P 16: Poster Session 3

Time: Wednesday 16:30–18:30 Location: Empore Lichthof

P 16.1 Wed 16:30 Empore Lichthof

The electric field of an electron in a electron-hole plasma with degenerate electrons. Possibility of formation of a superconductivity state — •Saltanat P. Sadykova[1] and Anri A. Rukhadze[2] — [1]Forschungszentrum Jülich (Julum.), Jülich, Germany — [2]Prokhorov General Physics Institute, Russian Academy of Sciences, Vavilov Str. 38., Moscow, 119991, Russia

We consider the possibility of formation of a superconductivity state either in a semiconductor or in a electronhole plasma with the degenerate electrons due to the attractive forces between the electrons as a result of the exchange effects through the electron-hole sound wave [1] by analogy to the phonon waves in a solid state. We have determined the view of an interaction potential between two electrons in a degenerate electron-hole plasma [2]. The potential appears to be attractive at distances large than the Debye radius and decreases as $1/r^3$. We discuss the conditions at which the bound electron state - so called "Cooper Pair" in a such field can be formed.

[1] A.F. Alexandrov, L.S. Bogdankevich, A.A. Rukhadze, Principles of Plasma Electrodynamics (Springer, Heidelberg,1984), pp. 167-170.
[2] S.P. Sadykova, A.A: Rukhadtze, Contributions to Plasma Physics. 2019, 1-7

P 16.2 Wed 16:30 Empore Lichthof

Interaction of runaway populations and instabilities — •Andrej Lier[1], Gergely Papp[1], Philipp Lauber[1], Ola Embreus[2], and George Wilkie[3] — [1]Institute for Plasmaphysics, Garching, Germany — [2]Chalmers University, Gothemburg, Sweden — [3]PPPL, Princeton, NJ, USA

Fusion-born alpha particles in ITER disruption simulations are investigated as a possible drive of Alfvenic instabilities, whose ability to expel runaway electron (RE) seed particles is explored in the pursuit of a passive, inherent RE mitigation system. Utilizing a linearized Fokker-Planck solver, the distribution functions of the highly energetic alpha population during a disruption are computed. A linear gyrokinetic magnetohydrodynamic (MHD) code calculates the Alfven spectrum supported by the plasma which is connected to the previously obtained distribution functions through a self-consistent nonlinear wave-particle interaction tool in order to evaluate the MHD-mode drive. The disruptions themselves are simulated as an exponential temperature drop with iterations taking place over the exponential decay time and final temperature. Focusing on fast thermal quenches and on the spatial density gradient of the suprathermal ion population, we found it capable of exciting weakly damped Alfven Eigenmodes present in the cold post-disruptive plasma in spatial and temporal regimes correlated with runaway electron formation.

P 16.3 Wed 16:30 Empore Lichthof

Non-linear MHD Assessments of Stellarator-like Tokamaks — •Rohan Ramasamy[1,2], Matthias Hoelzl[1], Erika Strumberger[1], Qingquan Yu[1], Javier Artola[3], Karl Lackner[1], and Sibylle Günter[1] — [1]Max Planck Institute for Plasma Physics, Garching, Germany — [2]Max Planck/Princeton Research Centre for Plasma Physics — [3]ITER Organization, Route de Vinon sur Verdon, 13067 St Paul Lez Durance Cedex, France

Quasi-axisymmetric stellarators (QAS) have been proposed as a hybrid approach to plasma confinement, offering both the desirable magnetohydrodynamic (MHD) stability of stellarators, as well as the favourable energy transport properties of tokamaks. The non-linear MHD code JOREK is currently being extended in order to assess these devices. A 3D MHD model and non-axisymmetric grid, appropriate for stellarator simulations are being developed, as well as improvements to the current numerical solver.

In the short term, previous linear studies have shown that axisymmetric approximations to QAS devices can preserve the stability structure observed in 3D simulations. It has therefore been proposed to assess the non-linear evolution of QAS equilibria using such an approximation. This contribution presents simulation results of large scale instabilities in stellarator-like devices, validating against other MHD codes, and analytic solutions, to provide an intuition for the non-linear dynamics of stellarators.

P 16.4 Wed 16:30 Empore Lichthof

Machine Learning Methods as Surrogate Models for the Power Exhaust in Tokamaks — •Martin Brenzke[1], Sven Wiesen[1], Matthias Bernert[2], David Coster[2], Jenia Jitsev[3], Udo von Toussaint[2], EUROfusion MST1 Team[4], and the ASDEX Upgrade Team[5] — [1]Forschungszentrum Jülich, Institut für Energie- und Klimaforschung, 52425 Jülich, Germany — [2]Max Planck Institute for Plasma Physics, 85748 Garching, Germany — [3]Jülich Supercomputing Center (JSC), Institute for Advanced Simulation (IAS), Research Center Jülich, 52425 Jülich, Germany — [4]See the author list of B. Labit et al. 2019 Nucl. Fusion 59 086020 — [5]See the author list of H. Meyer et al. 2019 Nucl. Fusion 59 112014

One of the main challenges in the design of an economically viable fusion reactor are the thermal loads experienced by the targets in a divertor-based design. These thermal loads cause degradation of the target material and limit the lifetime of a divertor. Modeling these thermal loads is one of the most important points in determining the operating scenarios for future fusion devices and remains a challenging yet crucial task. In light of current developments and successes in the field of machine learning techniques, data-driven modeling is an interesting option for this problem. We present results for a machine learning-based modeling approach using experimental data from the ASDEX Upgrade experiment. We focus on a comparison of the performances of several machine learning approaches.

P 16.5 Wed 16:30 Empore Lichthof

Developments towards an electron-positron plasma in a magnetic dipole trap — •J. Horn-Stanja[1], A. Deller[1], U. Hergenhahn[1], S. Nissl[1], E. V. Stenson[1], M. R. Stoneking[1], T. Sunn Pedersen[1], H. Saitoh[2], C. Hugenschmidt[3], M. Singer[3], J. R. Danielson[4], and C. M. Surko[4] — [1]Max Planck Institute for Plasma Physics, Germany — [2]The University of Tokyo, Japan — [3]Technische Universität München, Germany — [4]University of California San Diego, USA

The electron-positron many-body system in the plasma state is distinguished by the mass equality of the constituents, leading to stability and wave-physics properties fundamentally different from those of conventional plasmas. The creation of such "pair plasma" in the magnetic field of a levitated dipole is the goal of the APEX/PAX collaboration.

Although lossless injection and second-long trapping of positrons has been demonstrated in experiments with a supported dipole at the first-class positron source NEPOMUC, the number of available positrons remains a key challenge. While a small positron Debye length in the pair plasma eventually requires the use of a multicell storage trap, current single-particle experiments will benefit from the recent development of the intense NEPOMUC primary beam at lower energies or the upcoming installation of a buffer gas trap at NEPOMUC which will provide dense positron pulses. First experiments using electrons and positrons simultaneously in a dipole trap are one such example.

In this contribution, we discuss recent and upcoming developments within the scope of the APEX project.

P 16.6 Wed 16:30 Empore Lichthof

Electron Bernstein wave heating at harmonics of the electron cyclotron resonance frequency — •Alf Köhn-Seemann and Eberhard Holzhauer — IGVP, Universität Stuttgart, Germany

Electron Bernstein waves (EBWs) provide a method to transfer energy to a plasma whose density exceeds the corresponding cut-off density of an injected microwave. No high-density cut-off exists for EBWs and they are very well absorbed at harmonics of the electron cyclotron resonance frequency. In addition, they can also drive significant toroidal net currents with current drive efficiencies exceeding those normally achieved by standard electron cyclotron resonance heating. EBWs are, however, electrostatic waves and need thus be coupled to externally injected electromagnetic waves. We discuss the different coupling mechanisms and how their efficiency depends on the plasma parameters. We will use both, full-wave simulations and ray-tracing calculations to illustrate the effect of increasing harmonics number by decreasing magnetic field strength. It will be shown how going to higher harmonics will change the propagation paths and the coupling efficiencies. The results obtained from numerics will be compared with experimental results obtained from the TJ-K stellarator with its density gradient lengths comparable to the wavelength of the injected microwave.

P 16.7 Wed 16:30 Empore Lichthof

The GIRAFFE experiment: in situ tensile tests of irradiated tungsten fibers — •Bailey Curzadd[1,2], Johann Riesch[1], Till Höschen[1], Alexander Feichtmayer[1,2], and Rudolf Neu[1,2] — [1]Max-Planck-Institut für Plasmaphysik, Garching, Deutschland — [2]Technische Universität München, München, Deutschland

Although its low erosion rate and low retention of tritium make tungsten (W) the preferred plasma-facing material for future fusion reactors, its low-temperature brittleness is a potentially critical vulnerability that could lead to the premature failure of plasma-facing components. The degradation of essential material properties by the fusion environment - especially by neutron irradiation and gas atoms (H/He) trapped in the microstructure - greatly increases the likelihood of component failure. However, the degradation of W in the fusion environment is poorly characterized. For this reason, a novel experiment to better understand the mechanisms by which the mechanical properties of W are worsened by radiation damage and trapped impurities is in development. A principal research goal is the investigation of synergistic interactions between the factors that lead to material deterioration. Displacement damage will be produced by bombardment of samples with protons or heavy ions. Samples will be subsequently or simultaneously loaded with impurity gases, and the mechanical properties determined via in situ tensile testing. Due to the low penetration depth of protons and heavy ions in W, thin fibers and foils ($\approx 5\ \mu$m) are foreseen as samples. The fine microstructure of these samples enables the simulation of bulk material behavior.

P 16.8 Wed 16:30 Empore Lichthof

Characterization of lanthanum-hexaboride electron emitters as cathodes in pressure gauges for strong magnetic fields — •Bartholomaeus Jagielski, Uwe Wenzel, Mirko Marquardt, Jiawu Zhu, Thomas Sunn Petersen, and the W7-X Team — Max Planck Institute for Plasma Physics, Greifswald, Germany

In order to evaluate the particle exhaust rate on the pumping ducts at the sub-divertor, the neutral gas pressure can be measured. In the last operation phase (OP 1.2) of the Wendelstein7-X (W7-X) pressure recordings took place with ASDEX Pressure Gauges (APG) and with newly developed Crystal Cathode Pressure Gauges (CCPG). While the cathodes from thoriated tungsten of the APGs regularly bent under the influence of the magnetic field (2,1T) and the resulting Lorentz forces, the CCPGs, equipped with an emitter made of lanthanum hexaboride, functioned largely without problems [1]. The simple cylindrical geometry, relatively high resilience to cathode poisoning, low workfunction (2.5eV) etc., makes the LaB6-emitter a promising candidate for future, precise manometers in a range between 1mbar to 10^{-6} mbar and for a successful application in future fusion plants (ITER, DEMO). For the next campaign of W7-X (OP 2.0) the LaB6-cathodes are being tested in different experimental environments and characterized with recent ANSYS simulations. The design, preliminary results of the investigations, with and without external magnetic field, and the latest optimization as well as future plans of/for the CCPGs are presented. [1] U. Wenzel et al, J. Instrum.12(09), C09008 (2017).

P 16.9 Wed 16:30 Empore Lichthof

Statistical analysis of ballooning effect for sawtooth crashes in ASDEX Upgrade — •Oleg Samoylov, Valentin Igochine, Branka Vanovac, Matthias Willensdorfer, Hartmut Zohm, and ASDEX Upgrade Team — Max Planck Institute for Plasma Physics, Boltzmannstr. 2, 85748 Garching, Germany

Sawtooth oscillations are nonlinear periodic relaxations of core plasma density and temperature in tokamaks. While the oscillations are often observed and known for decades, the process by which the periodic collapse of the core plasma temperature occurs is still only partially understood. There is no final model that could fully describe all experimental measurements. Some of the proposed sawtooth models predict a higher rate of the crashes at the low field side due to the ballooning effect. To prove the hypothesis, we statistically study the occurrence of the crashes at the low field side in ASDEX Upgrade. The main diagnostic for this study was 2D electron cyclotron emission (ECE) diagnostic, which measured temperature perturbations at the q=1 magnetic surface at the low field side. 200 sawtooth crashes were analyzed. 39 % of the sawtooth crashes were observed in the 2D ECE window, whereas in case of symmetrical occurrence only 23.6 % crashes were expected. This shows weak ballooning effect for the crashes used in the studies.

P 16.10 Wed 16:30 Empore Lichthof

First Steps towards TALIF Measurements of the H Atom Velocity Distribution Function and Density in Negative Ion Sources — •Frederik Merk, Christian Wimmer, Stefan Briefi, Emile Carbone, Ursel Fantz, and the NNBI-Team — Max-Planck-Institut für Plasmaphysik, Boltzmannstr. 2, 85748 Garching, Germany

H^- (and D^-) ion sources are required for neutral beam injection on the ITER fusion device. The test facility BATMAN Upgrade (BUG) is used to investigate the physics of these sources. H^- ions are produced in a low-temperature, low-pressure plasma environment by surface-conversion of H or H_x^+ at a (caesiated) low work function surface. As the dominant process is the H atom conversion, the H^- conversion yield depends on the flux of H atoms onto the surface. This flux is determined by the H atom velocity distribution function and the corresponding density. In order to determine reliable values for both parameters a TALIF (two-photon absorption laser induced fluorescence) system will be installed at the test facility. For the installation of the diagnostic under the harsh environment of the ion source (100 kW rf power, 45 kV high voltage), a stepwise approach is chosen. First, the TALIF implementation scheme and calibration is tested for O atoms in a small plasma torch. Then, a TALIF system for H is installed in a controlled environment on a small H_2 ICP experiment. Finally, the optimized diagnostic system is transferred to BUG, which will be the first time that such a system is installed at a H^- ion source. The design and the current status of the TALIF system is presented.

P 16.11 Wed 16:30 Empore Lichthof

Effects of oxide layers on deuterium uptake, retention and release in self-damaged tungsten — •Kristof Kremer[1,2], Maximilian Brucker[1,3], and Thomas Schwarz-Selinger[1] — [1]MPI for Plasma Physics, Boltzmanstraße 2, D-85748 Garching, Germany — [2]TUM, James-Franck-Straße 1, D-85748 Garching, Germany — [3]Ulm University, Albert-Einstein-Allee 11, D-89081 Ulm, Germany

Understanding hydrogen isotope (HI) retention in first-wall materials is crucial to predict fuel loss in future fusion devices, but the influence of surface oxides is discussed controversially in literature.

We examine the effect of thick (25–100 nm) tungsten-oxide layers on uptake, retention and release of HI in tungsten (W) by oxidizing the sample and then exposing it to a deuterium (D) plasma at low ion energy (< 5eV/D) and low temperature (370 K) to minimized erosion of the oxide. As samples, self-damaged W is used. Damaging with 20 MeV W ions creates a $\sim 2\,\mu$m thick, defect-rich getter layer that retains HIs. Nuclear reaction analysis, Rutherford back scattering and Thermal Desorption Spectroscopy (TDS) are used to quantify the amount of oxygen, the depth profiles of the retained D and the outgassing behavior. A strong influence of surface oxide layers on D uptake is observed, i.e., oxide layers strongly suppress D uptake. The oxide layer itself is only partially reduced by plasma exposure and only partially evaporated during TDS up to 1000 K. The role of thin (~ 2 nm), natural oxide layers are subject of future investigations. In this regard, we are setting up an in-situ experiment to examine HI uptake, retention and release on oxide-free W surfaces.

P 16.12 Wed 16:30 Empore Lichthof

Investigations of the peaking of ion temperature profiles in non-inductive high-beta advanced scenarios — •Maximilian Reisner[1], Emiliano Fable[1], Jörg Stober[1], Alexander Bock[1], Alejandro Bañon Navarro[1], Alessandro Di Sienna[1], Rainer Fischer[1], Rachael McDermott[1], and The ASDEX Upgrade team[2] — [1]Max-Planck-Institut für Plasmaphysik, 85748 Garching bei München, Germany — [2]See the author list of H. Meyer et al. 2019 Nucl. Fusion 59 112014

Non-inductive advanced Tokamak scenarios are a possible way for future nuclear fusion power plants to run in non-pulsed operation. In these scenarios, the ohmic current is replaced by externally driven current and a substantial bootstrap-current. Since the bootstrap current is produced in the presence of pressure gradients, internal transport barriers (ITBs) or regions of reduced transport are favorable to such scenarios. There are several mechanisms that are thought to be connected to the reduction of turbulence in the plasma core, in particular the ExB-shear and electromagnetic fast ion effects. In this contribution, the results of experiments conducted in the tokamak ASDEX Upgrade will be presented that aim to study these mechanisms in more detail. Furthermore, a new heuristic model to more accurately describe the reduction of turbulence in such high-beta non-inductive scenarios in the quasi-linear transport-code TGLF will be presented. This new model is calibrated on experimental results and simulations of the gyrokinetic code GENE.

P 16.13 Wed 16:30 Empore Lichthof

Supercapacitors-Based Power Supply for ASDEX Upgrade Tokamak — •Antonio Magnanimo[1], Markus Teschke[1], Gerd Griepentrog[2], and ASDEX Upgrade Team[1] — [1]Max-Planck-Institut für Plasmaphysik, 85748 Garching Bei München, Germany — [2]Technische Universität Darmstadt, 64283 Darmstadt, Germany

ASDEX Upgrade (AUG) electrical power is provided by three Flywheel Generators (FG) that are charged up before the start of a plasma pulse with up to 15 MW for several minutes. The energy stored is then used to satisfy the high power needs during a plasma pulse of up to 450 MW. The biggest FG (EZ2) in case of a major fault could not be replaced by any other FG of such size, so an alternative power supply is needed. Supercapacitors are well known for their very high specific power, due to their internal structure. Combining this technology with a proper power converter topology such as the Modular Multilevel Converter (MMC), it would be possible to feed the coils of future Tokamaks with higher performances and reliability. The MMC topology, indeed, allows a discrete-leveled output voltage and, thanks to its high cells number, it can operate continuously even in case of fault of some cells, while a FG could not. In this poster the concept of a Supercapacitors-based power supply for Toroidal Field Coils of AUG is presented, highlighting the main advantages and challenges that this project requires. Furthermore, a charger concept able to optimize the available time between consecutive shots and an overview of the present experimental setup are given, showing some of the components to be tested for the first small-scale prototype.

P 16.14 Wed 16:30 Empore Lichthof

The Edge Density Profile in Tokamaks — •Christian Schuster[1,2], Elisabeth Wolfrum[1], Ulrich Stroth[1,2], and ASDEX Upgrade Team[1] — [1]MPI für Plasmaphysik, Garching — [2]Physik-Department E28, Technische Universität München

To obtain sufficient fusion power in a future reactor, the plasma in the core has to be hot and dense. Combined with the low plasma density at the wall of current tokamaks, this necessitates maintaining a density gradient. In H-mode the increase in density occurs mainly at the edge of the plasma, in a region known as the pedestal. But also in L-mode there is a steep increase in density at the same position. To extrapolate to future reactors, knowledge about the underlying processes that determine the shape of the density profile is needed.

There are several effects that are responsible for this large density gradient at the edge. We approximate all transport processes in the plasma with an effective diffusivity and mean flow. In H-mode the diffusivity is lowered drastically in the pedestal compared to the core, but the presence of a mean radial flow, called pinch, is unclear [M Willensdorfer, NF 2013]. On the other hand, it was shown that the density profile at the edge often also depends strongly on the source, i.e. neutral atoms entering the edge region [RJ Groebner, PoP 2002].

In steady state it is not possible to disentangle these effects. Modulation experiments were used previously for the analysis of transport in the plasma core. In this contribution we prepare the extension of this technique to the pedestal region, using new diagnostic possibilities and modeling of the tokamak edge.

P 16.15 Wed 16:30 Empore Lichthof

Scale-Resolved Multi-Field Experimental Investigation of Turbulence for the Validation of Gyrokinetic Simulations — •Klara Höfler[1,2], Tim Happel[2], Pascale Hennequin[3], Pedro Molina Cabrera[4], Tobias Görler[2], Elisee Trier[2], Ulrich Stroth[1,2], and the ASDEX Upgrade Team[2] — [1]Physik Department TUM, E28, Garching, Germany — [2]Max Planck Institut für Plasmaphysik, Garching, Germany — [3]Laboratoire de Physique des Plasmas, Ecole Polytechnique, Palaiseau, France — [4]MIT Plasma Science and Fusion Center, Cambridge, Massachusets, USA

Turbulence directly deteriorates the performance of fusion plasmas by causing significant particle and heat transport. The corresponding density and temperature fluctuations are measured on the ASDEX Upgrade tokamak via Doppler reflectometry, poloidal correlation reflectometry and a correlation electron cyclotron emission diagnostic. A long history of gyrokinetic validations showed a good agreement between individual experimental quantities and simulations. This contribution presents a plasma scenario designed for measurements of a large variety of turbulence quantitites at the same radial position and provides a powerful foundation for validation of codes. Detailed studies of density fluctuations such as wavenumber spectra, correlation lenghts radial and perpendicular to the confining magnetic field, turbulence decay times, the perpendicular velocity and spectra of perpendicular plasma flows are shown together with simulations done with the gyrokinetic code GENE. Particular emphasis is put on poloidally resolved perpendicular velocity measurements done with Doppler reflectometry.

P 16.16 Wed 16:30 Empore Lichthof

Excitation and dissociation of CO_2 heavily diluted in noble gas atmospheric pressure plasmas — •Christoph Stewig, Theresa Urbanietz, Steffen Schüttler, Volker Schulz-von-der-Gathen, Marc Böke, and Achim von Keudell — Experimental Physics II, RUB, Bochum, Germany

The storage of renewable energies into chemical fuels due to the dissociation of CO_2 has been an inspiring idea for years. Hereby, non-equilibrium plasmas may be a promising candidate, as they allow dissociation reactions without the necessity of high temperatures. The vibrational pumping of the CO_2 due to repeated collisions with energetic plasma compounds is one of the discussed reaction channels.

Utilizing an atmospheric RF driven plasma jet, the dissociation efficiency of CO_2 has been investigated. Helium, argon and different helium-argon admixtures where used as carrier gases for the discharge. As expected, argon leads to a much higher conversion efficiency and lower specific energy inputs (SEI) for dissociation. However, only a small admixture of argon to a helium plasma changes the conversion characteristics of said plasma to an argon-like behaviour, whereas the vibrational temperatures of CO_2 remain unchanged. This points towards a direct dissociation process instead of vibrational pumping prior to dissociation.

P 16.17 Wed 16:30 Empore Lichthof

Plasma Sterilization for Space Applications — •Alisa Schmidt[1], Meike Müller[2], Markus Thoma[1], Hubertus Thomas[2], and Petra Rettberg[3] — [1]I. Physikalisches Institut, Justus-Liebig-Universität, Gießen, Germany — [2]Institut für Materialphysik im Weltraum, Deutsches Zentrum für Luft- und Raumfahrt e.V., Weßling, Germany — [3]Institut für Luft- und Raumfahrtmedizin, Deutsches Zentrum für Luft- und Raumfahrt e.V., Köln, Germany

In the search for extraterrestrial life, decontamination of the surface of spacecraft and lander is of great importance. Since currently used methods – dry heat and hydrogen peroxide – are effective but material damaging for sensitive surfaces, in this contribution the application of cold atmospheric surface micro-discharge (*SMD*) afterglow plasma sterilization for spacecraft decontamination was investigated. Inactivation tests were performed with *Bacillus atrophaeus* spores on stainless steel carriers placed at the bottom of stainless steel tubes with varying heigths and diameters. It could be shown, that spore inactivation was achieved inside the tubes but much slower than outside at a treatment time of $60min$. Furthermore, the height of the diffusion barriers did not result in significant differences in inactivation rates but with increasing diameter the sporicidal effect increased respectively. By operating a fan to circulate the gas in the treatment chamber, higher inactivation rates could be achieved at unchanged treatment times. Moreover, it could be demonstrated, that the method of applying spores to the sample carrier influences the inactivation rate of the plasma treatment.

P 16.18 Wed 16:30 Empore Lichthof

Power measurement and balance of an rf-driven dielectric barrier atmospheric pressure plasma jet — •Tristan Winzer, Natascha Blosczyk, Judith Golda, and Jan Benedikt — Institute of Experimental and Applied Physics, Kiel University, Germany

Atmospheric pressure plasmas have received increasing attention in recent years due to their potential applications in industrial processes and in plasma medicine. Their non-equilibrium characteristics enable treatment of surfaces which are sensitive to heat. For all plasma processes, the power dissipated in the plasma is a key value. Its measurement is a requirement for comparison between different plasma sources, operating conditions and of experimental results with numerical models.

However, the accurate measurement of voltage, current and the phase shift between them is challenging in particular at rf-driven sources due to high frequencies. We therefore designed an experimental setup allowing us to measure these values with high stability and reproducibility. Using an oscilloscope and custom-designed software, we were able to monitor the power dissipated in an rf-driven dielectric barrier discharge operating at atmospheric pressure. The dependence on applied voltage and gas-mixture and a power balance will be presented.

P 16.19 Wed 16:30 Empore Lichthof

Actinometric measurements of an RF-driven atmospheric pressure plasma including calibration of a spectrometer via a tungsten-band lamp — •Natascha Blosczyk, Judith Golda, Tristan Winzer, and Jan Benedikt — Institute of Experimental and Applied Physics, Kiel University, Germany

Atmospheric pressure plasmas have a wide range of usage in surface modification or medicine, because they generate active species such as atomic oxygen. The densities of these species depend on different parameters including gas composition and residence time in the plasma, therefore the influence of those parameters has to be examined. However, the determination of these dependencies is challenging, because many diagnostic methods interfere with the plasma.

In this contribution, an optical spectroscopy measurement of an RF-driven atmospheric pressure plasma jet operated in helium with admixture of oxygen and argon, taking an actinometric approach to measure the atomic oxygen density, is presented. The dependency of the results on total gas flow, position in jet and oxygen admixture is determined using a simplified actinometric approach. Further, the results are compared to those of an improved actinometric calculation taking in consideration additional effects influencing generation and depletion of atomic oxygen.

P 16.20 Wed 16:30 Empore Lichthof

Simulation of pressure increase in HVDC relays during plasma arcing — •Crispin Masahudu Ewuntomah[1] and Jens Oberrath[2] — [1]Institute of Product and Process Innovation, Leuphana University Lüneburg, Germany — [2]Modeling and Simulation, Department of Electric Power Engineering, South Westphalia University of Applied Science, Soest, Germany

During short circuit situations in high voltage direct current (HVDC) relays, plasma arcs are formed. The arcs extremely vaporize the contact spots of the relays such that, significant pressure is built up in the enclosed chambers of the relays. The pressure buildups may lead to explosions. To quantify such buildups, a Panasonic AEV14012 relay is being investigated, using short circuit experimental results and a numerical model established in COMSOL. The thermal plasma parameters derived from the numerical model are used to simulate the time dependent increase of pressure within the enclosed chamber of the relay. The results show the plasma arc formation, time dependent arc evolution, and pressure increase. It is established from the results that; the excessive vaporization of the contacts increases the pressure in the enclosed chamber significantly, which is quantified by the numerical model.

P 16.21 Wed 16:30 Empore Lichthof

Diagnostic of magnetron sputtering deposition in process plasma using thermal probes — •Felix Schlichting, Julia Cipo, and Holger Kersten — Institute of Experimental and Applied Physics, University of Kiel, Germany

In recent studies the intrinsic properties, determined by the I-V characteristics of magnetised films deposited by magnetron sputtering, were correlated with the plasma parameters obtained by passive thermal probe (ptp) measurements [1]. By measuring the energy flux coming from the target and plasma in a magnetron sputtering source, the functional dependence between deposition properties and film properties can be analysed. This knowledge is important in developing memristive devices, used in neuromorphic engineering or image processing algorithms, and for understanding the signal-to-noise ratio in magnetic field sensors. The ptp can simultaneously be used for energy flux measurements and as a planar Langmuir probe, yielding also the electrical properties of the plasma. The parameters have been determined in radial position across the substrate region.

[1] F. Zahari et al., Journal of Vacuum Science & Technology B 37, 061203 (2019)

P 16.22 Wed 16:30 Empore Lichthof

Measurements with a Diagnostic Package for Electric Propulsion Satellite Platforms — •Tony Krüger, Thomas Trottenberg, Alexander Spethmann, and Holger Kersten — Institute of Experimental and Applied Physics, University of Kiel, Germany

To measure the plasma environment of electrically propelled satellites, a novel electric propulsion diagnostic package (EPDP) is currently being developed. Spacecrafts often carry sensitive instruments and other subsystems which might be disturbed or degraded due to the unintended backflow from applied plasma thrusters [1]. With their exhaust plume and its resultant surface-modification effects, these thrusters significantly influence the spacecraft's environment. To gain control of these effects, the EPDP contains a retarding potential analyzer, a planar Langmuir probe, and an erosion sensor to measure relevant plasma parameters [2]. In the course of the Heinrich Hertz (H2Sat) telecommunication satellite financed by the DLR, the EPDP system is currently being developed for its maiden flight on H2Sat, which is scheduled for launch in 2022. This contribution shows up-to-date measurements with the EPDP performed in our ion beam chamber. [1] Trottenberg et al., Development of a Flight Electric Propulsion Diagnostic Package (EPDP) for EP Satellite Platforms, IEPC-2019-345, 36th International Electric Propulsion Conference University of Vienna, Austria, September 15-20, 2019, [2] Wang et al., Deep Space One Investigations of Ion Propulsion Plasma Environment, J. Spacecr. Rockets, vol. 37, pp. 545-555, 2000

P 16.23 Wed 16:30 Empore Lichthof

Combination of a quartz crystal microbalance and a force probe as a diagnostic tool for an ion beam experiment — •Manuel Maas, Mathis Klette, and Holger Kersten — Institute of Experimental and Applied Physics, University of Kiel, Germany

Many properties of a solid surface can be modified by a thin deposited film. One way to deposit thin films is via energetic ions. This method of physical vapor deposition is called sputtering. In order to monitor and optimize this process, different diagnostics are needed. Especially, angular resolved measurements are highly demanded.

A commonly used diagnostic for the deposition process is the quartz crystal microbalance [1]. It is a shear mode resonator which can be used to determine the deposited mass loading. Another diagnostic for sputtering is a force probe [2]. This diagnostic developed in our group uses the deflection of a rod to obtain the applied force. In particular, the deflection is determined by interferometric measurements.

The quartz crystal microbalance and the combined probe are tested in an ion beam experiment by sputtering aluminium and aluminiumoxide. The angular distribution of the sputtered/reflected atoms is measured. To evaluate the obtained data, a simulation based on the software TRIM is used [3].

[1]G. Sauerbrey, Zeitschrift für Physik 155, 206-222 (1959).

[2]Spethmann, A., Trottenberg, T., Kersten, H., Phys. Plasmas 24(2017), 093501.

[3]J. Biersack and L. Haggmark, Nucl. Instrum. Methods 174, 257 (1980).

P 16.24 Wed 16:30 Empore Lichthof

Formation of Zn Nanostructures using Low Energy Ion Beam Sputtering — Alexander Prediger, •Mathis Klette, Thomas Trottenberg, and Holger Kersten — Institute of Experimental and Applied Physics, University of Kiel, Germany

The formation of dune, ripple or dot-like nanostructures on surfaces by low energy ion beam sputtering has been subject to intensive study in the past few decades [1][2]. Most of the research focused on the creation of nanostructures on single crystalline semiconductor materials, such as GaSb, InP, and Si. Only a few studies were performed for metals or amorphous materials.

In this work, we present nanostructures synthesized by an ion beam directed onto amorphous zinc targets. The zinc targets were treated by a 1200 eV argon ion beam for up to 60 minutes under different angles of incidence. The properties and morphology of the samples were studied with contact angle measurements, scanning electron microscopy (SEM) and X-ray photoelectron spectroscopy (XPS). The SEM images show surfaces covered in a grid of tilted needle-like structures. Under certain conditions, samples show spherical clusters at the tip of the needle, likely caused by strong electric fields. The experiment allows to study the influence of ion species, target materials, pressure, ion beam energy, and processing time on these needle-like structures.

[1] R. Gago, et al., Nanotechnology **13**, 304-308 (2002)

[2] F. Frost, A. Schindler, and F. Bigl, Phys. Rev. Lett. **85**, 4116-4119 (2000).

P 16.25 Wed 16:30 Empore Lichthof

On the status of the investigation of the INCA discharge — •Christian Lütke Stetzkamp, Tsanko Vaskov Tsankov, and Uwe Czarnetzki — Institute for Plasma and Atomic Physics, Ruhr University Bochum, D-44780 Bochum, Germany

Recently a novel concept for collisionless electron heating and plasma generation at low pressures was theoretically proposed [1]. It is based on periodically structured vortex fields, which produce certain electron resonances in velocity space. The concept was experimentally realized by the inductively coupled array (INCA) discharge and first experimental results in atomic gas plasmas were presented in [2].

Here, an overview of the recent advances in the analysis of the discharge are given. Experimental results regarding the discharge operation in molecular gases as well as investigation of an alternative electric field configuration proposed in [1] are presented. The future challenges and possibilities of the concept are discussed.

[1] U. Czarnetzki and Kh. Tarnev, Phys. Plasmas 21, 123508 (2014)
[2] Philipp Ahr et al, Plasma Sources Sci. Technol. 27, 105010 (2018)

P 16.26 Wed 16:30 Empore Lichthof

Dynamical and static structure factor of non-ideal ions in quantum plasmas — Zhandos Moldabekov[1,2], •Hanno Kählert[2], Tobias Dornheim[3,2], and Michael Bonitz[2] — [1]Institute for Experimental and Theoretical Physics, Al-Farabi Kazakh National University, Almaty, Kazakhstan — [2]ITAP, Christian-Albrechts-Universität zu Kiel — [3]Center for Advanced Systems Understanding (CASUS), Görlitz

Advances on dense plasma diagnostics [1] should make it possible to probe ion acoustic modes at warm dense matter and dense plasma conditions. This motivates a theoretical investigation of the ionic dynamical structure factor (DSF). We have computed the DSF employing a linearly screened ion potential in molecular dynamics simulations. Electronic correlations were taken into account using local-field corrections in the STLS approximation [2,3]. The range of plasma parameters at which the STLS approximation is applicable for the description of the screening has been defined in Ref. [4]. The impact of electronic correlations on the ionic DSF is elucidated by comparing the STLS based results to MD data with a screened ion potential in the random phase approximation. Finally, the applicability of the Yukawa model for the description of the ionic DSF in dense plasmas is discussed [5].

[1] E. E. McBride *et al.*, Rev. Sci. Instrum. **89**, 10F104 (2018).
[2] K. S. Singwi *et al.*, Phys. Rev. **176**, 589 (1968).
[3] S. Tanaka and S. Ichimaru, J. Phys. Soc. Jpn. **55**, 2278 (1986).
[4] Zh. Moldabekov *et al.*, Phys. Rev. E **98**, 023207 (2018).
[5] Zh. Moldabekov *et al.*, Phys. Rev. E **99**, 053203 (2019).

P 16.27 Wed 16:30 Empore Lichthof

Metadata schemas and ontologies for plasma technology — •Markus M. Becker[1], Steffen Franke[1], Fabian Hoppe[2], Jessica Laufer[1], Lucian Paulet[1], Harald Sack[2], Volker Skwarek[3], Tabea Tietz[2], and Simon Tschirner[3] — [1]INP Greifswald — [2]FIZ Karlsruhe — [3]HAW Hamburg

The necessity and potential of systematic archiving and publication of digital research data is increasingly seen in the scientific landscape. Transparency of research, validation of research results, and the creation of a basis for data-driven science are among the benefits. However, proper labelling of the research data provided and uniform quality criteria are essential factors for the interdisciplinary reuse of data. Recently, a first metadata schema for documentation of research data in the field of applied plasma physics and plasma medicine has been introduced (arXiv:1907.07744). The present contribution discusses planned extensions to this core schema for specific applications and introduces activities aiming at enabling and permanently supporting data-driven research and knowledge transfer in the field of plasma technology. These activities include the development of a plasma ontology for semantic linking of metadata schema elements and objects on the basis of collaborative systems available to the plasma physics community. Furthermore, blockchain technology is used for automated quality checks, transparent data publications, and monitoring of scientific reputation.

The German Federal Ministry of Education and Research (BMBF) funded this work under grant marks 16QK03A, 16QK03B, 16QK03C.

P 16.28 Wed 16:30 Empore Lichthof

Beschleunigung und Fortbewegung von ultrahochenergetischen kosmischen Strahlen — •Jonas Graw, Martin Weidl und Frank Jenko — Max-Planck-Institut für Plasmaphysik

Ultrahochenergetische kosmische Strahlen sind elektrisch geladene Teilchen, die sich mit Energien größer als 10^{18} eV im Kosmos bewegen. Es ist nicht bekannt, wie diese Teilchen zu solch hohen Energien kommen und stellt eines der größten Rätsel der Astrophysik dar. Daher wollen wir die Beschleunigungsmechanismen von kosmischer Strahlung in unserer Forschung analysieren.

Als Quellen ultrahochenergetischer kosmischer Strahlung gelten aktive Galaxienkerne. Diese stoßen Gas parallel zur Rotationsachse mit sehr hohen Energien und Beschleunigungsraten aus. Den emittierten Teilchenstrahl bezeichnet man als Jet. Im Jet werden Schockwellen ausgebildet, in welchen einige Teilchen zu extrem hohen Energien beschleunigt werden. In unserer Forschung verwenden wir astrophysikalische Plasmen mit mehreren Ionenspezies in hochenergetischen Umgebungen. Derzeit untersuchen wir den Phasenraum aus Wellenvektor $\mathbf{k}$ und Kreisfrequenz ω. Dabei analysieren wir die unterschiedlichen Moden, die sich aus analytischen Überlegungen und Simulationen ergeben. Besonders interessant sind dabei die Moden, die nicht im Elektronen-Protonen-Plasma existieren.

Die Beschleunigung von ultrahochenergetischen kosmischen Strahlen hängt dabei maßgeblich mit der Welle-Teilchen-Interaktion mit dem Plasma zusammen. Mit der Analyse des Plasmas wollen wir somit unser Verständnis über die Beschleunigungsmechanismen intensivieren.

P 16.29 Wed 16:30 Empore Lichthof

Atomic computations for plasma and astro physics — •Stephan Fritzsche — Helmholtz Institute, Jena, Germany — Friedrich-Schiller University Jena

JAC [1], the Jena Atomic Calculator, has been developed for performing (relativistic) atomic structure calculations of different kind and complexity. In particular, this code has been designed and worked out to compute not only atomic state functions and properties but also cross sections, rates, angular distributions for a quite large number of atomic processes, including photo ionization and recombination, electron-impact processes and many others. JAC automatically generates self-consistent fields and, hence, is suitable for mass production of atomic data as they are frequently needed in plasma and astro physics. Moreover, further work will support atoms within different plasma models in order to better understand atomic behavior within different environments, from thin to very dense plasma.

[1] S. Fritzsche, Comp. Phys. Commun. 240 (2019) 1.

P 16.30 Wed 16:30 Empore Lichthof

Scattering and absorption diagnostics for nanodusty plasmas — •Harald Krüger and André Melzer — Institute of Physics, University Greifswald

Dusty plasmas with nanoparticles have drawn increased attention in the last few years. Beside the existing experimental setups with nanoparticles grown in the rf discharge, we present the insertion of industrial, nanoscaled dust with a gas jet injection setup.

The confined particles are investigated in terms of size and density distribution by a Mie scattering and absorption spectroscopy setup.

For the determination of the size the angular resolved scattering intensity for perpendicular und parallel polarized incident laser light is recorded. Two different approaches to calculate the resulting size of the particles and their challenges will be discussed.

Simultaneous to the size measurement, particle density measurements have been carried out. Here, the absorption of a broadband light source in the visible spectrum is recorded. Using an Abel inversion algorithm, the spatially resolved particle density distribution can be calculated.

P 16.31 Wed 16:30 Empore Lichthof

Dust Clusters and Dust-Density Waves in Magnetized Dusty Plasmas — •Andre Melzer, Harald Krüger, and Stefan Schütt — Institute of Physics, University Greifswald

The effects of magnetic fields on dusty plasmas have attracted high interest, recently, due to the availability of superconductive magnets for such experiments. Dusty plasmas consist of charged dust particles immersed in a discharge plasma with electrons, ions and neutrals. We now have performed experiments on dusty plasmas under strong magnetic fields.

On the one hand, dust clusters trapped in the sheath of an rf discharge have been Studied for different magnetic field strengths ranging from a few milliteslas to 5.8 T. The dynamics of the dust clusters are analyzed in terms of their normal modes. From that various dust properties such as the kinetic temperature, the dust charge and the screening length are derived.

On the other hand, different dust clouds of micron-sized dust particles are trapped in the sheath of the discharge and the self-excited dust density waves were studied for various magnetic field strengths ranging from 0 mT to about 2 T. From the comparison of the measured wave properties and a model dispersion relation the ion density and the dust charge are extracted.

P 16.32 Wed 16:30 Empore Lichthof

Particle charge determination from configurational temperature — •Michael Himpel and Andre Melzer — Institute of Physics, Greifswald University

The configurational temperature can be used to determine the temperature of a particle crystal from its positions rather than its velocities. This method has been found to yield the same results as the kinetic temperature measured with particle velocities. If both, the positions as well as the velocities, are measured with reasonable accuracy it is possible to extract the underlying particle charge. This poster will show the concept of the configurational temperature and present the application to dusty plasma experiments with the possibility to determine the individual charges of the particles in a two-dimensional cluster.

P 16.33 Wed 16:30 Empore Lichthof

The apokamp: Transient luminous event in physical laboratory — •Vasily Kozhevnikov, Andrey Kozyrev, Aleksandr Kokovin, Alexey Sitnikov, Eduard Sosnin, Victor Panarin, Victor Skakun, and Victor Tarasenko — Institute of High Current Electronics, Tomsk, Russian Federation

In 2016 the group of experimentalists led by Eduard Sosnin has been discovered a novel phenomenon in low-temperature plasma physics: an extended plasma jet developing perpendicular to the bending point of the pulsed arc discharge channel between two electrodes. The discharge has been entitled an apokamp. It was shown experimentally that the apokamp in low-pressure air represents an exact tiny analogue of large-scale stratospheric transient luminous events, e.g. blue jets or sprites depending on the operating pressure. Here we give first theoretical backgrounds for the apokamp phenomenon in terms of deterministic DC-discharge theory. We use so-called two-moment model of a multicomponent discharge plasma to describe a self-sustained periodic discharge in pure oxygen both in the inter-electrode gap and in the surrounding space above the electrodes.