P 6: Theory and Modelling

Time: Monday 16:30–18:45 Location: SPA HS202

P 6.1 Mon 16:30 SPA HS202

Analysis of electrode asymmetry effects in oxygen ccrf discharge plasmas — •Igor Sheykin, Markus M. Becker, and Detlef Loffhagen — INP Greifswald, Felix-Hausdorff-Str. 2, 17489 Greifswald

Capacitively coupled radio frequency (ccrf) discharges between plane-parallel electrodes are generally asymmetric, where effects of asymmetry are especially important at lower pressures. In modelling studies of such discharges a symmetric geometry is usually used. In the present contribution a time-dependent, spatially one-dimensional fluid model containing continuity equations for the densities of electrons and relevant heavy particles, the electron energy balance equation and Poisson's equation and taking the discharge asymmetry in accordance with [1] is used to analyse the influence of the discharge asymmetry on the plasma parameters. First results are discussed for oxygen plasmas at the experimental conditions given in [2] for a pressure of 30 Pa and applied voltages between 200 and 500 V at a frequency of 13.56 MHz. The modelling results show that the calculated bias voltages are in good agreement with measured ones. The charged particles obtained by modelling have similar distributions over the gap in symmetric and asymmetric discharges, but their shapes differ more with larger asymmetry of the discharge particularly in front of the electrodes.

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[1] M. S. Barnes et al., J. Appl. Phys. **61** (1987) 81
[2] C. Küllig et al., Plasma Sources Sci. Technol. **19** (2010) 065011

P 6.2 Mon 16:45 SPA HS202

The characteristics of RF modulated plasma boundary sheaths: A numerical study of the standard model — •Schabnam Naggary and Ralf Peter Brinkmann — Lehrstuhl für Theoretische Elektrotechnik, 44801 Bochum, Deutschland

The characteristics of radio frequency (RF) modulated plasma boundary sheaths are studied within the so-called "standard model". This model assumes that the applied radio frequency ω_{RF} is considerably larger than the plasma frequency of the ions but smaller than that of the electrons. It comprises a phase-averaged ion model – consisting of an equation of continuity (with ionization neglected) and an equation of motion (with collisional ion-neutral interaction taken into account)–, a phase resolved electron model – consisting of an equation of continuity and the assumption of Boltzmann equilibrium –, and Poisson's equation for the electrical field. Previous investigations have studied the standard model under additional approximations, most notably the assumption of a step-like electron front [V.A. Godyak and Z.K. Ghanna, *Sov. J. Plasma Phys.* **6**, 372 (1979)]. This manuscript presents an investigation and parameter study of the standard model which avoids any further assumptions. The resulting density profiles and overall charge-voltage characteristics are compared with those of the step-model based theories of Lieberman for the non-collisional [M.A. Lieberman, *IEEE Trans. Plasma Sci.* **16**, 638 (1988)] and fully collisional [M.A. Lieberman, *IEEE Trans. Plasma Sci.* **17**, 338 (1989)] limiting cases.

P 6.3 Mon 17:00 SPA HS202

PlasmaPIC: 3D plasma simulation tool — •Robert Henrich, Michael Becker, and Christian Heiliger — I. Physikalisches Institut, Justus-Liebig-Universität Gießen

We present our self developed PlasmaPIC simulation tool, which is a full 3D particle in cell (PIC) simulation tool. PlasmaPIC is well suited for describing inductively coupled plasmas in micro Newton radio frequency ion thrusters. Until a few years ago such a simulation was inconceivably for modeling radio frequency ion thruster (RIT) on the order of a few centimeters due to the enormous computational effort. In our PlasmaPIC simulation tool we reduce the calculation time from months to several hours, by incorporating a very efficient massive parallelization. In addition, our PlasmaPIC simulation tool can handle arbitrary geometries, which can be imported from CAD tools. By using PlamaPIC we are able to determine precisely all plasma parameters in our thruster even with very high temporal and spatial resolution. In contrast, this precise determination cannot be done by measurements, because the plasma parameters cannot appropriately measured in our small thruster without influencing it. Especially, for a better understanding and hence further optimizations of our thruster precise plasma parameters are necessary. For that reason our PlasmaPIC simulation tool is required. With our PlasmaPIC simulation tool we are now on the verge to predict performance parameters for new designs of our thrusters on a microscopic level.

P 6.4 Mon 17:15 SPA HS202

Weakly adaptive particle weighting algorithms in Particle in Cell Codes. — •Denis Eremin, Ralf Peter Brinkmann, and Thomas Mussenbrock — Ruhr-Universität Bochum, Universitätsstrasse 150, Bochum, Deutschland

Particle-in-cell simulations of low-temperature plasmas are often made in 2D cylindrical (r,z) geometry, following typical symmetry of the experimental facilities. In such a geometry one usually disretizes electrostatic field (electromagnetic fields) on a grid, which is either uniform in r squared, or uniform in r. The second method of discretization yields better resolution of the field(s) near the axis, but requires an adaptive weighting algorithm for the particles. Assuming constant number of superparticles in each cell at the beginning of the simulation (which is warranted by the statistical nature of the PIC codes), initial superparticle weights must be proportional to their radial position. During the simulation, superparticle with large weights coming from the radial periphery close to the axis tend to replace the particles with small weights initially located at the axis, which leads to dramatic increase of the statistical noise there. The superparticles with small weights, in turn, tend to accumulate close to the periphery of the discharge, which is undesired due to the memory limitations. Once in a while, superparticles with large weights must therefore be split in the course of their motion toward the axis, and superparticles with small weights must be merged as they tend toward the radial periphery of a discharge. In this contribution the authors discuss how to construct such an algorithm which would distirb the physics of the discharge only minimally.

P 6.5 Mon 17:30 SPA HS202

Revision of the Coulomb logarithm in the ideal plasma — •Peter Mulser[1], Gernot Alber[1], and Masakatsu Murakami[2] — [1]Institut für Angewandte Physik, TU Darmstadt, Hochschulstr. 6, 64289 Darmstadt — [2]Institute of Laser Engineering (ILE), Osaka University, Yamada kami, Osaka, Japan

The standard picture of the Coulomb logarithm in the ideal plasma is controversial and self-contradictory, the arguments for the lower cut off need revision. The two cases of far subthermal and of far superthermal electron drift motions are accessible to a rigorous analytical treatment. We show that the lower cut off b_min is a function of symmetry and shape of the shielding cloud, it is not universal. In the subthermal case shielding is spherical and b_min is to be identified with the de Broglie wavelength; at superthermal drift the shielding cloud exhibits cylindrical (axial) symmetry and b_min is the classical parameter of perpendicular deflection. In both situations the cut offs are determined by the electron-ion encounters at large collision parameters. This is in net contrast to the governing standard meaning that attributes b_min to the Coulomb singularity at vanishing collision parameters b and, consequently, assigns it universal validity. The origin of the contradictions in the traditional picture is analyzed.

P 6.6 Mon 17:45 SPA HS202

Modellierung einer Indium(I)iodid Niederdrucklampe — •William Truong, Celal Mohan Ögün und Rainer Kling — Lichttechnisches Institut des Karlsruher Instituts für Technologie, Engesserstr. 13, Gebäude 30.34, 76131 Karlsruhe, Deutschland

Die Kompaktleuchtstofflampen sind in der Allgemeinbeleuchtung sehr verbreitet, aber kämpfen noch immer gegen Akzeptanzprobleme, da sie wie vor das gesundheitsschädliche Quecksilber als elementarer Bestandteil enthalten. Die vorgestellte Arbeit ist Teil eines Projekts, bei dem das Quecksilber durch das nicht toxisches Material Indium(I)iodid ersetzt wird. Für die Effizienzverbesserung und weitere Entwicklung dieser Lampe ist die Charakterisierung der Plasmaprozesse von größter Bedeutung. Zu diesem Zweck wurde die quecksilberfreie Niederdruckentladung nach dem erweiterten Korona-Modell modelliert. Die für das Modell benötigten unbekannten Parameter wie die Stoßquerschnitte und Diffusionskoeffizienten wurden nach dem Gryzinski-Modell und der Chapman-Enskog-Theorie berechnet. Dieses Modell ermöglicht die Bestimmung der Plasmaparameter wie Elektronendichte und Elektronentemperatur anhand der optischen Messdaten. Hinzu kommt, dass das Strahlungsverhalten der Lampe bei unterschiedlichen Rahmenbedingungen wie dem Puffergasdruck und der Coldspot-Temperatur mithilfe dieses Modells vorausberechnet werden kann. Die berechneten Emissionskoeffizienten stimmen mit den gemessenen überein.

P 6.7 Mon 18:00 SPA HS202

Non-filamentated ultra-intense and ultra-short pulses in Raman seed amplification — •Götz Lehmann and Karl-Heinz Spatschek — Theoretische Physik I, Heinrich-Heine Universität, Düsseldorf

Ultra-intense and ultra-short laser pulses may be generated up to the exawatt-zetawatt regime due to parametric processes in plasmas. The minimization of unwanted plasma processes leads to operational limits, which we discuss with respect to filamentation. It is shown that the limit for transverse filamentation, which originally was derived for plane waves, is actually less stringent for seed pulse propagation. Because of fast motion, the leading pulse-front can stay filamentation-free, whereas the rear parts show transverse modulations. Results from two-dimensional and three-dimensional three-wave-interaction models are compared with PIC and Vlasov simulations. Although wavebreaking occurs, the kinetic simulations show that the leading pumped pulse develops a form similar to that obtained from the three-wave-interaction model.

P 6.8 Mon 18:15 SPA HS202

Zyklotrondämpfung von parallel propagierenden Wellen in kinetischen Plasmasimulationen — •Cedric Schreiner[1] und Felix Spanier[2] — [1]Lehrstuhl für Astronomie, Universität Würzburg, Deutschland — [2]Center for Space Research, North-West University Potchefstroom, Südafrika

Bereich um die Zyklotronfrequenz einer Teilchenspezies des Plasmas, so tritt Zyklotrondämpfung auf, wobei Feldenergie der Welle in kinetische Energie der Teilchen umgesetzt wird.

Die analytische Beschreibung, für die das Lösen der komplexen Dispersionsrelation in warmen Plasmen nötig ist, gestaltet sich jedoch schwierig. Nur unter vereinfachenden Annahmen lassen sich die Dämpfungsrate Γ und der Realteil der Wellenfrequenz ω berechnen, sodass Näherungslösungen für schwache ($\Gamma \ll \omega$) oder starke ($\Gamma \gg \omega$) Dämpfung gefunden werden können.

Particle in Cell (PiC) Simulationen bieten die Möglichkeit, gedämpfte Wellen bei beliebigen Frequenzen nahe der Zyklotronresonanz einer Mode zu untersuchen. Dabei lassen sich Aussagen über die analytisch nur schwer zugängliche Dämpfungsrate treffen und der Einfluss der dissipierten Wellenenergie auf das Geschwindigkeitsspektrum der Teilchen nachvollziehen.

P 6.9 Mon 18:30 SPA HS202

3-D electron shear flow instabilities of an electron current sheet and generation of flux ropes in collisionless magnetic reconnection — •Neeraj Jain and Joerg Buechner — Max-Planck/Princeton Center for Plasma Physics, Max-Planck Institute for Solar System Research, Max-Planck-Str. 2, 37191, Katlenburg-Lindau, Germany

In collisionless magnetic reconnection, electron current sheets (ECS) with thickness of the order of electron inertial length forms embedded inside an ion current sheet with thickness of the order of ion inertial length. These ECS's are susceptible to a variety of instabilities which have potential to affect the reconnection rate and/or the structures. We study three dimensional electron shear flow driven instabilities of an electron current sheet using an electron-magnetohydrodynamic model. Linear growth rate of the fastest mode drops with the thickness of ECS. The nature of the instability also changes with the thickness of ECS. When the half thickness is close to one electron inertial length, the fastest instability is two dimensional (no variations along flow direction) tearing mode and flux ropes are expected to form during the nonlinear evolution of the instability. For half thickness sufficiently larger or smaller than one electron inertial length, the fastest mode has finite variations along the direction of flow and is not tearing mode. Three dimensional nonlinear electron-magnetohydrodynamic simulations show the formation of flux ropes for the half thickness close to one electron inertial length.