International Helmholtz
Graduate School
for Plasma Physics

HEPP Colloquium @ DPG-AMOP 2014

Book of Abstracts

SOC:

M. S. Weidl, C. Killer & S. S. Cerri

19-20 March 2014, Humboldt Universität, Berlin

INP Greifswald

Contents

Chapter 1

HEPP Colloquium timetable

1.1 HEPP Colloquium 2014 – day I

1.1.1 Social Event

- **Date**: Wednesday March 19th
- **Time**: 09:00 - 10:30
- **Chair**: Carsten Killer
- **Event**: ***Berliner Unterwelten - "Dark Worlds" Tour***
- **Place**: Brunnenstr. 105, Subway Station "Gesundbrunnen"
- **Meeting point and time**: We meet at **08:30** in the **hotel lobby**. Gesundbrunnen is just a short subway ride from Alexanderplatz.

1.1.2 Helmholtz Graduate School for Plasma Physics I

- **Location**: Spandauer Str. 1 (SPA) HS202
- **Date & Time**: Wednesday, March 19th, 14:00–16:05
- **Session ID**: P16
- **Chair**: Carsten Killer

P16: Helmholtz Graduate School for Plasma Physics I

14:00–14:25	P16.1	*Transport analysis of high radiation and high density plasmas at ASDEX Upgrade*	L. Casali (IPP, GAR)
14:25–14:50	P16.2	*Nitrogen migration and retention in ASDEX Upgrade*	G. Meisl (IPP, GAR)
14:50–15:15	P16.3	*Non-equidistant Particle-In-Cell for Ion Thruster Plume simulation*	J. Duras (EMAU, HGW)
15:15–15:40	P16.4	*Algorithm development for safeguarding the Wendelstein 7-X divertor during steady state operation*	A. Rodatos (IPP, HGW)
15:40–16:05	P16.5	*Recent progress in studying the dynamics of finite 3D dust clouds*	A. Schella (EMAU, HGW)

1.1.3 Poster Session – Helmholtz Graduate School for Plasma Physics

- **Location**: Spandauer Str. 1 (SPA), Foyer
- **Date & Time**: Wednesday, March 19th, 16:05–18:30
- **Session ID**: P17

P17: Poster Session – Helmholtz Graduate School for Plasma Physics

P17.1	*Acceleration of test particles in imbalanced magneto-hydrodynamic turbulence*	M. S. Weidl (IPP, GAR)
P17.2	*The role of collisions in 2D gyrokinetic turbulence: the freely decaying electrostatic case*	S. S. Cerri (IPP, GAR)
P17.3	*Exploration of radiation cooling for startup plasmas at Wendelstein 7-X with EMC3-EIRENE simulations*	F. Effenberg (FZJ)
P17.4	*Reconstruction of q-profiles using Monte-Carlo-technique*	A. Bock (IPP, GAR)
P17.5	*Preconditioning for Eigenvalue Computations in Gene*	J. Braeckle (TUM)
P17.6	*Upgrade of the Edge Charge Exchange System at the ASDEX Upgrade tokamak*	M. Cavedon (IPP, GAR)
P17.7	*Towards non-linear simulations of full ELM crashes in ASDEX Upgrade*	A. Lessig (IPP, GAR)
P17.8	*Numerical Methods for 3D Tokamak Simulations using a Flux-Surface independent Grid*	A. Stegmeier (IPP, GAR)
P17.9	*First Turbulence Measuremenents using Poloidal Correlation Re ectometry at AUG*	D. Prisiazhniuk (IPP, GAR)
P17.10	*Poloidal asymmetries of heavy impurities in the ASDEX Upgrade plasma*	T. Odstrcil (IPP, GAR)
P17.11	*Experimental study of the radial structure of turbulence with a ultra-fast sweeping reflectometer in ASDEX Upgrade*	A. Medvedeva (IPP, GAR)

continue...

P17.12	*Negative ion formation in Ion-Molecule collisions*	A. Ebanezar John (EMAU, HGW)
P17.13	*Electromagnetic simulations of tokamaks and stellarators*	M. Cole (IPP, HGW)
P17.14	*Numerical studies for the nuclear fusion reactor Wendelstein 7-X*	H. Hölbe (IPP, HGW)
P17.15	*Experimental investigations on the dust density distribution in spatially extended dust clouds*	C. Killer (EMAU, HGW)
P17.16	*Selective fluid mode excitation in finite 3D Yukawa-ball*	M. Mulsow (EMAU, HGW)
P17.17	*Possibility of a Kondo resonance at the wall recombination of positive ions*	M. Pamperin (EMAU, HGW)
P17.18	*Time-resolved measurements of cluster mass distribution in a pulsed gas aggregation system*	S. Drache (EMAU, HGW)
P17.19	*Stellarator-specific developments for the systems code PROCESS*	F. Warmer (IPP, HGW)
P17.20	*Einfluss von Alfvén Eigenmoden und Ionenzyklotronheizung auf die schnelle Ionen-Verteilung im Tokamak ASDEX Upgrade*	M. Weiland (IPP, GAR)
P17.21	*Investigation of mass selected poly-anionic clusters by laser excitation and photoelectron spectroscopy*	M. Müller (EMAU, HGW)
P17.22	*Modelling the effect of resonant magnetic perturbations in ASDEX Upgrade with the extented MHD code XTOR-2F*	J. Griesshammer (IPP, GAR)

1.2 HEPP Colloquium 2014 – day II

1.2.1 Helmholtz Graduate School for Plasma Physics II

- **Location**: Spandauer Str. 1 (SPA), HS202
- **Date & Time**: Thursday, March 20th, 10:30–12:30
- **Session ID**: P22
- **Chair**: Martin Simon Weidl, Silvio Sergio Cerri

P22: Helmholtz Graduate School for Plasma Physics II

		Invited Talk	
10:30–11:15	P22.1	*Cosmic rays*	R. Schlickeiser (RUB)
11:15–11:40	P22.2	*Block Structured Grids for GENE (Gyrokinetic Electromagnetic Numerical Experiment)*	D. Jarema (TUM)
11:40–12:05	P22.3	*Interaction between the neoclassical equilibrium and ITG turbulence in gyrokinetic simulations*	M. Oberparleiter (IPP, GAR)
12:05–12:30	P22.4	*Nonuniversal power-law spectra in turbulent systems*	V. Bratanov (IPP, GAR)

1.2.2 HEPP students' internal meeting

- **Date**: Thursday March 20th
- **Time**: 19:30–20:30
- **Chair**: Silvio Sergio Cerri, Martin Simon Weidl
- **Place**: "***White Trash Fast Food***", Schönhauser Allee 6-7, 10119 Berlin
- **Meeting point and time**: we meet at **19:00** in the **hotel lobby** (the place is at ∼15 minutes walking from the hotel, according to Google Maps).

Chapter 2

Abstracts

2.1 Talk abstracts

Day I

(P16.1)
Transport analysis of high radiation and high density plasmas at ASDEX Upgrade

L. Casali, M. Bernert, R. Dux, R. Fisher, A. Kallenbach, O. Kardaun, B. Kurzan, P. Lang, A. Mlynek, R. McDermott, F. Ryter, M. Sertoli, G. Tardini, and H. Zohm – Max-Planck-Institut für Plasmaphysik, EURATOM-Assoziation, Boltzmannstr. 2, D-85748 Garching

Future fusion reactors will operate under more demanding conditions compared to present devices. They will require high divertor and core radiation by impurity seeding to reduce heat loads on divertor target plates. In addition, high core densities are required to reach adequate fusion performance. These scenarios are addressed at the ASDEX Upgrade tokamak. Here we present the transport analysis of such scenarios. Plasmas with high radiation by impurity seeding: a non coronal radiation model was developed and compared to the bolometric measurements in order to provide a reliable radiation profile for transport calculations. Power balance analyses taking into account the radiation distribution show no change in the core transport during impurity seeding. High density plasmas with pellets: very good agreement between experimental values and transport calculations is found. Both reveal that τ_E remains constant despite the density increase. Hence the density dependence of ITER98 ($\tau_E \sim n_e^{0.41}$) is not adequate to describe this regime. The kinetic profiles reveal a transient phase at the pellet start due to a slower density build up compared to the temperature decrease. The low particle diffusion can explain the confinement behaviour.

(P16.2)
Nitrogen migration and retention in ASDEX Upgrade

G. Meisl[1], K. Schmid[1], M. Oberkofler[1], K. Krieger[1], S.W. Lisgo[2], L. Aho-Mantila[3], F. Reimold[1], V. Rohde[1], and ASDEX Upgrade Team[1] – [1]Max-Planck-Institut für Plasmaphysik, EURATOM-Assoziation, Boltzmannstr. 2, 85748 Garching, Germany ; [2]ITER Organization, FST, Route de Vinon, CS 90 046, 13067 Saint Paul Lez Durance Cedex, France ; [3]VTT, FI-02044 VT

To limit the power load in high-power plasma operation, impurity seeding is mandatory. Nitrogen has been established as optimal choice in ASDEX Upgrade. However, as N is subject to wall pumping, a self-consistent model of the N source flux distribution is required.

N retention in tungsten was studied in laboratory experiments under well-defined exposure conditions. The applicability of the so established model of W-N interaction was tested by experiments in ASDEX Upgrade. W samples were exposed to plasmas with and without N seeding and analyzed by ion beam analysis. Using these data as boundary condition, N transport and re-distribution in the plasma were studied by self-consistent WallDYN-DIVIMP modelling. The dynamic change of the N erosion source at plasma exposed W surfaces was then computed by WallDYN using an improved W-N surface model. First simulations show, in agreement with the experiment, a strong rise of the N re-erosion flux within the first second. By this approach the experimental results from sample analysis, spectroscopy and N pumped by the vacuum system can be interpreted for the first time within a unified self-consistent model.

(P16.3)
Non-equidistant Particle-In-Cell for Ion Thruster Plume simulation

J. Duras – Ernst-Moritz-Arndt Universität Greifswald, D-17489, Germany

The interaction of ion thrusters and satellites is determined by the plume plasmas. Since the mean free paths are such that the probability for collisions relaxing the distribution functions to Maxwellians is quite low, a correct model of the plume plasma has to be kinetic. Unfortunately, the well-established Particle-In-Cell (PIC) method is only momentum conserving and free of artificial self forces in the case of equidistant meshes. This allows only small domains for the plume due to computational time restrictions. Those simulations suffer from the strong influence of the solution from the boundary conditions at the end of the plume domain.

In the outer plume the densities of electrons and ions decrease by 4-8 magnitudes compared with the thruster channel. This leads to an increasing Debye length, which gives the possibility to enlarge the domain by using a non-equidistant grid. Therefore, momentum and energy conservation in 1D electrostatic PIC codes using non-equidistant grids are studied. A modified two point central difference scheme for non-equidistant grids is suggested, which can be proven analytically and numerically to give the exact solution for the electrical field. In addition a 2D axis-symmetric Poisson solver for non-equidistant grids using the Finite Volume Method is presented.

(P16.4)
Algorithm development for safeguarding the Wendelstein 7X divertor during steady state operation

A. Rodatos[2], M. Jakubowski[2], H. Greuner[1], G. A. Wurden[3], and T. Sunn Pedersen[1]1 – [1]Max-Planck-Institut für Plasmaphysik, EURATOM-Assoziation, Boltzmannstr. 2, D-85748 Garching ; [2]Max-Planck-Institut für Plasmaphysik, EURATOM-Assoziation, Wendelsteinstr. 1, D-17491 Greifswald ; [3]Los Alamos National Laboratory, Los Alamos, NM 87544 USA

The divertor of Wendelstein 7X is designed to withstand steady state heat fluxes of $10\,MW/m^2$ and $15\,MW/m^2$ transiently [1]. However higher local heat fluxes are possible. 10 thermographic infrared (IR) observation systems will be installted to monitor the divertor and its center goal is the detection of overheated areas in real time. Besides an increased plasma heat flux, there are at least two potential causes of an elevated diverter surface temperature. First redeposited eroded material forming surface layers with a poor thermal connection to the underlying water-cooled tiles [2]. Second, delaminated CFC tiles will exhibit an elevated surface temperature relative to properly bonded tiles. Using the measured characteristic time scales for the thermal response, gained from experiments at GLADIS[3], we have concluded that it is possible to distinguish between healthy, delaminated, surface-coated and delaminated surface-coated tiles.

[1] H. Greuner, et al., Fusion Technology **Vol. 1** (1998) 249
[2] A. Herrmann, et al., Phys. Scr. **T128** (2007) 234
[3] H. Greuner, et al., J. Nucl. Mater. **367-370** (2007) 1444

(P16.5)
Recent progress in studying the dynamics of finite 3D dust clouds

A. Schella, M. Mulsow & A. Melzer – Institut für Physik, Ernst-Moritz-Arndt-Universität Greifswald, 17489 Greifswald, Germany

Dusty plasmas had become a versatile model system to study diverse physical concepts at the kinetic level since individual particles can be traced by means of video microscopy. One decade ago, Arp et al. conducted groundbreaking experiments with a finite number of harmonically trapped dust particles in a plasma. Due to their mutual particle-particle interaction and their shell-like structures, these 3D dust clouds are termed Yukawa balls. In these finite ensembles volume effects and boundary related effects are always competing, making a quantitative physical description a challenging task.

In my contribution, I will focus onto recent progress in studying the dynamics of finite dust clouds. Here, laser heating is a generic approach drive these systems to the fluid state. During the last years, not only the associated phase transition, but moreover statistical properties of dust clouds were explored. There, a close relationship between transport and disorder even in finite ensembles was demonstrated. Furthermore, I will emphasize the role of dust clusters in studying the recrystallization process of finite matter by means of experiments.

Financial support via SFB TR-24 and HEPP is gratefully acknowledged.

Day II

(P22.1)
[Invited] Cosmic rays

R. Schlickeiser – Institut für Theoretische Physik, Lehrstuhl IV: Weltraum- und Astrophysik, Ruhr-Universität Bochum, 44780 Bochum

Cosmic rays denote a population of cosmic charged particles with individual particle energies up to 10^{20} eV. The nonthermal emission processes of cosmic ray nucleons and electrons dominate the photon emission in many astrophysical sources. In the tutorial the fundamentals of cosmic ray astrophysics are reviewed, stressing the importance of electromagnetic acceleration and transport processes in magnetized systems (as the interplanetary and interstellar medium) with ordered magnetic fields $B_0 \gg \delta B \gg \delta E$ being much greater than the turbulent magnetic and electric field components. The ordering $B_0 \gg \delta B \gg \delta E$ necessary for explaining the observed near isotropy of cosmic rays, is the basis for a perturbation scheme leading to the modified diffusion-convection cosmic ray transport equation that describes all electromagnetic acceleration and transport processes discussed today. In unmagnetized cosmic systems (such as the intergalactic medium) a similar peturbation scheme based on $\delta B \gg \delta E$ can be developed. Understanding cosmic $(\delta B, \delta E)$-fluctuations in space plasmas therefore is of crucial importance e.g. the role of collective and noncollective modes and wave-like, weakly-propagating and aperiodic fluctuations. The similarities and differences to the transport theory in magnetized fusion plasmas are highlighted.

(P22.2)

Block Structured Grids for GENE (Gyrokinetic Electromagnetic Numerical Experiment)

H.-J. Bungartz[2], T. Görler[1], D. Jarema[2], F. Jenko[1], T. Neckel[2] & D. Told[1] – [1]Max-Planck-Institut für Plasmaphysik, EURATOM-Assoziation, Boltzmannstr. 2, D-85748 Garching ; [2]Scientific Computing in Computer Science, Technische Universität München, Boltzmannstr. 3, 85748 Garching

In its global version, GENE computes the evolution of the particles distribution function in a five-dimensional space, whose geometrical part spans over a large part of a plasma confinement device. The temperature of the plasma may vary strongly inside the confinement device, leading to different properties of the background distribution functions in the velocities space. More specifically, in regions of high temperature, there are more particles showing high velocity values, corresponding to a distribution function with long wings and a smooth peak at the mean velocity value, whereas the distribution function for regions of relatively low temperature displays a sharp peak. Constructing a rectangular Cartesian grid requires thus a big interval of velocity values to account for the fast particles and a fine resolution to resolve the sharp peak. This leads to a considerable increase in the number of points of the five-dimensional regular grid, and makes computations slow and inefficient. We develop block-structured grids that are adjusted to the temperature profiles and have a significantly reduced number of points in comparison to rectangular grids, resulting in faster global plasma gyrokinetic simulations.

(P22.3)

Interaction between the neoclassical equilibrium and ITG turbulence in gyrokinetic simulations

M. Oberparleiter & F. Jenko – Max-Planck-Institut für Plasmaphysik, EURATOM-Assoziation, Boltzmannstr. 2, D-85748 Garching

While the fundamental theory of neoclassical transport in magnetic confinement devices was established decades ago, it still holds a number of relevant open questions. We use the gyrokinetic code GENE to investigate a potential interaction mechanism between turbulent and neoclassical physics via modifications of the zonal flow pattern by the neoclassical radial electric field. As a model system, an external sinusoidal electrostatic potential is imposed on ITG turbulence in the flux tube limit. This allows us to study the impact of long and intermediate wavelength radial electric fields on turbulent structures for a wide range of paremeters. Based on these results radially global simulations with and without neoclassical effects are performed to investigate the impact of the true neoclassical radial electric field. Additionally, we test some of the analytical propositions how neoclassical transport is modified near the magnetic axis, where the orbit width becomes of the order of the minor radius of the flux surface. In particular, a heat source localised on the axis is used to show the nonlocality of the ion heat transport.

(P22.4)

Nonuniversal power-law spectra in turbulent systems

V. Bratanov[1], F. Jenko[1], D. Hatch[2] & M. Wilczek[3] – [1]Max-Planck-Institut für Plasmaphysik, EURATOM-Assoziation, Boltzmannstr. 2, D-85748 Garching ; [2]Institute for Fusion Studies, University of Texas at Austin, Austin TX 78712, USA ; [3]Department of Mechanical Engineering, The Johns Hopkins University, 3400 NorthCharles Street, Baltimore MD 21218, USA

Turbulence is generally associated with universal power law spectra in scale ranges without significant drive or damping. Although many examples of turbulent systems do not exhibit such an inertial range, power law spectra may still be observed. In search for simple models exhibiting such a behavior, we first consider a modified version of the Kuramoto-Sivashinsky equation. By means of semi-analytical and numerical studies, one finds power laws with nonuniversal exponents at high wave numbers if the ratio of nonlinear and linear time scales is (roughly) scale-independent. As a further step we examine a two-dimensional fluid model with intrinsic drive and an additional cubic nonlinearity possessing a damping effect. Our analysis reveals again nonuniversal power laws that depend on the linear parameters.

2.2 Poster abstracts

(P17.1)

Acceleration of test particles in imbalanced magnetohydrodynamic turbulence

M. S. Weidl[1,2], B. Teaca[2,3,4] & F. Jenko[1,2] – [1]Max-Planck-Institut für Plasmaphysik, EURATOM-Assoziation, Boltzmannstr. 2, 85748 Garching, Germany ; [2]Max-Planck/Princeton Center for Plasma Physics ; [3]Applied Mathematics Research Centre, Coventry University, Coventry CV1 5FB, United Kingdom ; [4]Max-Planck-Institut für Sonnensystemforschung, Max-Planck-Str. 2, 37191 Katlenburg-Lindau, Germany

The spatial structure and the strength of the turbulent electric field in a plasma are strongly affected by cross-helicity, a quantity which measures the level of alignment of the velocity and the magnetic field. Although often neglected in numerical magnetohydrodynamic (MHD) simulations, cross-helicity can reach significant values in many astrophysical plasmas, such as the solar wind.

We study the transport and acceleration properties of charged particles in plasmas with non-zero cross-helicity, or imbalanced turbulence, by performing test particle simulations in parallel with three-dimensional MHD simulations. The cross-helicity level of the MHD steady-state is controlled by using a correlated forcing scheme for velocity and magnetic fields. We discuss the decrease of the turbulent heating rate in systems with non-zero cross-helicity and compare its scaling with theoretical predictions. Our results are expected to be relevant for any plasma in which turbulent heating is important, for example the heating of dust particles in the interstellar medium.

(P17.2)

The role of collisions in 2D gyrokinetic turbulence: the freely decaying electrostatic case

S. S. Cerri, A. Bañón Navarro, H. Doerk, D. Told & F. Jenko – Max-Planck-Institut für Plasmaphysik, EURATOM-Assoziation, Boltzmannstr. 2, D-85748 Garching

Turbulence in weakly collisional magnetized plasmas is one of the most fascinating and challenging topics, both for astrophysical and laboratory plasmas. In this context, collisional gyrokinetic theory plays an important role.

We present a study of freely-decaying 2D electrostatic turbulence on the sub-ion Larmor scale by means of numerical simulations with the gyrokinetic code GENE [1]. The effect of the collisionality regime on the turbulent spectra is here systematically investigated. In the low collisionality regime, we show an excellent agreement with the existing analytical theory [2,3] and previous numerical investigations [4–6]. However, we find deviations from the theory for increasing collision frequency. In this intermediate collisionality regime, non-universal power laws due to multiscale dissipation arise.

[1] GENE webpage: `gene.rzg.mpg.de`
[2] Schekochihin et al., *Plasma Phys. Control. Fusion* **50**, 124024 (2008)
[3] Plunk et al., *J. Fluid Mech.* **664**, 407 (2010)
[4] Tatsuno et al., *Phys. Rev. Lett.* **103**, 015003 (2009)
[5] Tatsuno et al., *J. Plasma Fusion Res.* **9**, 509 (2010)
[6] Tatsuno et al., *Phys. Plasmas* **19**, 122305 (2012)

(P17.3)

Exploration of radiation cooling for startup plasmas at Wendelstein 7-X with EMC3-EIRENE simulations

F. Effenberg[1], Y. Feng[2], S. Bozhenkov[2], H. Frerichs[1], H Hölbe[2], D. Reiter[1], O. Schmitz[1] & T. S. Pedersen[2] – [1]Institute of Energy and Climate Research - Plasma Physics, Forschungszentrum Jülich GmbH, Association EURATOM-FZJ, Partner in the Trilateral Euregio Cluster, 52425 Jülich, Germany ; [2]Max-Planck Institute for Plasma Physics, Association EURATOM-IPP, 17491 Greifswald, Germany

The stellarator Wendelstein 7-X will use a limiter configuration in the first plasma operation phase. In this field configuration the edge does not include magnetic islands and the scrape-off layer is defined by five poloidal graphite limiters at the toroidal symmetry planes. Exploring options to reduce the heat flux to these components is important for optimization of the performance and duration of these first plasmas.

The 3D plasma transport Monte-Carlo code EMC3-EIRENE is based on a fluid model for electrons and ions, on a kinetic model for neutral particles, and a simplied fluid approach for impurity ions. For startup plasmas with heating power up to 5 MW, plasma transport simulations are performed taking impurities due to carbon sputtering from the limiters into account. The reduction of heat load to plasma facing components by radiative cooling is investigated with respect to intrinsic carbon and active injected nitrogen.

(P17.4)

Reconstruction of q-profiles using Monte-Carlo-technique

A. Bock[1], J. Stober[1], R. Fischer[1], P. Mc Carthy[2], M. Reich[1] & ASDEX Upgrade Team[1] – [1]Max-Planck-Institut für Plasmaphysik, EURATOM-Assoziation, Boltzmannstr. 2, 85748 Garching, Deutschland ; [2]Department of Physics, University College Cork, Cork, Ireland

The helicity of magnetic field lines is an important property of equilibrium states of magnetically confined plasmas. It can be expressed through so-called q-profiles and has decisive influence not only on transport of heat and particles in the plasma, but also on its stability.

Typically magnetic equilibria are being calculated through iterative techniques where the solutions of the Grad-Shafranov-equation are being varied until the result is in sufficient agreement with the experimentally measured quantities. Aside from physical data, other less physical aspects like the choice of basis functions play a role which can make these techniques biased. Sampling possible equilibria using Monte-Carlo-simulations can yield more unbiased results.

This poster gives and overview over the basics of equilibrium reconstruction, describes a new reconstruction technique for q-profiles/equilibria based in Monte-Carlo-simulations and compares it with previous results.

(P17.5)
Preconditioning for Eigenvalue Computations in Gene

J. Braeckle & T. Huckle – TU Muenchen, Fakultät für Informatik, Boltzmannstr. 3, D-85748 Garching

In the Plasma Turbulence Code Gene, turbulences are examined by finding the rightmost eigenvalues of the linear gyrokinetic operator. Finding these inner eigenvalues with the Jacobi- Davidson method requires an iterated solving of shifted linear systems $(I - uu^*)(A - \lambda_k I)(I - uu^*)x_k = b_k$ (restriced to the subspace orthogonal to u) with a non-hermitian matrix A given as an implicit operator and changing eigenvalue approximations λ_k of A. With λ_k being a good approximation of an eigenvalue, $(A-\lambda_k I)$ gets almost singular, and therefore this system has to be modified with a preconditioner $(I-uu^*)M(I-uu^*)$. Besides a good preconditioning quality ($M \approx (A-\lambda_k I)^{-1}$), we are interested in high scalability, a preconditioner applicable on implicit systems and with cheap updating capabilities for a sequence of different shifted matrices. With respect to these properties, we try to solve this problem using the SPAI method and polynomial preconditioners.

(P17.6)
Upgrade of the Edge Charge Exchange System at the ASDEX Upgrade tokamak

M. Cavedon, T. Puetterich, E. Viezzer & ASDEX Upgrade Team – Max-Planck-Institut für Plasmaphysik, EURATOM-Assoziation, Boltzmannstr. 2, D-85748 Garching

The edge charge exchange recombination spectroscopy (CXRS) system at ASDEX Upgrade has been upgraded. Time and spatial resolution have been increased in order to study fast phenomenas. First measurements of ion temperature, rotational velocity and impurity density with the new system are presented.
Three new optical heads have been installed looking toroidally at the plasma edge increasing the total line of sights (LOSs) from 8 to 33. Moreover, the existing poloidal head has been refurbished with 22 LOSs instead of 8. The radial coverage is 5 times wider than the pedestal region while the radial resolution is below one fourth of it. The upgrade of both systems allows detailed profiles to be measured at each timepoint and therefore to study fast transient events.
A new lens-based Czerny-Turner like spectrometer ($f = 2.8$) has been designed. Making use of an interference filter, it is now possible to arrange more spectra in a limited area of the CCD camera chip. This allows to run up to 9 channels at 25 μs (= 40 kHz) exposure time (standard resolution: 2.3 ms). However, the actual time resolution is limited by the signal intesity. External impurity seeding is planned to be used in order to reach the best compromise between signal to noise ratio and measurements speed.

(P17.7)

Towards non-linear simulations of full ELM crashes in ASDEX Upgrade

A. Lessig, M. Hoelzl, K. Lackner & S. Günter – Max-Planck-Institut für Plasmaphysik, EURATOM-Assoziation, Boltzmannstr. 2, 85748 Garching, Germany

Edge localized modes (ELMs) of large size are a severe concern for the operation of ITER due to the large transient heat loads on divertor targets and wall structures. Using the non-linear MHD code JOREK, we have performed first simulations of full ELM crashes in ASDEX Upgrade, taking into account a large number of toroidal Fourier harmonics. The evolution of the toroidal Fourier spectrum and the drop of pedestal gradients are studied. In particular, we confirm a previously introduced quadratic mode coupling model for the early non-linear evolution of the mode structure and present first results concerning the evolution in the fully non-linear phase.

Eventually, we aim to identify different ELM types in our simulations as observed in experiments and to compare the results to experimental observations, e.g., regarding the pedestal evolution and the heat deposition patterns. Work is ongoing to increase poloidal resolution and include diamagnetic stabilization of high mode numbers.

(P17.8)

Numerical Methods for 3D Tokamak Simulations using a Flux-Surface indeoendent Grid

A. Stegmeir – Max-Planck-Institut für Plasmaphysik, EURATOM-Assoziation, Boltzmannstr. 2, 85748 Garching, Germany

A numerical approach for 3D Tokamak simulations using a flux surface independent grid is presented. The grid consists of few poloidal planes with a Cartesian Isotropic grid within each poloidal plane. Perpendicular operators can be discretised within a poloidal plane using standard second order finite difference methods. The discretisation of parallel operators is achieved with a field line following map and an interpolation. The application of the support operator method to the parallel diffusion operator conserves the self-adjointness of the operator on the discrete level and keeps the numerical decay rate at a low level. The developed numerical methods can be applied to geometries where an X-point is present.

(P17.9)

First Turbulence Measuremenents using Poloidal Correlation Reflectometry at AUG

D. Prisiazhniuk[1], A. Kramer-Flecken[2], G. Conway[1] & U. Stroth[1] – [1]Max-Planck-Institut für Plasmaphysik, EURATOM-Assoziation, Boltzmannstr. 2, 85748 Garching, Germany ; [2]Institut für Energieforschung - Plasmaphysik, Forschungszentrum Jülich, Association EURATOM-FZJ, 52425 Jülich, Germany

The new poloidal correlation reflectometer (PCR) system (previously used on TEXTOR) has been installed on AUG. The system consist of two Ka-band and one U-band reflectometer. The waveguides connecting the reflectometers with the antennas array are allow the operation of reflectometers in O-mode and X-mode polarization. The transmitting antenna is surrounded by 4 receiving antennas all having square geometry to allow poloidal and toroidal correlation measurements. With the 2^{nd} Ka-band reflectometer the investigation of radial correlation is possible.

The main parameters measured by the system are perpendicular rotation velocity and inclination of turbulence eddies relative to the toroidal direction. Furthermore turbulence properties such as poloidal correlation length, radial correlation length and turbulence decorrelation time can be accessed. These are important quantities for plasma edge studies and are currently not available at AUG. First measurements from the commissioning phase will be presented at this conference.

(P17.10)
Poloidal asymmetries of heavy impurities in the ASDEX Upgrade plasma

T. Odstrčil[1], T. Puetterich[1], A. Gude[1], R. Dux[1], D. Mazon[2] & ASDEX Upgrade Team[1] – [1]Max-Planck-Institut für Plasmaphysik, EURATOM-Assoziation, Boltzmannstr. 2, 85748 Garching, Germany ; [2]CEA, IRFM F-13108 Saint Paullez-Durance, France

For heavy and highly charged impurities multiple mechanisms exist that produce non-constant impurities densities on the flux surfaces. As for neoclassical and turbulent transport models such an asymmetrie is highly importance an effort is launched to experimentally characterize the asymmetries comparing them with theoretical expectations.

In the ASDEX Upgrade tokamak (AUG) is routinely observed increase of outboard tungsten density in fast rotating plasma. This asymmetry is caused by the centrifugal force pushing tungsten ions outward due to its high mass. Furthermore, the high charge makes heavy impurities sensitive to poloidal variations of the plasma potential. The variation can be generated by magnetic trapped ions heated by RF heating. In such a case, the presence of an inboard asymmetry or at least the absence of an outboard asymmetry due to the centrifugal force can be observed. Finally, ion-impurity friction enhanced by the large charge of the impurity ions may cause a relatively weak up-down asymmetry of the impurity density.

The aim of this poster is to show first evidence of these asymmetries in the AUG plasmas, the description of the used methodology, and to compare with theoretical models based on the parallel force balance.

(P17.11)
Experimental study of the radial structure of turbulence with a ultra-fast sweeping reflectometer in ASDEX Upgrade

A. Medvedeva[1,2,3,4], C. Bottereau[3], F. Clairet[3], G. Conway[1], S. Heuraux[2], D. Molina[3] & U. Stroth[1,4] – [1]Max-Planck-Institut für Plasmaphysik, EURATOM-Assoziation, Boltzmannstr. 2, D-85748 Garching ; [2]Commissariat a l'energie atomique et aux energies alternatives, 13108 Saint Paul Lez Durance ; [3]Universite de Lorraine, 34 cours Leopold, 54000 Nancy ; [4]Technische Universität München, James-Franck-Str. 1, D-85748 Garching

Confinement of fusion plasmas is restricted by anomalous transport where micro-turbulence is suspected to play a major role. Experimental documentation of this turbulence, its dependence on the plasma temperature, density, current will provide insights in the nature of this turbulence and the driving parameters. In this work advantage is taken of the ultra-fast sweep capabilities of the V & W band (50-110 GHz) reflectometers, developed by CEA, to record fast plasma turbulent events on ASDEX Upgrade. The X-mode polarization will provide a rather large radial access to the plasma from the very edge to, under certain conditions, the center. The scope of the work is to exploit the specific strengths of the diagnostic in order to study the radial spectra of fluctuations, radial turbulence spreading and the fast dynamic profile evolution after confinement transitions or changes in the discharge control parameters. First experimental data obtained during the ASDEX Upgrade campaign 2014 will be presented.

(P17.12)
Negative ion formation in Ion-Molecule collisions

A. Ebanezar John & R. Hippler – Institut für Physik, Ernst-Moritz-Arndt-Universität Greifswald, 17489 Greifswald

Positively charged H^+, H_2^+, He^+, and Ar^+ ions, with impact energies of 50 – 350 keV, were employed to bombard O_2 and SF_6 molecules. The collision cross sections of positive and negative ionic fragments were determined and their dependence on impact energy will be presented.

Besides positively charged ion fragments, negatively charged secondary ions are an important contibution for various applications especially in atmospheric chemistry and plasma physics.

One of the exciting observation is superoxide anion O_2^- belong to the reactive oxygen species(ROS). We propose formation of superoxide anion to proceed via a charge-transfer reaction with the positively charged incident ion,

$$X^+ + O_2 \longrightarrow X^{2+} + O_2^- \tag{2.1}$$

where an electron transferred to the oxygen molecule originates from the incident ion, (X=H_2^+or He^+ or Ar^+) having atleast one electron for the reaction. Measured cross sections for O_2^- formation are about 2 orders of magnitude smaller compared to O_2^+ formation, which is attributed to the larger energy transfer required.

(P17.13)
Electromagnetic simulations of tokamaks and stellarators

M. Cole & A. Mishchenko – Max-Planck-Institut für Plasmaphysik, EURATOM-Assoziation, Wendelsteinstr. 1, 17491 Greifswald, Germany

A practical fusion reactor will require a plasma β of around 5%. In this range Alfvénic effects become important. Since a practical reactor will also produce energetic alpha particles, the interaction between Alfvénic instabilities and fast ions is of particular interest. We have developed a fluid electron, kinetic ion hybrid model that can be used to study this problem. Compared to fully gyrokinetic electromagnetic codes, hybrid codes offer faster running times and greater flexibility, at the cost of reduced completeness.

The model has been successfully verified against the worldwide ITPA Toroidal Alfvén Eigenmode (TAE) benchmark, and the ideal MHD code CKA for the internal kink mode in a tokamak. Use of the model can now be turned toward cases of practical relevance. Current work focuses on simulating fishbones in a tokamak geometry, which may be of relevance to ITER, and producing the first non-perturbative self-consistent simulations of TAE in a stellarator, which may be of relevance both to Wendelstein 7-X and any future stellarator reactor. Preliminary results of these studies will be presented.

(P17.14)
Numerical studies for the nuclear fusion reactor Wendelstein 7-X

H. Hölbe – Max-Planck-Institut für Plasmaphysik, EURATOM-Assoziation, Wendelsteinstr. 1, D-17491 Greifswald

The nuclear fusion experiment Wendelstein 7-X is currently under construction in Greifswald, Germany. After completion in 2014, the experiment will be the largest and most advanced stellarator ever built. The cryostat hosting the superconducting coils and the vacuum vessel has a diameter of 16 meters and a height of 5 meters, and the magnetic field will be 2.5 T on axis.

Wendelstein 7-X is designed to prove simultaneous high density, high temperature, steady-state plasma operation. The first plasma is planned for 2015. After first tests the plasma pulse time will be gradually increased up to 30 minutes from 2019 on.

The core plasma temperature in this device will be over 100 million degree. Therefore, contact with the plasma facing components must be done carefully. One challenge in this connection is that the plasma shape will change during operation due to internal plasma currents generated by the plasma itself. Using state-of-the-art codes, we are investigating and developing operational scenarios for the first, relatively short plasma pulses, that allow us to address important issues for the later steady-state operation.

(P17.15)
Experimental investigations on the dust density distribution in spatially extended dust clouds

C. Killer, M. Himpel & A. Melzer – Institut für Physik, Ernst-Moritz-Arndt-Universität Greifswald, 17489 Greifswald

Large dust clouds confined in the discharge volume of low temperature rf plasmas often feature interesting phenomena such as a central void and the propagation of self-excited dust density waves. Most experimental diagnostics in the field of dusty plasmas focus either on 2-dimensional slices of the dust system (using laser sheets) or on small 3-dimensional observation volumes. Due to the limitations of these methods it is therefore difficult to measure global properties of the dust cloud.
In this contribution, a novel approach towards the reconstruction of the dust density distribution is presented. A two-dimensional projection of the dust cloud can be obtained by measuring the light extinction of a homogenously illuminated cloud, effectively observing the dust clouds shadow. Assuming cylindrical symmetry, the radial dust density profile can be derived via Abel inversion. This method is especially suited to investigate the three-dimensional character of the void and dust density waves. It is furthermore possible to compare the radial dust density distribution to the plasma glow structure, which can also be reconstructed by Abel inversion. Hence, the influence of the dust presence and dust dynamics on the plasma glow can be investigated.

(P17.16)
Selective fluid mode excitation in finite 3D Yukawa-balls

M. Mulsow, A. Schella & A. Melzer – Institut für Physik, Ernst-Moritz-Arndt-Universität Greifswald, Felix-Hausdorff-Str. 6, D-17487 Greifswald

In low-temperature plasmas micrometer-sized particles are able to form highly ordered structures. Using a harmonic three-dimensional trapping potential strongly coupled finite systems can be created, the Yukawa-balls. An established model to describe the dynamic properties of these finite crystal-like structures are normal modes. Here the possible oscillations of all individual particles are composed to describe the collective motion.

In opposite to this, Kählert and Bonitz recently proposed [1,2] to consider the cluster as a uniform cold fluid droplet, neglecting the movement of single particles. The collective motions are then interpreted as superpositions of orthonormal fluid modes.

In our experiments, we utilize a special cuvette with conducting corners to manipulate the cluster using electrical fields in a uniform way that copes perfectly with the fluid mode approach. Thus, on the one hand theoretical predictions concerning mode resonance can be tested while on the other hands new scenarios to manipulate three dimensional Yukawa-balls can be developed in order to gain new insights on their dynamic properties.

[1] H. Kählert and M. Bonitz, Phys. Rev. E 82, 036407 (2010)
[2] H. Kählert and M. Bonitz, Phys. Rev. E 83, 056401 (2011)

(P17.17)
Possibility of a Kondo resonance at the wall recombination of positive ions

M. Pamperin, F. X. Bronold & H. Fehske – Institut für Physik, Universität Greifswald, 17489 Greifswald, Germany

Wall recombination of positively charged ions is one of the main surface-based loss processes for positive ions in a low-temperature gas discharge. Together with volume-based charge production and destruction processes it controls the overall charge balance of the discharge. Depending on the electronic structure of the ion and the wall an ion may recombine either via Auger neutralization or via resonant charge transfer. Both processes are of fundamental interest. The time-dependent ion-surface system represents a quantum-impurity system supporting–under appropriate conditions–a Kondo resonance which is one of the paradigms in the physics of highly correlated electrons and should also affect the wall recombination. Indeed He and Yarmoff [1] interpreted the anomalous temperature dependence of the neutralization of Sr^+ ions at a Au surface in terms of a Kondo resonance. To support this claim we calculated within an Anderson-Newns model the temperature dependence of this particular atom-surface collision using quantum-kinetic equations and a pseudo-particle representation for the electronic configurations of the ion. We found that a Kondo resonance indeed shows up and affects the neutralization rate. To gain further insight we also studied the neutralization of Mg^+ or Ga^+ ions at a Au surface where the Kondo effect is not expected.

[1] X. He and J. A. Yarmoff, Phys. Rev. Lett. **105**, 176806 (2010).

(P17.18)

Time-resolved measurements of cluster mass distribution in a pulsed gas aggregation system

S. Drache, F. Berg, V. Straňák, M. Ganeva, H. Wulff & R. Hippler – Institut für Physik, Ernst-Moritz-Arndt Universität, Felix-Hausdorff-Str. 6, D-17487 Greifswald

Owing to their large surface to volume ratio, nano-size particles (clusters) exhibit unique physical and chemical properties. These particles of a few nm size can find application in, e.g. micro electronics, chemical catalysts, or quantum dots. In our experiment Cu cluster particles were synthezised in a gas aggregation nanocluster source. In contrast to the conventional constant gas flow the buffer gas was delivered in pulses. The aim was to alter the clusters mass distribution by means of a time dependent pressure in the aggregation region. For time-resolved analysis a labview-controlled quadrupole mass filter (QMF) was installed and the pressure in the cluster source was also monitored. As a first result, cluster current and mass quickly respond to pressure changes. Since the QMF mass range is limited, deposited clusters were also examined by atomic force microscopy (AFM). Results show a broadened mass distribution compared to the unpulsed experiment. Finally, clusters were co-deposited during reactive Ti magnetron sputtering in an Ar/O_2 atmosphere to study nanoparticles embedded in a TiO_2 matrix. GIXD and XPS reveal that clusters become x-ray amorphous and oxidized in the confining TiO_2 matrix.

(P17.19)

Stellarator-specific developments for the systems code PROCESS

F. Warmer[1], P. Knight[2], C. D. Beidler[1], A. Dinklage[1], Y. Feng[1], J. Geiger[1], F. Schauer[1], Y. Turkin[1], D. Ward[2], R. Wolf[1] & P. Xanthopoulos[1] – [1]Max-Planck-Institut für Plasmaphysik, EURATOM-Assoziation, Wendelsteinstr. 1, D-17491 Greifswald, Germany ; [2]Culham Centre for Fusion Energy, Abingdon, Oxfordshire, OX14 3DB, United Kingdom

The code package PROCESS is a tool widely used for Tokamak systems studies. In this study, however, the application of PROCESS to Stellarators is addressed. In order to incorporate a Stellarator module in the systems code PROCESS, Stellarator-specific models are considered which reflect the differences due to the confinement concept. These include: a geometry model based on Fourier coefficients which can represent the complex 3-D plasma shape, a divertor model which assumes diffusive cross-field transport and high radiation at the X-point, a coil model which is a scaling based on the Helias 5-B design and a transport model which employs a confinement time scaling derived from empirical scalings and by sophisticated 1-D neoclassical and anomalous calculations. This approach is investigated to ultimately allow one to facilitate a direct comparison between Tokamak and Stellarator power plant designs.

(P17.20)
Einfluss von Alfvén Eigenmoden und Ionenzyklotronheizung auf die schnelle Ionen-Verteilung im Tokamak ASDEX Upgrade

M. Weiland, B. Geiger, R. Bilato, P. Schneider, G. Tardini, P. Lauber, F. Ryter, M. Schneller & ASDEX Upgrade Team – Max-Planck-Institut für Plasmaphysik, EURATOM-Assoziation, Boltzmannstr. 2, D-85748 Garching

Schnelle, supra-thermische Ionen werden im Tokamak ASDEX Upgrade durch Neutralteilcheninjektion und Ionenzyklotronheizung (ICRF) erzeugt und werden für Plasmaheizung und Stromtrieb benötigt. Eine Möglichkeit, sie zu untersuchen, ist die spektroskopische Beobachtung von Linienstrahlung (Fast-ion D-alpha, kurz: FIDA), die durch Ladungsaustausch entsteht. Die schnellen Ionen können hier durch ihre starke Dopplerverschiebung von den thermischen Teilchen unterschieden werden, und so deren radiales Dichteprofil gemessen werden.

Durch die Analyse des gesamten Dopplerspektrums können Informationen über Bereiche der 2D-Geschwindigkeitsverteilung $f(v_\parallel, v_\perp)$ gewonnen werden. Die Beobachtung aus verschiedenen Blickrichtungen erlaubt dann eine tomografische Entfaltung von $f(v_\parallel, v_\perp)$. Dazu wurde die FIDA Diagnostik an ASDEX Upgrade von zwei auf fünf Blickrichtungen ausgebaut, sowie zur simultanen Beobachtung des rot- und blauverschobenen Teils des Dopplerspektrums erweitert. Diese neu entwickelten Diagnostikverfahren erlauben die Beobachtung von Veränderungen im Geschwindigkeitsraum, die von Alfvén Eigenmoden ausgelöst werden. Ferner wird die weitere Beschleunigung von schnellen Ionen durch ICRF-Absorption der zweiten Harmonischen untersucht.

(P17.21)
Investigation of mass selected poly-anionic clusters by laser excitation and photoelectron spectroscopy

M. Müller[1], G. Marx[1], P Oelssner[2], J. Tiggesbäumker[2], R. Wolf[3], K.-H. Meiwes-Broer[2] & L. Schweikhard[1] – [1]Ernst-Moritz-Arndt-Universität, Greifswald, Germany ; [2]Universität Rostock, Germany ; [3]Max-Planck-Institut für Kernphysik, Heidelberg, Germany

Photoelectron spectroscopy (PES) experiments open insight into the electronic structure of atomic clusters. In the case of multiply negatively charged clusters, electron affinities and Coulomb barriers of these species can be probed by varying the wavelength of the photo-detachment laser[1]. In addition, poly-anionic metal clusters serve as model systems for electron-correlation phenomena[2]. A setup is presented, which combines a Paul trap, used for cluster-size selection and poly-anion production by sequential electron attachment[3], with a magnetic-bottle time-of-flight electron spectrometer[1]. As a first test PES on mono- and di-anion fullerenes with ultraviolet nanosecond laser pulses has been performed. In the future the measurements will be extended to poly-anionic metal clusters in order to explore their electronic properties. The project is part of the Collaborative Research Center (SFB) 652.

(P17.22)

Modelling the effect of resonant magnetic perturbations in ASDEX Upgrade with the extented MHD code XTOR-2F

J. Griesshammer – Max-Planck-Institut für Plasmaphysik, EURATOM-Assoziation, Boltzmannstr. 2, D-85748 Garching

Resonant magnetic perturbations (RMPs) are used in medium sized tokamaks like ASDEX Upgrade or DIII-D for the mitigation of edge localized modes (ELMs), which allows reduction of the maximum head load power on the divertor plates. The poloidal mode number spectrum of the applied RMPs is wide and penetration into the plasma of the RMP at resonant magnetic surfaces is complex due to non-ideal MHD plasma dynamics and geometry. The fully toroidal extented MHD code XTOR-2F is used to study RMP penetration, the effect of RMPs on confinement deteriorating tearing modes (TMs) and plasma rotation. Apart from RMP amplitude and mode spectrum also the influence of different plasma equilibria and plasma fluid models are (to be) studied.

Chapter 3

Other DPG sessions of possible interest

Plasma Physics Division

ID	Date & Time	Location	Session
P 1	Mon, 10:30 - 12:25	SPA HS201	Dusty Plasmas I
P 2	Mon, 10:30 - 12:50	SPA HS202	Magnetic Confinement I
P 3	Mon, 14:00 - 6:00	SPA HS201	Plasma Technology I
P 4	Mon, 14:00 - 15:15	SPA HS202	Theory of Quantum Plasmas I
P 5	Mon, 16:30 - 18:25	SPA HS201	Low Temperature Plasmas I
P 6	Mon, 16:30 - 18:45	SPA HS202	Theory and Modelling
P 7	Mon, 17:30 - 18:30	Kinosaal	Kernfusion
P 8	Tue, 10:30 - 12:00	SPA HS201	Diagnostics I
P 9	Tue, 10:30 - 12:00	SPA HS202	Theory of Quantum Plasmas II
P 10	Tue, 14:00 - 15:55	SPA HS201	Dusty Plasmas II
P 11	Tue, 14:00 - 16:35	SPA HS202	Magnetic Confinement II
P 12	Tue, 16:30 - 18:30	SPA Foyer	Poster Session - Magnetic Confinement
P 13	Tue, 16:30 - 18:30	SPA Foyer	Poster Session - Diagnostics
P 14	Tue, 16:30 - 18:30	SPA Foyer	Poster Session - Theory and Modelling
P 15	Tue, 16:30 - 18:30	SPA Foyer	Poster Session - Laser Plasmas
P 18	Wed, 16:30 - 18:30	SPA Foyer	Poster Session - Plasma Technology
P 19	Wed, 16:30 - 18:30	SPA Foyer	Poster Session - Low Temperature Plasmas
P 20	Wed, 16:30 - 18:30	SPA Foyer	Poster Session - Dusty Plasmas
P 21	Thu, 10:30 - 12:45	SPA HS201	Plasma Technology II
P 23	Thu, 14:00 - 16:00	SPA HS201	Low Temperature Plasmas II
P 24	Thu, 14:00 - 16:00	SPA HS202	Laser Plasmas I
P 25	Thu, 16:30 - 18:15	SPA HS201	Low Temperature Plasmas III
P 26	Thu, 16:30 - 17:15	SPA HS202	Laser Plasmas II
P 27	Fri, 10:30 - 13:00	SPA HS201	Theory of nonideal Plasmas
P 28	Fri, 10:30 - 12:00	SPA HS202	Diagnostics II
P 29	Fri, 14:00 - 15:30	SPA HS201	Plasma Technology III
P 30	Fri, 14:00 - 16:15	SPA HS202	Plasma Wall Interactions

Extraterrestial Physics Division

ID	Date & Time	Location	Session
EP 1	Mon, 14:00 - 16:00	DO24 1.103	Astrophysik
EP 2	Mon, 16:30 - 18:30	DO24 1.103	Erdnaher Weltraum
EP 3	Tue, 10:30 - 12:30	DO24 1.103	Erdnaher Weltraum / Planeten
EP 4	Tue, 14:00 - 16:00	DO24 1.103	Planeten
EP 5	Tue, 16:30 - 18:30	DO24 Foyer	Postersitzung
EP 6	Thu, 10:30 - 12:30	DO24 1.103	Exoplaneten und Astrobiologie
EP 7	Thu, 18:00 - 18:30	SPA Kapelle	Sonne und Heliosphäre (I)
EP 8	Fri, 10:30 - 13:00	DO24 1.103	Sonne und Heliosphäre (II)

Symposia

ID	Date & Time	Location	Session
			Symposium Plasma und Optische Technologien
SYOT 1	Tue, 10:30 - 10:40	SPA Kapelle	Einführung in das Symposium
SYOT 2	Tue, 10:40 - 12:50	SPA Kapelle	Verbund PluTO: Plasma und optische Technologien
SYOT 3	Tue, 14:00 - 16:30	SPA Kapelle	SFB zu Plasma und Optische Technologien
			Symposium Plasma-Astrophysik
SYPA 1	Thu, 14:00 - 18:00	SPA Kapelle	Plasma Astrophysics