P 27: Complex Plasmas and Dusty Plasmas II

Time: Thursday 14:00–15:55 Location: KI 1.174

Fachvortrag P 27.1 Thu 14:00 KI 1.174

Self-diffusion in single-component Yukawa fluids — •Sergey Khrapak[1,2], Boris Klumov[1,3], and Lenaic Couedel[1] — [1]Aix Marseille University, CNRS, Laboratoire PIIM, Marseille, France — [2]Institut fuer Materialphysik im Weltraum, Deutsches Zentrum fuer Luft- und Raumfahrt (DLR), Wessling, Germany — [3]Joint Institute for High Temperatures, Russian Academy of Sciences, Moscow, Russia

It was suggested in the literature that the self-diffusion coefficient of simple dense fluids can be approximated as a ratio of the squared thermal velocity of the atoms to the "fluid Einstein frequency." We have tested this suggestion using a single-component Yukawa fluid as a reference system. Yukawa fluid is particularly suitable for such a test, because the Einstein frequency is trivially related to the important thermodynamics property, excess internal energy, relatively well known in a wide parameter regime. The available simulation data on self-diffusion in Yukawa fluids, complemented with new data for Yukawa melts, are carefully analyzed. It is shown that although not exact, this earlier suggestion nevertheless provides a very sensible way of normalization of the self-diffusion constant. Additionally, we demonstrate that certain quantitative properties of self-diffusion in Yukawa melts are also shared by systems like one-component plasma and liquid metals at freezing. The observations are briefly discussed in the context of the theory of momentum transfer in complex (dusty) plasmas.

P 27.2 Thu 14:25 KI 1.174

Plasma dynamics around a dust cluster embedded in the sheath of a rf discharge — Jens Schleede, Lars Lewerentz, •Franz Xaver Bronold, Ralf Schneider, and Holger Fehske — Institut für Physik, Ernst-Moritz-Arndt-Universität Greifswald, 17489 Greifswald, Germany

We employ a PIC-MCC/PPPM simulation to investigate the plasma dynamics around a three-dimensional dust cluster of 44 particles embedded in the sheath of an argon rf discharge. Our approach tracks self-consistently the charge of the particles and the plasma flow towards and through them. The geometry of the cluster, its position in the sheath, both assumed to be fixed, and the plasma parameters are essentially identical to the experimental setups for investigating dust clouds in plasmas. We find strong shadowing and focusing effects leading to a broad distribution of the charges accumulated by the grains suggesting that theoretical models studying dynamical effects of the cluster which assume identical charges and reciprocal forces between the grains may have to be modified to be also applicable to dust arrangements trapped in the sheath of a rf discharge. From the time-resolved electron fluxes, visualized by tracer particles, we moreover identify density fronts and convection patters driven by the repulsion between the incoming electrons and the electrons collected by the particles. As expected the electron flux is neither isotropic nor laminar. Charging models developed for an isolated particle are thus also not applicable to an arrangement of grains trapped in the sheath of a rf discharge. – Supported by DFG through CRC/Transregio TRR24.

P 27.3 Thu 14:40 KI 1.174

Measuring the full Stokes vector of scattered light for in situ kinetic Mie ellipsometry via division of aperture. — •Andreas Petersen, Franko Greiner, and Sebastian Groth — Institute of Experimental and Applied Physics, Kiel University, Germany

Nanodusty plasmas are of interest to basic plasma physics as well as to plasma technology. The confinement provided by the discharge and the interparticle forces are the major factors which determine particle density. To investigate the plasma, size and spatial distribution of the particles are needed. We present a new setup featuring a division of aperture camera in combination with a liquid crystal retarder. This allows us to measure the four Stokes parameters of laser light scattered by the probed nanoparticles. This method builds upon and expands Imaging Mie [1]. It uses a kinetic approach [2] to allow in situ measurement of particle radii.
[1] F. Greiner et al., Plasma Sources Sci. Technol. 21, 065005 (2012)
[2] S. Groth et al., J. Phys. D: Appl. Phys. 48, 465203 (2015)

P 27.4 Thu 14:55 KI 1.174

Particle size estimation of optical thick nanoparticle clouds — •Franko Greiner[1], Nils Rehbehn[1], Florian Kirchschlager[2], and Sebastian Wolf[3] — [1]Institute of Experimental and Applied Physics, Kiel University — [2]Department of Physics and Astronomy, UCL London — [3]Institute of Theoretical Physics and Astrophysics, Kiel University

Up till now the basic physics of nanodusty plasmas is only little examined. Such plasmas have a very high dust density and therefore a high degree of electron depletion, i.e. the Havnes parameter is high compared to unity. The density and size of the nanoparticles are the key parameters for the understanding of the nanodusty plasma. In the interesting regime of high particle size and/or density, the nanodusty plasma becomes optical thick and standard Mie ellipsometry, which relies on single scattering, fails. Recently we have presented a method to include multiple scattering into Mie ellipsometry. We used 3D Monte-Carlo polarized radiative transfer simulations which allow us to calculate the characteristics of light scattered by the nanoparticle cloud with arbitrary optical depth [1]. Including the spatio-temporal development of the experimental density profile into the simulation enables us to estimate the particle radius for high optical depths.
[1] F. Kirchschlager et al., Appl. Phys. Lett. **110**, (2017)

P 27.5 Thu 15:10 KI 1.174

A second look at void closure in complex plasmas — •Erich Zaehringer, Igor Semenov, Christina A. Knapek, Milenko Rubin-Zuzic, Daniel P. Mohr, Peter Huber, and Hubertus Thomas — DLR German Aerospace Center, Institute of Materials Physics in Space

Complex Plasmas are small micrometer sized particles injected into a low temperature rf-plasma. The particles are getting charged by electron and ion fluxes and form systems with gaseous, liquid and solid properties. Normally complex plasmas are compressed to 2D systems in laboratory conditions while they form a 3D cloud in micro-gravity with a particle free region in the center which is called void. The void can be suppressed by gas flow or additional electric fields, however, both ways add stress to the system. Another way is the reduction of rf-power, which was successfully used on the ISS before. The comparison of simulations and emission patterns reveal a lot of open questions, which were targeted by experiments of the 29. DLR parabolic flight campaign. The absence of a void in 1D self-consistent simulations indicates that the void is caused by 2D effects or more difficult geometries. In the experiments we could close and reopen the void by decreasing and increasing the rf-power. Other effects, such as particle mixtures in the former void region and dust density waves across the particle cloud, were observed.
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P 27.6 Thu 15:25 KI 1.174

Two dimensional dust density wave diagnostics (DDW-D) of nanoparticles in an argon radio frequency discharge — •Oguz Han Asnaz, Benjamin Tadsen, Franko Greiner, and Alexander Piel — Institute of Experimental and Applied Physics, Kiel University, Germany

The wavevector and wave frequency of self-excited dust density waves (DDW) in a nanodusty plasma can be used as a tool for plasma diagnostics, giving spatially resolved information about ion and electron densities, dust charge and the plasma potential. The presented approach expands upon the analysis presented in Ref. 1 and examines the complete two-dimensional cross-section of the wave field. This approach will be used to investigate changes in the nanodusty plasma parameters, when the reactive gas for growing nanoparticles is changed from acetylene to silane. Comparing the resulting wave fields for a-C:H and a-Si:H particles provides insight into the influence of the particle surface properties on the plasma parameters.
[1] B. Tadsen et al., Phys. Plasmas **22**, 113701 (2015)

P 27.7 Thu 15:40 KI 1.174

Pulsed rf-Discharge in Zyflex-Chamber — •Peter Huber[1], Christina A. Knapek[1], Daniel P. Mohr[1], Erich Zaehringer[1], Andrey M. Lipaev[2], Vladimir I. Molotkov[2], Hubertus M. Thomas[1], and Vladimir E. Fortov[2] — [1]DLR, Institut für Materialphysik im Weltraum, Weßling, Deutschland — [2]Joint Institute for High Temperatures, Moscow, Russia

Interrupting rf-discharge is a well known method to control processes in plasmas. For example, in semiconductor processing it can be used to control growth of particles from material out of the plasma phase. By switching off the discharge, "fog" of grown particles can be driven out of the plasma by gravity. On the other hand, pulsing the plasma gives a good possibility to tune effective electron temperature independently from plasma density. So you could tune interactions in complex plasma systems in a more flexible way.

Ekoplasma will provide Plasmalab, the future lab for complex plasma research on the international space station ISS. Together with its large cylindrical chamber Zyflex it will have many features to cover a wide range of physics in complex plasma research. It also includes a multifunctional rf-generator which can be pulsed at different frequencies with on/off times even less than 50 μs. Combining the feature of switching the discharge on and off with micro gravity conditions it will be possible to tune plasma parameters without losing particles due to gravitational forces.

In this contribution, we will show first results of particles levitated in a pulsed gas discharge in the current lab setup of Ekoplasma.