

5 PLASMA PHYSICS

Wednesday, 2. Sept. 2009, Room G

Time	ID	PLASMA PHYSICS <i>Chair: I. Furno, EPFL</i>
09:00		PLENARY SESSION
12:40		Postersession, Lunchbuffet
14:00	501	<p style="text-align: center;">Physics insight from plasma shaping of TCV tokamak plasmas</p> <p style="text-align: center;"><i>Antoine Pochelon, for the TCV Team [1]</i> <i>Ecole Polytechnique Fédérale de Lausanne (EPFL), CRPP, Association Euratom</i> <i>Confédération Suisse, PPB, Station 13, 1015 Lausanne, Switzerland</i></p> <p>Many important plasma performance parameters directly depend on the shape of the plasma cross-section. The unique shaping capability of the TCV tokamak ("Tokamak à Configuration Variable") has been exploited to study different aspects of tokamak transport and stability. TCV can produce plasmas with extreme shapes, elongation up to 2.8 and both negative and positive triangularity from -0.8 to $+1$, and is equipped with 4.5MW of localized Electron Cyclotron Heating (ECH). The TCV tokamak has produced a host of physics results on diverse topics such as core sawtooth instabilities, edge localised modes (ELMs), electron cyclotron heating (ECH) and current drive (CD), plasma control, MHD stability, internal transport barriers (ITB), innovative "snowflake" divertors. A significant fraction of TCV results has benefited from plasma shaping.</p> <p>Energy confinement in TCV has been demonstrated to depend strongly on triangularity in low-collisionality L-mode plasmas, improving towards negative triangularity. The observed dependences of the electron thermal diffusivity on triangularity (direct) and collisionality (inverse) are qualitatively reproduced by nonlinear gyro-kinetic simulations and shown to be governed by Trapped Electron Mode (TEM) turbulence. Both in the linear and non-linear phases, negative triangularity is found to have a stabilizing influence on the TEM by modifying the toroidal precessional drift of trapped electrons that resonantly drive the modes. Both heat transport measurements and gyro-kinetic simulations demonstrate the stabilising effect of electron-ion collisions, a statement further sustained by recent electron temperature turbulence measurements using correlation-ECE.</p> <p style="font-size: small;">This work was supported in part by the Swiss National Science Foundation. [1] A. Fasoli et al., IAEA Fusion Energy Conference, Geneva, Switzerland, October 2008, Paper OV/1-1</p>

14:30	502	<p style="text-align: center;">MHD stability calculations for H-mode plasmas with snowflake divertor configuration</p> <p style="text-align: center;"><i>Andreas Pitzschke¹, Francesco Piras¹, Roland Behn¹, S. Yu Medvedev²</i> ¹ EPFL SB CRPP-GE, Station 13, 1005 Lausanne, Switzerland ² M. V. Keldysh Institute for Applied Mathematics, Russian Academy of Sciences, Miusskaya pl., 4, 125047 Moscow, Russian Federation</p> <p>Recently, experiments on TCV have successfully demonstrated the formation of a snowflake (SF) divertor configuration under conditions of improved confinement (H-mode). This configuration, which is characterized by a 2nd order X-point, has found particular interest, since it offers a possible solution for the reduction of the power loading to the vessel wall and the divertor strike zones. The problem of power loading is serious for future tokamak-type fusion reactors and is aggravated by the presence of MHD instabilities near the plasma edge (ELMs), which cause substantial losses of particles and energy in form of short, intense bursts. These instabilities are driven by pressure gradients and current flows near the edge; the stability limits depend on various plasma parameters, including magnetic topology and shape of the cross section.</p> <p>It has been shown that the change in the magnetic field topology at the plasma boundary by a snowflake divertor results in a significant increase of the safety factor and the magnetic shear at the plasma edge. High magnetic shear at the plasma edge affects the maximum attainable pressure gradients and the threshold for the ELM activity. The MHD stability limits of the SF configuration were computed and are compared to those of the standard X-point configuration (SN). It is found that the SF configuration does not degrade MHD stability and that the current driven kink modes of medium n are even more stable compared to the SN configuration. Starting from plasma equilibria obtained during experiments on TCV, the influence of shaping of the plasma boundary on the stability limits has been investigated. For these simulations the shaping parameters (triangularity and elongation) have been varied within a range compatible with a snowflake configuration.</p>
14:45	503	<p style="text-align: center;">Ignition by laser-induced optical breakdown</p> <p style="text-align: center;"><i>Elisabeth Schwarz, Simon Gross, Balthasar Fischer, Ingo Muri, Johannes Tauer, Heinrich Kofler, Ernst Wintner</i> Vienna University of Technology, Institut für Photonik, Gusshausstrasse 27/387, 1040 Vienna, Austria</p> <p>The optical breakdown in air of atmospheric pressure was investigated at the wavelengths 1064 nm and 532 nm, and using a combination of both radiations, as well. The obtained thresholds for optical breakdown at 1064 nm and 532 nm were compared. Furthermore, the generated plasmas have been characterized by their amount of scattered laser light, energy transmission and temporal transmission. During plasma formation in air, an acoustic pressure wave is generated. The acoustic energy is compared to laser pulse energy and is found to be linearly dependant. Moreover, the frequency distribution of the acoustic pressure waves was analyzed.</p> <p>Furthermore, investigations to analyze details of the focal size dependence of ignition were carried out for different pressures and temperatures. Moreover, an energy balance was drawn to find out the quantity of laser energy deposited in the plasma and to gain information about the losses by scattering and transmission.</p>

<p>15:00</p> <p>time-slot used by 534</p>	<p>504</p> <p>canceled</p>	<p align="center">Laser-produced Plasma EUV Source Development at ETH Zürich</p> <p align="center"><i> Davide Bleiner, Bob Rollinger, Andrea Giovannini, Ndaona Chokani, Reza Abhari, ETH Zürich, Sonneggstrasse 3, 8046 Zürich, Switzerland</i></p> <p>In order to be applied in high volume manufacturing processes, an extreme ultraviolet lithography (EUVL) source must provide the required power, as well as yield long lifetimes of the components. One approach for a source employs the use of a laser produced plasma (LPP) EUV source, whereby a target is irradiated by a laser. At ETH Zürich, a program has recently been initiated to develop & characterize suitable laser-target configurations that have low cost-of-ownership, and to realize debris mitigation techniques that prolong the component lifetimes. For this purpose, at ETH Zürich, a plasma science facility has been constructed to measure the spatial & temporal distributions of radiation & particle fluxes over 4π sr, the inband & full-band emissions, as well as the heat load on collection optics. This facility is complemented by multi-scale computational tools that are used to simulate the LPP from the target length scales (μm) up to the optics length scales (m). We will, in this paper, describe the techniques of this multi-scale computational tool set, and present results for laser-target configurations in which we have examined issues of collector lifetime, debris load and radiation. In synergy with the companion experiments, this computational tool set shall accelerate the development of a EUV light source.</p>
<p>15:15</p>	<p>505</p>	<p align="center">F2-Laser LIBS Analysis of Polymer Materials</p> <p align="center"><i>Johannes Heitz ¹, Juraj Jasik ¹, Johannes D. Pedarnig ¹, Pavel Veis ²</i> ¹ <i>Applied Physics, CD-Lab Laser-Assited Diagnostics, Johannes Kepler University, Altenbergerstrasse 69, 4040 Linz, Austria</i> ² <i>Faculty of Mathematics, Physics and Informatics, Comenius University, Mlynsk. dolina F2, 84248 Bratislava, Slovakia</i></p> <p>Laser-induced breakdown spectroscopy (LIBS) is employed for the detection of trace elements in polyethylene (PE). For effective laser ablation of PE, we use a F2 laser (wavelength 157 nm) with a laser pulse length of 20 ns, a pulse energy up to 50 mJ, and pulse repetition rate of 10 Hz. The optical radiation of the laser induced plasma is measured by a VUV spectrometer with a detection range down to a wavelength of 115 nm. A gated photon-counting system is used to acquire time resolved spectra. The VUV LIBS spectra of PE are dominated by strong emission lines of neutral and ionized Carbon atoms. From time-resolved measurements of the Carbon line intensities, we determine the temporal evolution of the electronic plasma temperature, T_e. For this, we use Saha-Boltzmann plots with the electron density in the plasma, N_e, derived from the broadening of the Hydrogen H-alpha line. With the parameters T_e and N_e, we calculate the intensity ratio of the atomic Sulphur and Carbon lines at 180.7 nm and at 175.2 nm, respectively. The calculated intensity ratios are in good agreement with the experimentally measured results.</p> <p>(The co-operation is performed in the frame of the "Scientific and Technological Agreement WTZ Austria - Slovakia".)</p>

15:30	506	<p align="center">Correct fluid treatment of the collisionless Tonks-Langmuir model with a cold ion source</p> <p align="center"><i>Muhammad Kamran, Siegbert Kuhn</i> <i>Association Euratom-ÖAW, Inst. for Theoretical Physics, Innsbruck University,</i> <i>Technikerstraße 25, 6020 Innsbruck, Austria</i></p> <p>In [Plasma Phys. Control. Fusion 47, 1949 (2005)] a collisionless Tonks-Langmuir discharge model with a cold ion source was studied in a fluid treatment in which the ions were approximated to be cold ($T_i = 0$). In reality, however, the ions are not cold but rather have nonzero effective temperature even if the ion source is cold. In this work we use the kinetic results of [Phys. Plasmas 13, 063508 (2006)] to calculate the correct profiles of the polytropic coefficient $\gamma^i(z) = (dp^i/dn^i)(n^i/p^i) = 1 + (dT^i/dn^i)(n^i/T^i)$ (rather than setting it simply equal to 1 as was effectively done in the first reference), and on this basis formulate and solve a new fluid model yielding the correct profiles of the fluid quantities including the ion temperature $T^i(z)$. We conclude that proper choice of the polytropic coefficient is extremely important for a fluid model to be realistic, and that the usual simple choices ($\gamma^i = \text{const} = 1, 3/2, 3, \dots$) can lead to grossly erroneous results especially near the plasma-sheath boundary.</p>
15:45		
16:00		Coffee Break
		<i>Chair: C. Ionita, Uni Innsbruck</i>
16:30	507	<p align="center">Turbulence in the edge of magnetized plasmas: emergent structures and transport</p> <p align="center"><i>Alexander Kendl¹, Felix Gennrich¹, Josef Peer¹, Stefan Konzett¹, Tiago Ribeiro², Bruce D. Scott²</i> ¹ <i>Institute for Ion Physics and Applied Physics, Universität Innsbruck,</i> <i>Technikerstrasse 25, 6020 Innsbruck, Austria</i> ² <i>Max-Planck-Institut für Plasmaphysik, Boltzmannstrasse 2, 85748 Garching, Germany</i></p> <p>What have the likelihoods for fine weather in summer and for a future use of fusion energy got in common? Both the atmosphere and magnetized fusion plasmas are determined by similar structure formation processes in quasi-two-dimensional periodic nonlinear dynamical systems. Self-organization of waves and vortices on small scales leads to large-scale flows, which are, depending on conditions, either stable for a long time - or can break apart intermittently and expel large vortex structures. Plasma physicists are - similar to meteorologists - therefore interested in accurate predictions of these processes. In the START project "TEMP:EST" gyrofluid and gyrokinetic models for turbulence and structure formation in magnetized plasmas are developed, simulated numerically and compared to experiments. The aim is on a detailed understanding and predictability of the emergence of stable flows in fusion plasmas and the accompanying bursts of turbulence, in particular with a view on the international fusion experiment ITER.</p>

17:00	508	<p style="text-align: center;">Turbulence and Transport in TORPEX Simple Magnetized Toroidal Plasmas</p> <p style="text-align: center;"><i>Ivo Furno, Ambrogio Fasoli, Lucia Federspiel, Davoud Iraj, Etienne Küng, Benoit Labit, Stefan Müller, Gennady Plyushchev, Mario Podesta, Francesca Poli, Paolo Ricci, Christian Theiler</i> CRPP, EPFL, 1015 Lausanne, Switzerland</p> <p>Progress in understanding turbulence and related cross-field transport of fusion relevance is achieved in the simple magnetized plasmas of the TORPEX toroidal device, which provides a test bed for code benchmarking and theory validation. In TORPEX ($R=1\text{m}$, $a=0.2\text{m}$), a small vertical magnetic field $B_z < 4\text{mT}$ is superposed on a toroidal magnetic field $B_t < 100\text{mT}$ to form open helicoidal magnetic field lines, which, similarly to Scrape-Off Layers of fusion devices, feature grad_B and magnetic field curvature. Plasmas of different gases are produced by microwaves (2.45GHz, $P < 10\text{kW}$) with typical electron temperatures $\sim 5\text{-}15\text{eV}$ and densities ranging from $\sim 3^{16}\text{m}^{-3}$ for hydrogen to $\sim 3^{17}\text{m}^{-3}$ for neon. Drift and interchange instabilities are observed and characterized in terms of dispersion relation, driving mechanisms, and non-linear development into turbulence and blobs. At large vertical fields, blobs form from radially elongated structures that are sheared off by the ExB flow. These structures are in turn generated by interchange waves that increase in amplitude and extend radially following an increase of the radial pressure gradient. Using a two-dimensional 86 electrostatic probe array, we investigate the scaling of the cross-field speed upon the blob size and compare the results with semi-analytical blob models. The transport of heat, particles and momentum associated with both the interchange wave and the blobs is quantified. The cross-field transport caused directly by instabilities constitutes a different mechanism from that associated with the blobs. We present also fluid simulations, which, together with an analytical theory, predict the existence of an improved confinement regime with some common features to tokamak observations. The accessibility of this regime on TORPEX is explored by using different gases. This work was supported in part by the Swiss National Science Foundation.</p>
17:15	509	<p style="text-align: center;">Observation of a critical pressure gradient for the stabilization of interchange modes in simple magnetized toroidal plasmas</p> <p style="text-align: center;"><i>Lucia Federspiel, Benoit Labit, Paolo Ricci, Ambrogio Fasoli, Ivo Furno, Christian Theiler</i> EPFL SB CRPP-GE, Station 13, 1015 Lausanne, Switzerland</p> <p>The interchange mode is characterized by $k_{\parallel} \approx 0$ (flute mode) and is driven by pressure gradients in the unfavourable curvature region, i.e. where ∇B and ∇p are colinear. Theory predicts that this instability is driven unstable above a critical pressure gradient.</p> <p>Taking advantage of its flexibility and its high resolution both in space and time for the diagnostic setup, the existence of a critical pressure gradient for the interchange instability is demonstrated in the simple magnetized device TORPEX ($n_e \approx 10^{17}\text{m}^{-3}$, $T_e \approx 10\text{eV}$, $R = 1\text{m}$, $a = 0.2\text{m}$). Starting from a Neon plasma characterized by interchange turbulence, we increase the neutral gas pressure on a shot-to-shot basis. When a critical gas pressure is exceeded, two main changes are observed in the unfavorable curvature region: the pressure profile flattens locally such that the interchange mode previously detected is stabilized and, closer to the edge, the level of fluctuations is reduced by one order of magnitude while the pressure gradient remains almost unchanged. This transition is noticed to occur at</p>

		<p>different critical neutral gas pressures when varying RF power levels and/or vertical magnetic field values: a general trend on this critical pressure value is also deduced.</p> <p>In addition, we show that the critical pressure gradient measured experimentally is in good agreement with predictions made from a linear model for the interchange instability in TORPEX plasmas. Finally, other mechanisms that could contribute to the reduction of the fluctuation level are discussed, including the $E \times B$ velocity shear.</p> <p>This work is partly funded by the Fonds National Suisse de la Recherche Scientifique.</p>
17:30	510	<p style="text-align: center;">I-V Characteristic for a spherical emissive probe in low-density isotropic plasma</p> <p style="text-align: center;"><i>Alif Din, Siegbert Kuhn</i> <i>Association Euratom-ÖAW, Inst. for Theoretical Physics, Innsbruck University, Technikerstrasse 25, 6020 Innsbruck, Austria</i></p> <p>The I-V characteristic of an electron-emitting spherical probe in low-density plasma is calculated analytically and numerically. Assuming that in the plasma-probe transition (PPT) region collisions can be neglected, the charged-particle velocity distribution functions (VDFs) are calculated analytically via trajectory integration of the Vlasov equation. A comprehensive scenario is developed taking into account for each charged-particle species the three possible types of trajectories within the PPT region, namely (i) trajectories entering at the presheath-entrance sphere, (ii) trajectories entering at the probe surface, and (iii) trajectories confined within the PPT region.</p> <p>In a first application, our general trajectory-integration method was specialized to the more restricted situation of a non-emissive probe considered in [I. B. Bernstein and I. N. Rabinowitz, Phys. Fluids 2, 112 (1959)]. Perfect agreement has been found wherever applicable.</p> <p>In the second step we are now including the electrons emitted from the probe surface in addition to the electrons and ions entering the PPT region at the presheath-entrance sphere. By solving Poisson's equation for this three-species system within the PPT region with suitable boundary conditions we will be able to obtain the current-vs.-potential characteristic for the electron-emitting spherical probe in low-density plasma.</p> <p>In this presentation, our comprehensive method will be described and the results obtained will be discussed.</p>

17:45	511	<p>Minimisation of Entropy Production Rate in Photo-Hydrodynamics</p> <p><i>Frank Kassubek, Thomas Christen</i> <i>ABB Schweiz AG, Corporate Research, Im Segelhof, 5405 Baden, Switzerland</i></p> <p>Modelling of radiation transport in media with complex absorption spectra like hot gases or plasmas requires a large effort. In principle, the physics is described by a linear Boltzmann transport equation for the photon distribution function. Due to its large dimensionality, the solution of this equation is however practically very difficult.</p> <p>Instead, moment expansions can be used. By integration of the transport equation over wavenumber space, coupled equations for these moments are obtained. A closure of these equations is necessary to eliminate higher order moments and to obtain transport coefficients like effective absorption coefficients.</p> <p>We suggest to use an entropy production optimisation principle in order to define closure. Such principles, although not being universal physical laws but strictly only valid near thermal equilibrium, have been shown to describe far-from-equilibrium states astonishingly well. In the present case, we show that within a simple two-moment approximation, the proposed procedure delivers the correct absorption coefficients in the analytically known limits (i.e., the Rosseland limit for optically thick media and the Planck limit for optically thin media) and a reasonable interpolation in between without any fit parameter. For grey matter and a simple example of non-grey matter, we compare our results to the frequently used maximum entropy closure.</p> <p>We conjecture that the reason for success of this procedure lies in the linearity of the underlying Boltzmann transport equation.</p>
18:00	512 c a n c e l l e d	<p>Electron density estimates in the plasmasphere with Cluster data</p> <p><i>Clemens Grünberger, Arnaud Masson, ESA / ESTEC, 2311 Leiden, Netherlands</i></p> <p>The European Space Agency Cluster mission is the first multi-spacecraft mission orbiting our near-Earth environment. Four spacecraft simultaneously measure key physical quantities like the magnetic and electric field, electron and ion densities. However, Cluster crosses regions in Space where particle and wave instruments have difficulty sampling some local properties like the thermal electron density of the medium. It is important to indirectly derive such quantities, e.g. by exploiting the correlations between spacecraft-to-probe potential differences and plasma density.</p> <p>Inter-calibration work based on physical models of electron populations around the spacecraft is presented. We demonstrate, that the obtained equations can be used to estimate the electron density above 80 e-/cc in the plasmasphere, a giant torus of plasma co-rotating with the Earth, where no wave measurements are possible. For higher accuracy the changing solar activity has been taken into account.</p>
18:15		END

521 Wavelet analysis of plasma edge turbulence measurements and simulations

*Felix Gennrich, Alexander Kendl, Roman Schrittwieser, Codrina Ionita, Christian Maszl,
Franz Mehlmann
Universität Innsbruck, Institut für Ionenphysik und Angewandte Physik,
Technikerstraße 25/3, 6020 Innsbruck, Austria
AUG Team, Max-Planck-Institut für Plasmaphysik, Boltzmannstraße 2, 85748 Garching,
Germany*

Instabilities and turbulence, which occur in a tokamak, are of high interest in fusion physics and a detailed examination is essential for a successful operation of upcoming fusion experiments. Two dimensional turbulent mixing leads to particle and energy transport perpendicular to the magnetic field and especially the outer parts of a tokamak are subject to various turbulence events, such as Edge Localised Modes (ELMs).

In order to reveal potential similarities or special features, both classical analysis methods and Wavelet methods have been applied on ELM Type-I Langmuir probe measurements at ASDEX Upgrade. Moreover, simulation data obtained with a gyrofluid code have been investigated for comparison reasons.

Wavelet techniques allow a deeper insight into the characteristics of fluctuation data by means of a time-scale representation. Consequently, they provide a reasonable addition to common statistical tools like probability density and correlation functions or Fourier spectrograms, particularly in the case of highly non stationary ELM data.

522**Laser-heated emissive probes for plasmas**

*Codrina Ionita ¹, Roman Schrittwieser ¹, Ronald Stärz ¹, Ramona Gstrein ¹,
Thomas Windisch ², Olaf Grulke ², Thomas Klinger ²
¹ Institute for Ion Physics and Applied Physics, University of Innsbruck, Technikerstr. 25,
6020 Innsbruck, Austria
² Max Planck Institute for Plasma Physics, EURATOM Association, Wendelsteinstr. 1,
17491 Greifswald, Germany*

Precise measurement of the plasma potential is vital for understanding transport phenomena in plasmas. For sufficient electron emission the floating potential of an emissive probe becomes equal to the plasma potential. We have developed a probe consisting of a pin of lanthanum hexaboride of 1,5 mm diameter and 3 mm length. On its tip a laser beam from an infrared diode laser is focused with a wave length of 808 nm and a power up to 50 W. The probe tip can be heated to 2100 K leading to thermionic emission currents sufficient even for the SOL-plasma (scrape-off layer) of mid-sized tokamaks. The probe was tested in the helicon discharge VINETA at IPP Greifswald, using a radially movable shaft, with the laser beam focus always on the pin. Compared to conventional wire loop emissive probes our probe has several advantages, such as higher efficiency, longer lifetime and better time response.

<p>523</p>	<p style="text-align: center;">High frequency phenomena in plasma fireballs</p> <p style="text-align: center;"><i>Codrina Ionita ¹, Roman Schrittwieser ¹, Reiner Stenzel ²</i></p> <p style="text-align: center;">¹ <i>Institute for Ion Physics and Applied Physics, University of Innsbruck, Technikerstr. 25, 6020 Innsbruck, Austria</i></p> <p style="text-align: center;">² <i>Department of Physics and Astronomy, University of California, Los Angeles, P.O. Box 951547, 90095 Los Angeles, United States</i></p> <p>New forms of anode double layers, called "fireballs", have been observed in a thin unmagnetized discharge plasma. A fireball can appear on a small additional electrode biased positively with respect to the unperturbed plasma potential above the ionization potential of the background gas. They are created by excitation and ionization processes in front of the electrode. A double layer separates the fireball from the ambient plasma. By pulsing the electrode voltage the high frequency dynamics of fireballs were investigated. A sharp emission line is observed near the electron plasma frequency, i.e. at 136 MHz. The frequency changes during the density build-up of the fire ball. Weaker emissions are also seen during the density decrease indicated by the Langmuir probe. These electron oscillations may not be produced by beam-plasma interactions since the fireball can be smaller than a plasma wavelength. However, sheath-plasma instabilities may produce such high frequency oscillations.</p>
<p>524</p>	<p style="text-align: center;">Revisiting reflection properties of small hydrocarbons impinging on tungsten and carbon surfaces by means of 3D simulations</p> <p style="text-align: center;"><i>Alan Keim ¹, Nikolaus Endstrasser ¹, Bilal Rasul ¹, Fabio Zappa ², Alexander Kendl ¹, Paul Scheier ¹, Tilmann D. Märk ¹</i></p> <p style="text-align: center;">¹ <i>Institut für Ionenphysik und Angewandte Physik, Technikerstraße 25b/3, 6020 Innsbruck, Austria</i></p> <p style="text-align: center;">² <i>Departamento de Física, Universidade Federal de Juiz de Fora, Instituto de Ciências Exatas, 36036 Juiz de Fora, Brazil</i></p> <p>Sticking coefficients of deuterium on fusion relevant plasma sprayed tungsten (PSW) and carbon fibre composite (CFC) surfaces have been measured in the past for incident energies in the range of about 0-100eV. The samples cut from ASDEX-Upgrade tiles were exposed to a beam of CD₂⁺ at hyperthermal collision energies in a tandem mass spectrometer in Innsbruck. The deuterium content was determined by nuclear reaction analysis ex-situ at IPP Garching before and after exposure. The data obtained were evaluated assuming a collision energy independent ion specimen current. Preliminary ion trajectory simulations carried out by W. Schustereder et al. showed however that incident ion beam currents after passing the focusing lens stack are attenuated by more than a factor of three. Recent simulations reveal also a significant collision energy dependence of this ion specimen current. Therefore energy dependent beam attenuation corrected sticking coefficients are calculated and presented in this work.</p>

<p>525</p>	<p>Nonlinear gyrofluid computation of the ideal ballooning mode ELM scenario in tokamaks</p> <p><i>Alexander Kendl¹, Tiago Ribeiro², Bruce D. Scott²</i></p> <p>¹ <i>Institute for Ion Physics and Applied Physics, Universität Innsbruck, Technikerstrasse 25, 6020 Innsbruck, Austria</i></p> <p>² <i>Max-Planck-Institut für Plasmaphysik, Boltzmannstrasse 2, 85748 Garching, Germany</i></p> <p>The physical mechanisms and scalings of cataclysmic outbursts in high confinement tokamak edge plasmas, which evolve from a macro-scale linear ballooning instability into a fully developed micro-scale turbulent phase during the burst, are analysed numerically. We present gyrofluid simulations of edge localised ideal ballooning mode (ELM) events in the edge pedestal of toroidal magnetised plasmas. The range of scales reaches below the ion gyroradius, and the self-consistent evolution of the equilibrium is taken into account. The necessity of resolution to the ion gyroradius scale is shown directly by consistency checks: converged cases are not otherwise obtained. Even with the finite beta well above the ideal MHD threshold, the results are outside of either the MHD or collisional Braginskii paradigms, on which other approaches are based.</p>
<p>526</p>	<p>Simulations on the influence of rational magnetic surfaces on turbulence in the edge region of a tokamak fusion experiment</p> <p><i>Stefan Konzett¹, Dirk Reiser², Alexander Kendl¹</i></p> <p>¹ <i>Institut für Ionenphysik, Assoziation EURATOM-ÖAW, Technikerstrasse 25, 6020 Innsbruck, Austria</i></p> <p>² <i>Institut für Plasmaphysik, Forschungszentrum Jülich, EURATOM Assoziation, Wilhelm-Johnen-Straße, 52425 Jülich, Germany</i></p> <p>Using local turbulence simulations, the physics of rational magnetic surfaces and their influence on fully developed edge turbulence in a fusion reactor is discussed. In the linear regime rational surfaces are strongly dominated by resonant modes. The question is to what extent this dominance is sustained in strongly turbulent regimes at the edge of a fusion plasma. In this work a local drift fluid turbulence code has been applied. Results show footprints of low rationals in a wide range of parameters, despite a strong dominance of turbulence over linear dynamics. However, within the local drift fluid turbulence model, the findings suggest no substantial influence of rational surfaces on turbulent transport in the edge.</p>
<p>527</p>	<p>Drift waves and instabilities in ultra-cold quantum plasmas</p> <p><i>Cornelia Lechner, Christian Knapp, Alexander Kendl</i></p> <p><i>Institute for Ion Physics and Applied Physics, Universität Innsbruck, Technikerstrasse 25, 6020 Innsbruck, Austria</i></p> <p>Ultra-cold quasi-neutral plasmas merge the physics of strongly coupled plasmas and of ultra-cold quantum gases. Recent experiments have been reported on first observations of ultra-cold plasma waves and instabilities, which are counterparts of well-known drift instabilities in hot plasmas (where they are e.g. responsible for turbulent transport losses in fusion experiments). However, not much attention has yet been devoted to the theory of ultra-cold plasma instabilities. Here we present an analysis of possible theoretical approaches to ultra-cold plasmas, and discuss possible modifications of existing classical approaches by considering strong Coulomb coupling and quantum effects. In particular we discuss implications for the instability of high-frequency drift waves in magnetized ultra-cold plasmas.</p>

<p>528</p>	<p>Local electromagnetic characterization of type I ELMs on ASDEX Upgrade</p> <p><i>Franz Mehlmann¹, Nicola Vianello², Roman Schrittwieser¹, Volker Naulin³, Hans Werner Müller⁴, Matteo Zuin², Codrina Ionita¹, Jens Juul Rasmussen³, Volker Rohde⁴, Roberto Cavazzana², Marc Maraschek⁴, Catalin Lupu¹</i></p> <p>¹ <i>Institute for Ion Physics and Applied Physics, University of Innsbruck, Technikerstr. 25, 6020 Innsbruck, Austria</i></p> <p>² <i>Consorzio RFX, Associazione Euratom-ENEA sulla Fusione, Corso Stati Uniti 4, 35127 Padova, Italy</i></p> <p>³ <i>Association EURATOM/Riso, Technical University of Denmark, Frederiksborgvej 399, 4000 Roskilde, Denmark</i></p> <p>⁴ <i>Max-Planck-Institute for Plasma Physics, EURATOM Association; Boltzmannstr. 2, 85748 Garching b. München, Germany</i></p> <p>Plasma fluctuations in the scrape-off layer (SOL) of ASDEX Upgrade were investigated using a probe, which combines 6 graphite pins, to measure the radial and poloidal electric field and the ion density, and a three-fold pick-up coil, to register magnetic fluctuations in all three spatial directions. The probe was installed on the fast reciprocating midplane manipulator of ASDEX Upgrade, and inserted during H-mode shots. The probe was used to investigate the fine structure of type I ELMs (edge localized modes), observing the turbulent particle flux and density perturbations, correlating them with the magnetic fluctuations. Magnetic signals were analyzed to recognize the possible occurrence of current filaments associated to type I ELMs using techniques imported from astrophysical plasmas, as the evaluation of the hodograph of the perpendicular magnetic perturbations. The analysis shows compatibility with the existence of field-aligned current filaments as predicted by various ELM theories. Furthermore the current filament seems to coincide with the plasma filament observed by the Langmuir probes.</p>
<p>529</p>	<p>Transcranial stimulability of phosphenes by lightning electromagnetic pulses</p> <p><i>Josef Peer, Alexander Kendl</i></p> <p><i>Universität Innsbruck, Technikerstraße 25, 6020 Innsbruck, Austria</i></p> <p>The near electromagnetic environment of natural cloud-to-ground lightning is characterised by a series of transient electric and magnetic pulses. Transient magnetic pulses acting on the human brain are known to elicit visual perceptions when the electric field strengths induced in the visual cortex of the observer exceed threshold values of the order of 20-50 V/m. Various neurophysiological investigations on the characteristics of such phosphenes were done in recent years.</p> <p>The results of numerical computations of lightning electromagnetic pulses were compared with the electric fields induced by magnetic field shapes used in transcranial brain stimulation techniques. A considerable resemblance in duration, field strength, and shape of the induced electric fields was established. The outcome confirms the possibility of the perception of phosphenes for observers within a distance of roughly 100 m from the lightning striking point. Moreover, it enables the interpretation of ball lightning as a hallucination caused by lightning electromagnetic pulses.</p>

<p>530</p>	<p>Simultaneous measurements of edge plasma fluctuations with cold and emissive probes in ISTTOK</p> <p><i>Roman Schrittwieser¹, Christian Maszl¹, Codrina Ionita¹, Carlos Silva², Humberto Figueiredo², Volker Naulin³, Jens Juul Rasmussen³</i></p> <p>¹ <i>Institute for Ion Physics and Applied Physics, University of Innsbruck, Technikerstr. 25, 6020 Innsbruck, Austria</i></p> <p>² <i>Association EURATOM/IIST, Instituto de Plasmas e Fusão Nuclear, Lisbon, Av. Rovisco Pais, 1049 Lisbon, Portugal</i></p> <p>³ <i>Association EURATOM - Risø DTU, Technical University of Denmark, Frederiksborgvej 399, 4000 Roskilde, Denmark</i></p> <p>Edge fluctuations decisively determine losses of fusion plasmas. An array of four staggered emissive and one cylindrical probe was used in ISTTOK (Instituto Superior Técnico TOKamak). The emissive probes consisted of 5 mm long loops of 0,2 mm diameter W-wires heatable to electron emission, while unheated they act as cold probes. The cylindrical probe was biased to ion saturation. The array permits derivation of the radial turbulent flux. The poloidal electric field was taken from the difference between the floating potentials once of two cold probes and once of two emissive probes. The cross correlation between two emissive and two cold probes shows qualitatively the same behaviour. For the emissive probes, inside the limiter the signals are highly correlated which indicates a lower level of turbulence. With increasing radius the correlation decreases. This can be associated with a de-correlating shear layer. Investigations on intermittent events exhibit clear differences in the potential measured by emissive and cold probes. The former reveal more details of fluctuations than cold probes.</p>
<p>531</p>	<p>Monte Carlo Simulations for Hydrocarbon Break-Up and Transport in Scrape-Off Layer plasmas</p> <p><i>Josef Seebacher¹, Detlev Reiter², Alexander Kendl¹, Siegbert Kuhn³</i></p> <p>¹ <i>Institute for Ion and Applied Physics, University of Innsbruck, Technikerstrasse 25, 6020 Innsbruck, Austria</i></p> <p>² <i>Institute for Energy Research - Plasma Physics, Forschungszentrum Jülich, 52425 Jülich, Germany</i></p> <p>³ <i>Institute for Theoretical Physics, University of Innsbruck, Technikerstrasse 25, 6020 Innsbruck, Austria</i></p> <p>In modern tokamaks plasma-wall interaction processes can lead to formation of hydrocarbon molecules directly at material surfaces. For understanding the break-up of these molecules, which penetrate into the plasma, molecular physics data bases are required. For this purpose hydrocarbon molecules are studied by the group of T. D. Märk and P. Scheier at the Institute for Ion and Applied Physics. The transport of the molecular ions resulting from the break up processes of the hydrocarbons is significantly influencing their final deposition in the plasma. Kinetic Monte Carlo codes provide a tool for the simultaneous treatment of chemistry and transport. One of these codes is EIRENE (www.eirene.de) which has been expanded by new physics modules recently (PhD work of the responsible author) and now allows a unified description of neutrals, ions and photons in one unified code. Simulation results of methane gas puff modelling for real tokamaks will be presented.</p>

532	<p style="text-align: center;">Long time evolution of fast ion distributions in MHD-active tokamak plasmas</p> <p style="text-align: center;"><i>Thomas Gassner ¹, Klaus Schöpf ¹, Simon Pinches ²</i></p> <p style="text-align: center;"><i>¹ Institut für Theoretische Physik, Universität Innsbruck, Technikerstraße 25, 6020 Innsbruck, Austria</i></p> <p style="text-align: center;"><i>² EURATOM/UKAEA Fusion Association, Culham Science Centre, 14000 Abingdon, Oxfordshire, United Kingdom</i></p> <p>Fast ions in tokamak plasmas appear as a consequence of external heating and of fusion reactions. Modelling their behaviour in magnetically confined plasmas is a challenging task, since transport codes available for longer time simulation do not incorporate effects occurring on a short time scale such as perturbations by MHD modes. Codes describing these latter effects, however, are associated with the disadvantage of error accumulation for longer integration times. For that we propose here a modelling technique that combines two computational schemes, namely the HAGIS code for calculating fast ion re-distributions during MHD perturbations and the Fokker-Planck code FIDIT for simulating the evolution of the distributions between MHD-active periods. To switch accordingly between the codes proper stabilization/destabilization criteria are established. As a first test for the model we examine fast triton distributions generated by NBI in a specific JET discharge with fishbone mode activity.</p>
533	<p style="text-align: center;">Fractional fast ion transport in magnetically confined plasmas</p> <p style="text-align: center;"><i>Majid Khan, Klaus Schöpf, Victor Goloborod'ko, Victor Yavorskij</i></p> <p style="text-align: center;"><i>Institute for Theoretical Physics, University of Innsbruck, Technikerstr. 25, 6020 Innsbruck, Austria</i></p> <p>Using the symplectic method for orbit following integration a Chirikov-like particle motion is simulated to demonstrate the fractional nature of transport when the particle motion alters from stable trajectories to stochastic behavior. We refer to the model Hamiltonian $H=0.5r^2+Z\cos\vartheta \sin^m t$ with Z determining the perturbation strength and the parameter m taken at a high value about 30 to resemble the periodic δ function in Chirikov's model. Resorting to Hamiltonian motion invariants we calculate the standard mapping trajectory structure which reveals that, in some specific regions, the mean-square radial displacement $\langle (r-r_0)^2 \rangle$ of particles scales in time from t^1 to $t^{1.2}$ for $0.5 \leq Z \leq 1.5$, hence verifying there the fractional nature of transport. Next we applied this method to describe fast ion drift motion in tokamaks, particularly investigating the effect of coexisting perturbations on fast ion confinement.</p>

Measurement of electron density fluctuations in the TCV tokamak

*Cornelis de Meijere, Stefano Coda, Alessandro Marinoni
EPFL SB CRPP-GE, Station 13, 1015 Lausanne, Switzerland*

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Turbulence is an important mechanism for transport in fusion plasmas and one of the outstanding problems in classical physics. To study density fluctuations on TCV, two new diagnostics are being installed. Firstly, a tangential phase contrast imaging (PCI) system is now in the final stages of installation. The system employs a CO₂ laser beam traversing the plasma nearly parallel to the magnetic field and measures the line integral of electron density fluctuations along 24 chords with high temporal resolution. It resolves wave vectors from 0.17cm and is unaffected by gradients in the background density. The crucial merit of the tangential geometry is that by appropriate spatial filtering of the beam the integration length can be reduced to a few centimeters in some cases, thereby localizing the measurement. Rotating the filter moves the selected volume along the beam, which can also be translated radially over a few centimeters. Together with the flexibility of plasma positioning in TCV these features allow access to a large part of the poloidal cross section. Secondly, a simple reflectometer is currently in use on TCV. Two static sources (70GHz and 78GHz) are available and the system employs homodyne detection. Its main use is Xmode Doppler reflectometry to measure poloidal rotation. These diagnostics allow characterization of density fluctuations in TCV in the plasma edge and core, for the different regimes that TCV has access to, including exotic configurations such as the snowflake shaped divertor, which is currently being explored on TCV. Finally, the wide variety of shapes that TCV plasmas can take make this device particularly well suited for a systematic exploration of the effect of plasma shape on turbulence.