P 25: Theory and Modeling III

Zeit: Donnerstag 8:30–10:30 Raum: HS 2010

Hauptvortrag P 25.1 Do 8:30 HS 2010

Modeling streamer discharges in strong magnetic fields — •Jannis Teunissen[1], Anbang Sun[2], and Ute Ebert[3] — [1]Centre for Mathematical Plasma-Astrophysics, KU Leuven, Belgium — [2]Xi'an Jiaotong University, China — [3]Centrum Wiskunde & Informatica, Amsterdam, The Netherlands

There exist many electric discharges in which magnetic effects play a major role, but streamers are typically not one of them. However, it appears that in Jupiter's atmosphere streamers could actually be magnetized. Here we employ numerical simulations to investigate this phenomenon, using a combination of 3D particle-in-cell simulations, electron transport calculations, and plasma fluid modeling. We observe that streamer inception, propagation and branching are all affected by a strong external magnetic field, and we discuss how this can be related to the modified electron transport properties.

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Electron dynamics in magnetized technological plasmas: A kinetic description — •Ralf Peter Brinkmann and Dennis Krüger — Ruhr-Universität Bochum

Many advanced thin-film deposition processes like HIPIMS (High Power Impulse Magnetron Sputtering) or PIAD (Plasma-Ion Aided Deposition) employ magnetized plasmas at a pressure range of 0.1 to 1 Pa and a magnetic field of 10 to 100 mT. In such plasmas, the electron gyration radius rL is of the order of a millimeter, whereas the mean free path λ is much larger, typically comparable with the plasma source dimension L itself (some tens to hundreds of millimeters). It is generally acknowledged that in this regime fluid dynamics fails and a kinetic approach is required. This work employs the smallness of the parameter epsilon rL/λ*rL/L to reduce the complexity of that approach to a tractable level. As an application, the phenomenon of spoke formation in HIPIMS discharges is addressed.

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Electric double layers at plasma-wall interfaces — •Franz Xaver Bronold and Holger Fehske — Institut für Physik, Ernst-Moritz-Arndt-Universität Greifswald, 17489 Greifswald, Deutschland

The basic response of a plasma to a macroscopic body is the formation of the plasma sheath. It is the positive part of an electric double layer whose negative part is inside the solid. A stationary sheath develops if the generation of electrons and ions in the plasma is balanced by electron and ion losses at or inside the wall. A complete modeling of the plasma sheath has to take the losses into account. It should thus cover not only the plasma physics of the positive part of the double layer but also the solid state physics affecting the negative part. For a dielectric wall we developed such a model. It is based on two sets of Boltzmann equations operating in disjunct half-spaces: One set is for the electrons and ions in the plasma half-space while the other is for conduction band electrons and valence band holes in the wall half-space. The two sets are connected by a quantum-mechanically derived matching condition for the electron distribution functions and a semi-empirical model for hole injection due to neutralization of ions at the plasma-wall interface. Essential for the model is also the merging of the space charge region with, respectively, the neutral bulk plasma and the intrinsic or extrinsic bulk of the wall. To demonstrate the feasibility of our approach we present results for a collisionless double layer developing, respectively, at an intrinsic silicon dioxide and p-type silicon surface both facing a low-temperature hydrogen plasma. — Supported by DFG through CRC/Transregio TRR24.

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Kinetische Berechnung der Transportkoeffizienten der Elektronen in CO_2 — •Detlef Loffhagen — INP Greifswald, Felix-Hausdorff-Str. 2, 17489 Greifswald

Untersuchungen zum Verhalten von Elektronenschwärmen ermöglichen es, wesentliche Transportkoeffizienten der Elektronen in Gasen zu bestimmen. Hierbei werden häufig Time-of-Flight-Experimente durchgeführt, bei denen der hydrodynamische Zustand zur Ermittlung der Driftgeschindigkeit des Massenschwerpunkts, des zugehörigen longitudinalen Diffusionskoeffizienten und der effektiven Ionisationsfrequenz verwendet wird. Im Rahmen dieses Beitrages wird eine neues numerisches Verfahren zur Bestimmung dieser Transportkoeffizienten der Elektronen vorgestellt. Die Methode basiert auf der Lösung der orts- und zeitabhängigen Boltzmanngleichung der Elektronen in einer räumlich eindimensionalen Anordnung. Die Lösung dieser kinetischen Gleichung erfolgt auf der Grundlage der konventionellen Zweitermnäherung der Entwicklung der Geschwindigkeitsverteilung der Elektronen nach Legendre-Polynomen. Sie ermöglicht die Charakterisierung des raum-zeitlichen Verhaltens der Elektronenschwärme sowie die Bestimmung der Transportkoeffizienten des Massenschwerpunkts und der geschwindigkeitsgemittelten makroskopischen Größen der Elektronen. Erste Ergebnisse für CO_2 werden vorgestellt und mit experimentellen Daten und Resultaten von Monte-Carlo-Simulationen verglichen.

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Thermodynamics of the ions in the sheath — Uwe Czarnetzki and •Tsanko Tsankov — Institute for Plasma and Atomic Physics, Ruhr-University Bochum, 44780 Germany

Space charge sheaths form where the plasma is in contact with a surface. The high electric field in the sheath strongly accelerates the ions and largely determines the properties of their population reaching the wall. These properties are important for the plasma-wall interaction. One of the prominent parameters that describe the energy spread of the ions is their effective temperature.

Here, through a kinetic approach it will be shown, that in a fully collisionless sheath the effective ion temperature cools down due to an adiabatic expansion. The presence of collisions leads to ion energy flow and heating of the ions. This effect can reverse the trend of a decrease of the effective ion temperature as the ions approach the wall. Experiments and simulations show that even weak collisionality is sufficient for that. The results apply for both stationary and oscillating sheaths, provided the ion transport can be treated as quasi-stationary.

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Effective interaction potentials and dynamic properties of weakly coupled partially degenerate nonisothermal dense plasmas — •Zhandos Moldabekov[1,2], Tlekkabul Ramazanov[2], Sandugash Kodanova[2], Maratbek Gabdullin[2], and Moldir Issanova[2] — [1]ITAP, CAU, Kiel, Germany — [2]Al-Farabi Kazakh National University, Almaty, Kazakhstan

Hot dense plasma generated in NIF, Z-pinch, and GSI is usually nonisothermal and evolves from nonideal dense quantum plasma to ideal classical plasma. The effective pair interaction approach can be used for the fast and accurate study of the various physical properties of the weakly coupled semiclassical dense plasma. Therefore, the effective interaction potentials for the description of such plasma have been developed. Thermodynamic, microscopic, and transport properties of the weakly coupled dense nonisothermal plasma have been studied [1,2,3]. First of all, it is shown that developed effective interaction potentials correctly describes thermodynamic properties [1]. Secondly, the calculations of the transport properties in the simple pair collision approximation on the basis of the effective interaction potentials give good agreement with the orbital free DFT results [2]. Thirdly, the impact of the dynamical screening and electrons degeneracy on the stopping power has been analyzed. Finally, the impact of the nonideality effect on the characteristics of the DT tablet explosion has been considered.

[1] T.S. Ramazanov et al., Phys. Rev. E 92, 023104 (2015) [2] M.K. Issanova et al., Laser and Particle Beams 34, 457 (2016) [3] M.K. Issanova et al., Contrib. Plasma. Phys. 56, 425 (2016)

P 25.7 Do 10:15 HS 2010

Macroparticles in ion beam processing — •Elena Romashchenko, Igor Girka, and Alexander Bizyukov — V.N.Karazin Kharkiv National University, Svobody sq.,4, Kharkiv 61077, Ukraine

Ion beam processing of materials such as vacuum arc deposition and ion implantation is utilized to produce coatings with advantageous properties. The macroparticle (MP) contamination is the most important technological problem. The results of theoretical study of MP charging and dynamics in front of the negatively biased substrate for two energy regimes of ions are presented. The charge and dynamics of MP are governed by local parameters of ion and secondary electron emission fluxes in the sheath. The effect of electron emission from the substrate due to bombardment of multiply charged ions on MP dynamics is stud-

ied. It has been found that the MP number decreases with increasing substrate bias for both cases. It is shown that the maximum possible velocity of repelled MP increases with increasing substrate bias voltage.