliasson[2], Simon J. Freethy[3], Lucy A. Holland[4], Roddy G.L. Vann[4], and David Woodward[2] — [1]IGVP, University of Stuttgart, Germany — [2]SUP, Department of Physics, University of Strathclyde, Glasgow, U.K. — [3]Culham Centre for Fusion Energy, Culham, U.K. — [4]York Plasma Institute, York, U.K.

Coupling microwaves to plasmas where the density exceeds the cut-off density can be achieved by electron Bernstein waves (EBWs). These are electrostatic waves that have no high-density cut-off and are very well absorbed at the electron cyclotron resonance and its harmonics. In addition, EBWs can drive very efficiently toroidal net currents, which is of particular importance in spherical tokamaks like MAST-U.

EBWs can be excited via a two step mode conversion process: an injected O-mode couples to an X-mode at the O-mode cut-off which then propagates outwards again and can couple to EBWs in the vicinity of the upper-hybrid resonance. The overall efficiency is strongly dominated by the O-X conversion. In this work, we present simulations of the O-X coupling process in the MAST-U geometry. Different codes have been used and benchmarked against each other. The dependence on plasma scenarios, beam geometry and plasma density fluctuations were investigated in detail. High conversion efficiencies on the order of 90 % were found making this an attractive heating scheme for MAST-U.

P 19.27 Thu 16:00 P

Causality analysis between turbulent phenomena across the separatrix at the TJ-K stellarator. — •Nicolas Dumérat, Bernhard Schmid, and Mirko Ramisch — IGVP, University of Stuttgart

The use of convergent cross-mapping (CCM) as a causality inference technique has proven its capacity for unveiling causal coupling between two variables measured in the same dynamical system. CCM describes a measure of how well the mapping - from a small region within a multidimensional phase space reconstruction in one variable (from time-delay embedding) - compares to the actual representation of the second variable in its reconstructed phase space.

Thus, CCM allows for the identification of causal links and direction of influence between variables and is extended to the study of plasma turbulence. In this frame, the causal relationship between various turbulent phenomena across the confinement region of the stellarator TJ-K is studied. The causal dependencies between blob generation and the zonal-flow - drift-wave system are investigated through Langmuir probe measurements. Using conditional averaging and bandwidth filtering, different spatial and temporal scales can be isolated and studied individually, allowing for fine causality analysis.

P 19.28 Thu 16:00 P

Investigation of synergistic effects of irradiation damage, hydrogen retention and mechanical loading on tungsten — •Alexander Feichtmayer[1,2], Bailey Curzadd[1,2], Sebastian Estermann[1,2], Maximilian Fuhr[1,2], Till Höschen[1], Robert Lürbke[1,3], Johann Riesch[1], Thomas Schwarz-Selinger[1], Dominik Viebke[1,2], and Rudolf Neu[1,2] — [1]Max-Planck-Institut für Plasmaphysik, 85741 Garching, Germany — [2]Technische Universität München, 85741 Garching, Germany — [3]RWTH Aachen University, 52062 Aachen, Germany

One of the major challenges in the realization of a nuclear fusion power plant such as DEMO is the development of suitable materials for the highly loaded plasma-facing components. The main candidate for the armor inside a future fusion reactor is tungsten. It has a high melting point, low erosion rate and low hydrogen retention, but it is brittle below 500-600 K and irradiation causes further embrittlement.

Since there is no sufficient source for 14.1 MeV fusion neutrons for material tests available, it is proposed to simulate the damage by means of ion irradiation. To investigate the synergistic effects, in-situ experiments such as stress relaxation and tensile tests are performed on thin tungsten wires, during irradiation with high-energy ions and simultaneous loading with low-energy hydrogen. An additional sample heater will allow irradiation and testing under fusion-relevant temperatures up to 1800 K. Due to the fine grain structure of the samples, the experiments will provide results that can be transferred to bulk tungsten and serve also for the development of tungsten fiber-reinforced composites.

P 19.29 Thu 16:00 P

Ortsaufgelöste rovibratorische Besetzungstemperatur von Deuterium im Plasmasimulator PSI-2 — •Nikolas Klose, Stephan Ertmer, Arkardi Kreter, Gennady Sergienko, Bernhard Unterberg und Sebastijan Brezinsek — Forschungszentrum Jülich GmbH, Institut für Energie- und Klimaforschung - Plasmaphysik, 52425 Jülich, Deutschland

Im linearen Plasmasimulator PSI-2 wurden D_2-Moleküle mittels optischer Spektroskopie anhand der Fulcher-Banden ($3p^3\Pi_u \rightarrow 2s^3\Sigma_g^+$) untersucht. Die Hauptdiagonalenübergänge $\Delta v=0$ der ersten 5 Übergänge wurde analysiert und die rovibratorische Besetzungstemperatur als Funktion der Plasmaparameter (n_e: $2\cdot10^{-17}$ m^{-3} - $12\cdot10^{-17}$ m^{-3}; T_e: 2 eV - 12 eV) bestimmt, welche durch den Gasdurchfluss in PSI-2 (50 sccm - 490 sccm) und Strom der Bogenentladung (80 A - 150 A) variiert wurden. Weiterhin wurden die radialen Profile der rovibratorischen Besetzungstemperatur mit Langmuirsondendaten unter ionisierenden und rekombinierenden Plasmabedingungen verglichen. Die Rotationstemperatur des ersten diagonalen Übergangs ist nah an der Raumtemperatur, aber mit höheren Vibrationsquantenzahlen fällt T_{rot} signifikant ab.

P 19.30 Thu 16:00 P

Parallel expansion of a pellet plasmoid in a finite electric potential well — •Alistair Mark Arnold[1], Pavel Aleynikov[1], and Boris Breizman[2] — [1]Max-Planck-Institut für Plasmaphysik, Greifswald, Deutschland — [2]Institute for Fusion Studies, University of Texas, Austin, USA

We consider the expansion parallel to magnetic field lines of the plasmoid produced by a fuel pellet. In particular, we take into account the finite height of the electric potential well confining the plasmoid electrons. If it is assumed that electron bounce motion occurs much more rapidly than collisions and trapped electron self-collisions occur much more rapidly than other kinds of collisions, a quasi-equilibrium state is reached with a non-Maxwellian electron distribution function. A closed-form expression for the distribution function is obtained for an arbitrary well under the assumption that pitch-angle scattering dominates. Corresponding analytical expressions are found for particle and energy exchange between the passing and trapped electrons. Agreement with literature on mirror machines and even classical thermodynamics is found in appropriate wells. The non-Maxwellian distribution function precludes rigorous modelling of the plasmoid expansion using the Braginskii equations. The trapped distribution function is, however, specified by only two time-dependent quantities – a fluid closure of the system is possible despite the highly non-Maxwellian distribution. We seek to understand the influence of the above effects on the expansion rate and ultimate electron-ion energy balance during fuel pellet injection.

P 19.31 Thu 16:00 P

Global thermal equilibrium of non-neutral plasma in a magnetic quadrupole trap — •Patrick Steinbrunner[1], Matthew Stoneking[2], Thomas O'Neil[3], and Thomas Sunn Pedersen[1] — [1]Max Planck Institute for Plasma Physics, 17489 Greifswald, Germany — [2]Lawrence University, Appleton, Wisconsin 54911, USA — [3]University of California, San Diego, La Jolla, California 92093, USA

Global thermal equilibrium of a non-neutral plasma confined in a cylindrically symmetric trap is obtained by maximizing the entropy for a given number of particles, temperature and rotation frequency around the axis of symmetry [1]. Plasmas in such states are Boltzmann distributed and satisfy Poisson*s equation as it is observed in Penning-Malmberg traps, in which they are in principle confined indefinitely [1]. These traps consists of a homogeneous magnetic field as well as electrostatic potential walls produced by cylindrical electrodes. They can confine one sign of charge, and the amount of confined space charge is limited by the bias on the electrodes. We present an alternative concept using a magnetic quadrupole field, produced by a levitated current-carrying coil surrounded by another coil with opposite current wound around a grounded vacuum chamber. Computational results suggest that global thermal equilibrium states can be confined in this trap without the need of biased electrodes. Turning off the outer coil*s current would yield a dipole trap [2] in which both signs of charge have been confined for a finite time. [1] Dubin, D. H., & O*neil, T. M. (1999). Rev. Mod. Phys., 71(1), 87. [2] Boxer, A. C., et al. Nat. Phys., 6.3 (2010): 207-212.

P 19.32 Thu 16:00 P

Towards implementation of the FAIR prinicples in plasma science — •Markus M. Becker[1], Dirk Uhrlandt[1], Detlef Loffhagen[1], Peter Hill[2], Marina Prenzel[3], and Achim von Keudell[3] — [1]Leibniz Institute for Plasma Science and Technology (INP), Germany — [2]York Plasma Institute, University of York (UoY), UK — [3]Ruhr University Bochum (RUB), Germany

A few years ago, the FAIR data principles were proposed as a guideline for those wishing to enhance the reusability of their data by making them findable (F), accessible (A), interoperable (I) and reusable (R) [Wilkinson *et al.*, *Sci. Data* 3:160018 (2016)]. Since then, various activities aiming at implementation of the FAIR principles in different fields of plasma science have been started. Within the project QPTDat, INP works together with partner institutions on research data management (RDM) solutions for low-temperature plasma physics. This includes a close collaboration with the CRC 1316 at RUB, where the focus lays on the establishment of data stewards to support RDM in daily practise. The international project Fair4Fusion addresses the RDM needs in the field of fusion plasmas, while PlasmaFAIR at UoY strives to improve the quality and sustainability of plasma research software. This contribution presents current activities at INP, RUB and UoY and emphasizes the need for collaborations and community involvement to derive real benefits from the FAIR principles for research in plasma science.

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P 19.33 Thu 16:00 P

Ion-induced secondary electron emission of metal surfaces analysed in an ion beam experiment — •Rahel Buschhaus and Achim von Keudell — Experimentalphysik II, Ruhr-Universität Bochum, Deutschland

Electron emission of surfaces upon ion impact is one of the most fundamental plasma-surface-interaction. Many experimental and theoretical approaches address secondary electron emission coefficient determination (SEEC; amount of released electrons per incident ion) in literature. This determination may remain rather indirect though, because the process of ion-induced electron emission occurs often not isolated from all other plasma-surface-interactions. Using beam experiments avoids this complication and allows a precise electron yield determination. Target conditions in plasmas strongly affect electron emission of the target and thus have an impact on the discharge itself. However, data of oxidized and nitrided targets, as they would appear in any reactive plasma discharge, are very sparse and may even contain significant systematic errors, because they were often measured based on global modeling of the complex behavior of plasma discharges. SEECs of different metal foils such as Cu or Ni with various surface conditions are investigated in a beam experiment. Foils are exposed to beams of Ar^+ with E_{ion}=500 eV - 2 keV and electron yields are determined precisely. A model for the electron emission is presented to explain the data.

P 19.34 Thu 16:00 P

Studies on the plasma permeability of porous materials using polymers as marker materials — •Martin Leander Marxen[1], Luka Hansen[1], Armin Reimers[2], Fabian Schütt[2], Lena Marie Saure[2], Erik Greve[2], Rainer Adelung[2], and Holger Kersten[1] — [1]Institute for Experimental and Applied Physics, CAU Kiel — [2]Institute for Material Science, CAU Kiel

Highly porous materials are of large interest due to their broad potential for application, e. g. as sensors or catalysts making use of their extremly high surface areas. The plasma permeability of highly porous framework materials produced from tetrapodal zinc oxide (t-ZnO) in a low pressure capacitively coupled plasma was studied with a new, indirect approach. The t-ZnO materials have a porosity > 90 %. Furthermore, some of the samples have additional nanomaterial surface layers (e. g. graphene) deposited on the t-ZnO arms, resulting in a change of conductivity. A polymer (EPDM) was covered with the material of interest and then exposed to an oxygen plasma. The covering material was removed afterwards and the surface of the EPDM was investigated by water contact angle measurement and XPS. Changes of the surface can be attributed to plasma species that permeated the covering zinc oxide material and reached the surface. This approach offers an easy and affordable opportunity to get insight in how deep plasma can penetrate into highly porous structures with nano- and microscale features.

P 19.35 Thu 16:00 P

Control of Spokes in Magnetron Discharges — •Mathews George, Wolfgang Breilmann, Julian Held, and Achim von Keudell — Experimentalphysik II, Ruhr-University Bochum

Magnetron Sputtering is a Physical Vapour Deposition (PVD) process widely used in industry and scientific communities. Magnetron plasma appears to be homogeneous to the human eye, but shows localized zones of high brightness rotating in the ExB direction when observed with an ICCD camera with exposure times below 1μs. These local ionization zones, also called 'spokes' are assumed to play a role in the transport of particles and energy away from the target. DCMS was chosen for the development of spoke control as an initial test object since the spokes in DC regime are more uniform compared to HiPIMS. Amplified rectangular signals are applied to two pairs of drivers to raise the plasma potential inside a spoke by drawing electron current from the plasma at the highest gradients in the ExB direction. Ion saturation current shows the responses of the spoke frequency and intensity to the applied signal. The metal ion flux from the target surface is measured time and energy resolved with a mass spectrometer. An additional probe is added to study influence of the control signal on the plasma potential inside a spoke.

P 19.36 Thu 16:00 P

Azimuthal particle transport in high power impulse magnetron sputtering plasmas — •Sascha Thiemann-Monjé, Steffen Schüttler, Julian Held, and Achim von Keudell — Experimental Physics II, Ruhr-University Bochum, 44780 Bochum, Germany

In the past years high power impulse magnetron sputtering (HiPIMS) has become a well established method for depositing high quality hard coatings. Nevertheless, knowledge about the processes inside the discharge is still incomplete. This includes the azimuthal rotation of heavy particles which is induced by the electron Hall-current and is believed to be influenced by rotating ionization zones, the so called 'spokes'.

In this work, optical emission spectroscopy (OES) and x-ray photoelectron spectroscopy (XPS) combined with so called marker targets were used to gain further understanding of the above mentioned particle movement. While OES delivers information about the emitting particles inside the plasma, XPS measurements of substrates placed on the side of the plasma show the contribution of particles leaving the discharge. The measurements where done for circular targets with a diameter of 50 mm and 0.5 Pa Argon as working gas.

It could be shown that the maximum rotation velocity is in the range of 0.5 - 1.8 km/s depending on the measured species. This rotation is as well visible as asymmetric deposition distribution on the side of the discharge.

P 19.37 Thu 16:00 P

Analysis of single particle motion confined in the plasma sheath — •Sören Wohlfahrt and Dietmar Block — Institute of Experimental and Applied Physics, Kiel University, Germany

Microparticles are the essential component of a (dusty) complex plasma. Besides particle-plasma interaction and particle-particle interaction, the dynamics of a single particle are worth to be studied. Particles are typically confined in the plasma sheath, where they accumulate a negative charge that causes levitation in the electric field of the sheath. However, even for perfectly spherical particles the charging process is not isotropic. Small differences in the electron- and ion fluxes can create dipole moments on insulating particles. These dipoles should result in a rotation of the particle [1]. In addition, the particles can have an initial angular momentum due to the injection into the plasma. Thus, we investigate motion of single particles in the plasma sheath. We use angular- and polarization resolved light scattering (APRLS)[2] to analyse the precise motion and orientation of the particle relative to the incident laser beam. This allows us to determine even small deviations from the equilibrium position of the particle and track particle rotation with frequencies up to 500 Hz.

[1] I H Hutchonson, New J. Phys. 6, 43 (2004)
[2] S. Wohlfahrt, D. Block, Phys. Plasmas 28, 123701 (2021)

P 19.38 Thu 16:00 P

Molecular dynamics simulations of turbulent complex plasmas — •Eshita Joshi, Prapti Bajaj, Hubertus Thomas, and Mierk Schwabe — Institut für Materialphysik im Weltraum,Deutsches Zentrum für Luft- undRaumfahrt, Weßling, Germany

Turbulence remains one of the oldest unsolved problems in physics. Studying how a flow can transition from laminar to turbulent can deepen our understanding of how and when turbulence emerges. Complex plasmas are ionised gasses with micrometre sized *dust* particles immersed in them, and they are valuable in studying turbulence as the highly charged microparticles are big enough to be imaged directly when their flow becomes turbulent. We investigate the onset of turbulence by studying complex plasmas flowing past a disturbance. We perform molecular dynamics (MD) simulations of the experiment performed using the Plasmakristall-4 (PK-4) laboratory on board the International Space Station at low pressures to study the emergence and decay of turbulence.

P 19.39 Thu 16:00 P

Complex Plasmas in the Einstein Elevator — •Andreas Schmitz[1], Michael Kretschmer[1], Christoph Lotz[2], and Markus Thoma[1] — [1]I. Physikalisches Institut, Justus-Liebig-Universität, Gießen, Germany — [2]Instititut für Transport- und Automatisierungstechnik, Gottfried Wilhelm Leibniz Universität Hannover

An experiment with complex plasmas was conducted in a copy of the former International Space Station Plasmakristallexperiment-Nefedov laboratory in the University of Hannover's drop tower, the Einstein Elevator. For the experiment performed, an argon high-frequency plasma was generated in the plasma chamber at low pressures into which melamine-formaldehyde microparticles were injected. When the setup was dropped inside the Einstein elevator, the microparticles underwent an instantaneous transition from 0 g to 1 g and were subsequently lifted from the sheath region into the bulk plasma during the microgravity phase. The first results of the analysis of this experiment are presented here.

P 19.40 Thu 16:00 P

Study of QED effects in collision of near-surface accelerated electrons with high-intensity lasers — •Marko Filipovic, Christoph Baumann, and Alexander Pukhov — Institut für Theoretische Physik I, Heinrich-Heine-Universität, Düsseldorf, Germany

As the development of laser technology progresses, ever higher intensities and better beam qualities in laboratories become available. This advance enables new experimental setups in the study of laser-plasma interaction and quantum electrodynamic (QED) effects like quantum photon emission and pair production in extreme fields and densities.

We present two-dimensional Monte-Carlo particle-in-cell simulations of two high-intensity lasers grazing the surface of a solid-state target. Due to the fields near the target surface electrons are extracted and accelerated. Finally, the extracted electrons collide with the counter-propagating laser, which generates a QED cascade. Here, the processes are studied for various laser intensities, angle of incidence and point of incidence at the surface.

P 19.41 Thu 16:00 P

Ion spectroscopy of ultrashort laser pulse plasmas ignited by pre-pulses — •Lars Schwabe, Jan Riedlinger, and Georg Pretzler — Institut für Laser- und Plasmaphysik, Heinrich-Heine-Universität Düsseldorf

Illuminating solids with a high-intensity sub-10-fs laser creates a short-lived high-temperature plasma. The detailed processes during plasma generation are still not fully predictable today. We examined the emitted ions in terms of reached ionization states, probability and kinetic energy distribution, using a Thomson parabola spectrometer with an increased dynamic range to map ions with energies in the sub-100-keV range. Experiments were done with systematically varied laser parameters and pre-pulses, with peak intensities up to 10^{18} W/cm^2 at pulse durations down to 7 fs. The results allow conclusions on the plasma formation processes and the subsequent ionization dynamics in this ultrashort sub-120-fs domain.

P 19.42 Thu 16:00 P

Reconstructing the plasma temperature by optical probing method in femtosecond laser hydrogen jet interaction — •Long Yang[1,2], Constantin Bernert[1,2], Lingen Huang[1], Stefan Assenbaum[1,2], Martin Rehwald[1,2], Karl Zeil[1], Ulrich Schramm[1,2], Ilja Goethel[1,2], Thomas Kluge[1], Jan Vorberger[1], and Thomas E. Cowan[1,2] — [1]Helmholtz-Zentrum Dresden-Rossendorf, Institute of Radiation Physics — [2]Technische Universitat Dresden

Plasma temperature is a critical parameter in warm dense matter and unable to be measured directly. In this study, we apply a well-designed experiment to generate an adiabatic expanded, thermalized hydrogen plasma in few ps by 30fs 1.63e18W/cm2 short pulse laser and 5um diameter solid hydrogen jet interaction. With the optical laser probing method at different wave length, the plasma density in expansion process is recorded with optical shadow image. Then plasma temperature is reconstructed by finding the best fit between experiment and hydro with ray tracing simulations. The electron temperature is determined to be around 300eV through this method and compared to the PIC simulations. The results show that both PIConGPU and PICLS overestimate the electron temperature several factors. This is the first time that we design an experiment and benchmark to the PIC codes. The result would help us improve the existed laser plasma interaction model in PIC.

P 19.43 Thu 16:00 P

Temporally and energy resolved actinometry in a micro cavity plasma array — •Henrik van Impel, David Steuer, Volker Schulz-von der Gathen, Marc Böke, and Judith Golda — Ruhr University Bochum, Faculty of Physics and Astronomy, Experimental Physics II, Germany

Dielectric barrier discharges (DBDs) have many applications, such as the generation of ozone or the treatment of volatile organic compounds (VOCs). To understand the underlying processes, fundamental knowledge on the generation of reactive species is necessary. Here we investigate atomic oxygen production as a model system in a micro cavity plasma array, a customized surface DBD confined to geometrically arranged cavities of micrometer size. We studied the behavior and the plasma chemical processes with optical emission spectroscopy methods. The discharge is operated in helium with a molecular oxygen admixture of about 0.1% at atmospheric pressure using a 15 kHz and about 600V excitation voltage. High atomic oxygen densities can already be observed with energy resolved actinometry (ERA). Using a multi-photomultiplier setup and ERA, we measured the temporal evolution of the atomic oxygen density and the effective mean electron energy over the first ignitions, which are affected by the memory effect due to residual charges.

Project is funded within project A6 of the SFB 1316.

P 19.44 Thu 16:00 P

Periodic structures (LIPSS) on metallic coatings (Ti, Cu, Cr) induced by nanosecond laser — •Robin Labenski, Patrick Preissing, Sascha Chur, Marc Böke, Volker Schulz-von der Gathen, and Judith Golda — Ruhr University Bochum, Faculty of Physics and Astronomy, Experimental Physics II, Germany

Catalysts show an increased efficiency in dependence of their morphology and chemical composition. In our research we investigate the formation of Laser-induced Periodic Surface Structures (LIPSS) on metallic coatings (Ti, Cu, Cr, 20nm-100nm) on Si-wafer induced by pulsed laser irradiation (ns-Nd:YAG, 532nm/1064nm, 20Hz). We found that LIPSS usually appear right above the melting threshold of the respective surface material. Under normal incidence they develop a periodicity roughly equal to the used wavelength and are being oriented perpendicular to the polarization direction. For an increasing angle of incidence the periodicity changes in a for the applied polarization (s or p) characteristic manner. All results match prognosis of the Efficacy-Factor-Theory by Sipe [1]. In upcoming measurements we test the chemical composition of LIPSS when induced in different atmospheres and/or simultaneously being treated by the COST reference microplasma jet. Supported by DFG within SFB1316.

[1] JE Sipe "Laser-induced periodic surface structure. I. Theory", Phys. Rev. B 27.4 (1983)

P 19.45 Thu 16:00 P

RF-atmospheric pressure plasma jet as a source of vacuum-UV photons for photoionisation — •Natascha Blosczyk[1], Tristan Winzer[1], Judith Golda[1,2], and Jan Benedikt[1] — [1]Kiel University — [2]current address: Ruhr-Universität Bochum

Vacuum-UV(VUV) radiation has great use, not only as a means of analysing gas mixtures by their emission and absorption spectra, but also as a way to induce chemical reactions in a target gas. Therefore, the aim of this work is to study VUV-radiation of different atmospheric plasma sources and develop a way to efficiently use it for photoionisation at atmospheric pressure. The VUV-radiation of helium and helium/argon plasmas with excimer continua and line-radiation is measured by VUV-spectroscopy in the 60 to 200 nm range as function of the input power.

Acetylene is used as a model precursor to investigate the use of VUV-photons for photoionisation and follow-up chemistry, where the generated primary ions and ions formed in the polymerization reactions are detected by positive ion mass spectrometry. The VUV-generation in the plasma is separated from the diluted acetylene gas via a controlled gas flow. To further study the effects of the photons on the chemistry, the FTIR-spectrometry will be used to study the properties of deposited thin films from the VUV-photon activated gas mixture, as well as SMPS measurements to ensure a dust-free process.

P 19.46 Thu 16:00 P

Cold Atmospheric Plasma Decontamination of FFP3 Face Masks and Long-Term Material Effects — •Alisa Schmidt[1], Chen-Yon Tobias Tschang[1], Joachim Sann[2], and Markus H. Thoma[1] — [1]I. Physical Institute, Justus Liebig University, Giessen, Germany — [2]Institute of Physical Chemistry, Justus Liebig University, Giessen, Germany

Motivated by the shortages of face masks and safety clothing in the beginning of the corona pandemic, we conducted studies on decontamination of FFP3 face masks with cold atmospheric plasma (CAP) and resulting material effects. Therefore, the bactericidal (Escherichia coli) and sporicidal (Bacillus atrophaeus) efficacy of CAP afterglow decontamination of FFP3 mask material was investigated by decontamination experiments in a surface micro discharge (SMD) plasma chamber. In addition, a detailed analysis of changes in long-term plasma treated (15h) mask material and its individual components - ethylene vinyl acetate (EVA) and polypropylene (PP) - was carried out using surface analysis methods such as laser microscopy, contact angle measurements, X-ray photoelectron spectroscopy (XPS) as well as fabric permeability and resistance measurements. The microbiological experiments showed that plasma treatment of FFP3 face masks with CAP afterglow of an SMD device effectively inactivates E. coli and B. atrophaeus on the fabric. Furthermore, long-term material effects indicate that FFP3 masks can be plasma decontaminated and reused multiple times (up to 5h) but only to a limited extent, as otherwise permeability levels no longer meet DIN EN 149 specifications.

P 19.47 Thu 16:00 P

Comparison of mass spectrometry and optical measurements of plasma catalysis conversion of n-butane — •Laura Chauvet, Christoph Stewig, Theresa Urbanietz, Marc Böke, and Achim von Keudell — Ruhr-Universität Bochum Institute of Experimental Physics II Faculty for Physics and Astronomy Universitätsstraße 150 Building NB 5/174 D-44780 Bochum

With the progress in the production of renewable energy, the use of plasmas to convert molecules into value added species present a novel research field of interest. The coupling of plasma with a surface catalyst might exhibit synergetic effects enhancing the conversion or the selectivity of reactions.

In this framework, a plasma chamber has been designed to study the mechanisms involved in the conversion of carbon-based molecules by plasma catalysis. The chamber is fed by a helium flow with small admixtures of n-butane. A capacitively coupled atmospheric pressure RF discharge is used to dissociate n-butane. Different kinds of catalysts can be spray coated on the electrodes and brought into contact with the plasma. In this work, a sampling system has been designed to sample the gas directly from the edge of the discharge to perform in situ measurements by mass spectrometry. The measurements are compared to the ones performed by Fourier Transform Infrared Spectroscopy (FTIR) measurements. As mass spectrometry is not limited by infrared active species, it is a complementary method to benchmark the optical measurements.

P 19.48 Thu 16:00 P

CO2 utilization in 3D-printed barrier discharge reactors — •Dimas Adrianto[1], Milko Schiorlin[1], Volker Brüser[1], Ronny Brandenburg[1,2], and Sven Grundmann[2] — [1]Leibniz Institute for plasma science and technology, Greifswald, Germany — [2]University of Rostock, Rostock, Germany

Plasma technology and rapid prototyping are two emerging technologies, each with its own set of benefits. However, the benefits of these technologies are rarely combined. The discharge chamber of Dielectric Barrier Discharge (DBD) reactors for investigating CO2 utilization were created using a 3D printer in this study. Because of rapid prototyping's high adaptability and modification potential, the results of fluid dynamics simulations can be directly introduced in the plasma reactor manufacturing process. DBD reactors are made of methacrylic acid polymer and have an overall dimension of 120 x 120 mm, with a powered electrode size of 55 x 55 mm in the center. 3D-printed reactors were initially tested with three different feed-gases: synthetic air, nitrogen, and carbon dioxide to ensure that stable plasma could be generated. Based on electrical characterization, in particular voltage-charge plots, operation parameters such as applied voltage, plasma power, and effective capacitance were studied in detail. Three DBD reactors with different gas flow distribution and velocity profiles were then investigated for carbon monoxide formation in pure CO2. In future experiments, the production of value-added chemicals such as CO and methanol will be further studied.