P 7: Complex and Dusty Plasmas

Zeit: Montag 16:30–18:30 Raum: HS Foyer

P 7.1 Mo 16:30 HS Foyer

Nonlinear collisional plasma wakes of small particles — •Sita Sundar, Hanno Kaehlert, Jan-Philip Joost, Patrick Ludwig, and Michael Bonitz — Christian Albrechts Universitaet Kiel Germany - 24098

Dynamical screening and wake effects in complex plasmas have been the subject of many early investigations, including experimental [1] as well as theoretical work. However, it was shown using Linear Response(LR) theory [2] that the characteristic features of the wake potential for non-Maxwellian plasma are qualitatively different from Maxwellian streaming ions. Here, the electrostatic potential of a dust grain in streaming ions in the presence of collision frequency, ν is computed using three-dimensional particle-in-cell(PIC) code 'COPTIC' [3]. We compare our numerical results with the wake potential obtained from the LR formalism for Maxwellian and non-Maxwellian cases in linear as well as nonlinear regime. We discuss the physics of distribution function, flux etc. around the grain and present a parametric study of collision frequency vs. wake peak position, peak potential etc. for the non-Maxwellian streaming plasmas.

References:

[1] U. Konopka, G. E. Morfill, and L. Ratke, Phys. Rev. Lett. 84, 891 (2000).

[2] J.-P. Joost, P. Ludwig, H. Kaehlert, C. Arran, and M. Bonitz, Plasma Physics and Controlled Fusion 57, 025004 (2015).

[3] I. H. Hutchinson, Physics of Plasmas 18, 032111 (2011).

P 7.2 Mo 16:30 HS Foyer

Milli-gravity experiments with an improved PK-4 setup — •Michael Kretschmer, Markus Thoma, Christopher Dietz, and Benjamin Steinmüller — Justus-Liebig-Universität, Giessen, D

Plasmakristall 4 (PK-4) is a complex plasma laboratory installed onboard the International Space Station ISS since 2014. It is mainly used for studying complex plasmas in the fluid state by creating a dc discharge inside a glass tube with a low-pressure gas where microparticles are injected in. An engineering model of PK-4 resides at the university of Giessen (PK-4 GI). Unless the ISS unit, this setup can easily be altered and improved. It has been adapted for a parabolic flight campaign (PFC) with the A310 ZERO-G aircraft.

Additionally, PK-4 GI has been equipped with a new camera that allows the recording of the particles' motion with much higher resolution compared to the original camera. During the PFC with 124 parabolas, providing a g level of ±50 m-g, two main objectives were planned:

- Investigation of the phase transition of an electro-rheological (ER) plasma. In general, an ER liquid changes its mechanical properties, e.g. viscosity, when a voltage is applied. With PK-4 GI we can study this on the single-particle level.

- Demixing of two liquid phases. By injecting a mixture of particles with two different sizes into the plasma we can observe how the particles demix, from the individual to the collective particle scale.

- Wave phenomena are widely observed in complex plasmas. During the experiments described above we keep an eye also on this topic.

P 7.3 Mo 16:30 HS Foyer

Diagnostic of nanodust and nanodusty plasma — •Franko Greiner[1], Sebastian Groth[1], Benjamin Tadsen[1], Iris Pilch[2], Jonathan Schilling[1], and Alexander Piel[1] — [1]Institut für Experimentelle und Angewandte Physik, Christian-Albrechts-Universität Kiel — [2]Functional Materials Group, IFM, Linköping University, Sweden

A plasma containing submicron-sized particles is an interesting object from both basic plasma physics and plasma technology point of view. The density of the nanoparticles strongly depends on the ability of the discharge to confine particles and its interplay with the repelling forces between the particles. To diagnose the plasma, information on the size of the particle, their size- and spatial distribution, and their density are needed. With all this information dust density waves (DDW) can be used to diagnose the plasma. The advantage of the DDW diagnostic is that it is noninvasive and the waves can easily be studied by means of video microscopy. We discuss several findings and compare with results from other diagnostics like microwave interferometry and electrostatic probes.

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P 7.4 Mo 16:30 HS Foyer

Fast Langmuir probe measurements during nanoparticle growth in a CCRF plasma — •Erik von Wahl[1], Yerbolat A. Ussenov[2], T. S. Ramazanov[3], and Holger Kersten[1] — [1]Institute of Experimental and Applied Physics (IEAP), Kiel University, Germany — [2]National Nanotechnology Laboratory of Open type (NNLOT), Al - Farabi KazNU, Almaty, Kazakhstan — [3]Institute of Experimental and Theoretical Physics (IETP), Al-Farabi KazNU, Almaty, Kazakhstan

The oldest and well established technique to measure electron temperatures and electron densities in a plasma is the Langmuir probe, introduced by Mott-Smith and Langmuir.
However, in dust forming plasmas the current onto the probe may be distorted by charged dust particles and non-conductive contamination due to film forming radicals and ions. One approach to overcome this problem is by shielding the probe tip from its environment. In the present study ion bombardment by a negatively biased probe was used instead to keep it clean. Additionally, the V-I-characteristics were obtained by an advanced and fast voltage sweep pattern for the probe bias. By keeping the duration of positive bias shorter than the inverse of the nanoparticle's plasma frequency $\tau_d = 1/\omega_{pd}$ the negatively charged dust particles are not able to overcome the on average negative probe potential and, thus, cannot contaminate the probe.
Measured changes in electron density and temperature are presented during the entire growth cycle of nanoparticles. An upper limit for the dust plasma frequency will also be presented.

P 7.5 Mo 16:30 HS Foyer

Characteristics of the charge density distribution around a test charge in streaming plasmas — •Zhandos Moldabekov[1,2], Patrick Ludwig[1], Sita Sunda[1], Ingmar Schnell[1], and Michael Bonitz[1] — [1]Christian-Albrechts-Universität zu Kiel, Germany — [2]Al-Farabi Kazakh National University, Almaty

Interaction between dust particles in complex plasmas can significantly deviate from the simple Yukawa (Debye) type potential due to streaming of plasma particles. Recent progress on this problem has been achieved for both unmagnetized and magnetized plasmas. In the unmagnetized case, the deviation of the dust charge potential from the equilibrium result can be understood by the ion focusing effect of the negatively charged dust particle. Particularly, this is the case for the experiments on study of the complex plasma properties in the different types of gas discharges. Therefore, the development of the physical picture of the dust particles dynamics in such stationary nonequilibrium plasma requires the careful evaluation of the charge distribution of the focused ion cloud at different regimes of the plasma parameters. We take the ion acceleration by an external electric field explicitly into account, which leads to a non-Maxwellian velocity distribution. The results are compared to PIC and fluid simulations. Further attention is devoted to the construction of the analytical model within a multipole expansion approximation for the description of the lateral grain-grain interaction, i.e. perpendicular to the direction of the ion flow.

P 7.6 Mo 16:30 HS Foyer

Optical charge analysis of nanoparticles in RF discharges — •Harald Krüger and André Melzer — Institute of Physics, University Greifswald

Nanoscaled dust particles of aluminum oxide (Al_2O_3) in RF discharges can exhibit a charge-dependent resonance in Mie scattering in the infrared spectral range [1]. Measurements of this dependence will be used to determine the charge of the particles trapped in a dusty plasma.

In initial experiments the resonance has been detected. Besides the mere existence, the expected shifts of the resonance by a few wave numbers could not be measured with the resolution of the used FTIR spectrometer. Therefore the spectrum of the charged particles will be recorded in more detail using a high-resolution FTIR spectrometer.

[1] R. L. Heinisch, F.X. Bronold and H. Fehske, Phys. Rev. Lett. 109, 243903 (2012)

P 7.7 Mo 16:30 HS Foyer

Electric Field Reconstruction and Particle Trapping in Non-

linear Dust-Density Waves — •Stefan Schütt[1], Michael Himpel[1], Alexander Piel[2], and André Melzer[1] — [1]Institute of Physics, University Greifswald — [2]IEAP, University Kiel

Under laboratory conditions, micrometer-sized particles in a dusty plasma sediment in the lower discharge sheath. Under weightlessness, however, extended dust clouds can be generated and self-excited dust-density waves spanning over several wavelengths can be observed.

The dynamics of the dust particles is directly accessible by means of video microscopy. Using the reconstructed trajectories of individual particles, the potential in the wave field can be determined over a large spatial range. The decomposition into a modulation and a linear background component allows to determine the average electric field in the plasma. In this contribution, the application of this method to data obtained on parabolic flights is presented and the results are compared to numerical simulations.

In strongly non-linear dust-density waves, particles get trapped in an equilibrium of friction force and the modulated component of the electric field force. This can lead to a strongly deformed velocity distribution compared to linear waves. Molecular dynamics simulations of strongly coupled, driven waves are presented and compared to the experimental findings.

P 7.8 Mo 16:30 HS Foyer

Modification of microparticles due to intense laser radiation — •Dietmar Block, Jan Schablinski, and Frank Wieben — Institut for Experimental and Applied Physics, Kiel University, Germany

Recent experiments have demonstrated that it is possible to build an optical tweezer for dusty plasmas. It allows to trap and manipulate single particles from a 2-d plasma crystal. However, as soon as a particle is trapped it is exposed to intense laser radiation. To investigate the influence of intense laser radiation on the particle, the trapping and detrapping processes are studied with high spatial and temporal resolution. Our measurements show, that the trapped particle properties are different and that this change is reversible once the particle is detrapped.

P 7.9 Mo 16:30 HS Foyer

Simulation of ion wake effects in dusty plasmas — •Alexander Piel — IEAP, Kiel University

The focussing of supersonic ion flows by negatively charged dust particles and the associated accumulation of positive charge in the wake of the particle is a well known phenomenon [1]. In experiments, attractive forces between dust particles are often attributed to the attraction by the wake charge. In this contribution, results from a fast molecular dynamics code are presented that analyze the interparticle forces in detail. It is shown that net attractive forces are only found when the second particle is located transverse to the direction of the flow. The force is greatest in the plane of the maximum of the wake potential. Contrariwise, two flow-aligned particles only show repulsive forces. Further, the ion charge collection in two-particle systems is studied. The results are discussed w.r.t. the asymmetric interaction observed in resonance experiments [2].

These investigations were funded by DFG TR-24 project A2.

[1] D. Block et al, Contrib. Plasma Phys. 52, 804 (2012) [2] H. Jung et al, Phys. Plasmas 22, 053702 (2015)

P 7.10 Mo 16:30 HS Foyer

(In-)Compressibility of crystalline particle flows — •Jochen Wilms and Alexander Piel — Institute of Experimental and Applied Physics, Kiel University, Germany

Dust trapping of free-floating torus-shaped dust clouds in magnetized anodic plasmas has been studied extensively over the past few years. In an upright, ring-shaped confinement the particles are driven in azimuthal direction by the Hall component of the ion drag.[1] Because of acceleration and deceleration due to gravity a stationary but inhomogeneous flow pattern establishes. This flow shows many interesting properties, e.g., we observed shock-like phenomena, a crystallization of the flow, bifurcations and inverse bifurcations.[2] The laboratory experiments are accompanied by detailed 3D molecular-dynamics simulations which make measures accessible, which are beyond the possibilities of the real experiment. Recent results of these numerical experiments have shown that a toroidal dust flow in the incompressible fluid limit can evolve shock-like events which are similar to hydraulic jumps in open channel flows.[3] In this contribution we will discuss the hydrodynamics and the thermodynamics of flow properties and the hydraulic jump at the individual particle scale. Furthermore, we will examine on the microscopic level how a compressible medium like a dust cloud can act quasi-incompressible.

Funded by DFG in the framework of SFB-TR24, Project A2.

[1] I. Pilch et al., Physics of Plasmas **15**, 103706 (2008)
[2] J.Wilms et al., Physics of Plasmas **22**, 063701 (2015)
[3] A. Piel and J. Wilms, Physics of Plasmas **23**, 073701 (2016)

P 7.11 Mo 16:30 HS Foyer

The influence of pressure for the state of aggregation in complex plasmas — •Benjamin Steinmüller, Christopher Dietz, Michael Kretschmer, and Markus Thoma — I. Physikalisches Institut, JLU Gießen

The influence of neutral gas pressure for crystallization of extended three dimensional complex plasmas is investigated. The experiments are performed in a cylindrical parallel-plate radio frequency chamber under gravity conditions. To quantify the crystallization a new analysis method is proposed. This method is an extension of the scalar product of the local bond order parameter with the benefits from Minkowski structure metric. Both methods display the same behavior: At low pressure the complex plasma is in the solid state, while at high pressure it is in the liquid state. Former ground based experiments exhibited the opposite behavior.

P 7.12 Mo 16:30 HS Foyer

Kugelblitze - Evidenz und Interpretation — •Herbert Boerner — Mainz

Die Natur von Kugelblitzen ist ein kontroverses Thema der atmosphärischen Physik. Obwohl Berichte über Beobachtungen mehrere Jahrhunderte zurückreichen, ist sogar die Existenz der Kugelblitze keineswegs generell akzeptiert. Daher gibt es bisher auch keinen Konsensus über die Physik dieser leuchtenden Objekte. Dieser Vortrag diskutiert die vorliegende Evidenz in Form von Berichten, Fotografien und Videos. Mögliche Fehlinterpretationen von Beobachtungen und alternative Erklärungen wie Sinnestäuschungen werden diskutiert. Der Schwerpunkt wird hierbei auf neuere Beobachtungen gelegt. Abschließend werden die Chancen und Bedingungen für zukünftige kontrollierte Beobachtungen diskutiert, insbesondere im Hinblick auf die weite Verbreitung von Blitzortungssystemen und Videokameras.

P 7.13 Mo 16:30 HS Foyer

Korrelation von Kugelblitzbeobachtungen und positiven Wolke-Erde Blitzen — •Herbert Boerner — Mainz

Kugelblitze werden fast ausschließlich in Gewittern beobachtet, wobei diese Objekte eher selten oder sogar sehr selten auftreten. Überraschenderweise gibt es jedoch einige wenige Beobachtungen die von einer hohen Anzahl von solchen Objekten berichten, was auf besonders günstige Bedingungen für die Erzeugung hindeutet. Ein erster Hinweis auf eine mögliche Korrelation von Kugelblitzen und positiven Blitzen ergibt sich aus der Tatsache, dass in Wintergewittern mehr dieser Objekte beobachtet werden als man es von der geringen Zahl der Blitze erwarten würde. Ein besonders gut dokumentierter Fall aus Neuruppin (1994) stützt diese Vermutung. In dem Vortrag wird eine Reihe von solchen Beobachtungen analysiert um diese Korrelation zu verifizieren. Dazu werden die Eigenschaften von negativen und positiven Wolke-Erde Blitzen mit den Details der verschiedenen Beobachtungssituationen verglichen und eine Hypothese zu dem Erzeugungsmechanismus dieser Objekte vorgestellt.