P 8: Complex Plasmas and Dusty Plasmas I

Time: Tuesday 10:30–12:25 Location: KI 1.174

Invited Talk P 8.1 Tue 10:30 KI 1.174

Life in the void: nanoparticle formation in reactive plasmas — •Ferdi van de Wetering — Eindhoven University of Technology, Department of Applied Physics, P.O. Box 513, 5600 MB Eindhoven, the Netherlands

Reactive plasmas are plasmas where nanoparticles spontaneously form in the volume from the feed gas molecules. This can be advantageous since the produced particles generally have a monodisperse size distribution and therefore have a multitude of applications. It can also be detrimental, especially in the semiconductor industry, where plasmas are widely used in the production of integrated circuits.

Nanoparticle formation in these plasmas is generally accepted to follow a step-wise process: polymerization of the feed gas molecules, nucleation, coagulation and accretion of plasma ions and radicals. The resulting particles charge negatively by attachment of plasma electrons and are therefore confined in the positive plasma glow. Under certain conditions this results in a dense cloud of solid nanoparticles levitated in the plasma.

Sometimes, a macroscopic dust-free zone (void) develops as a result of forces pushing particles outward (such as the ion drag force). A new cycle of nanoparticle formation is impeded in the nanoparticle cloud, but it can start in the void region. By employing several diagnostics, such as microwave cavity resonance spectroscopy, electron microscopy, Mie scattering and emission spectroscopy, as well as modeling, we are able to explain the peculiar and interesting dynamics of the void and link this directly to the step-wise and cyclic formation of nanoparticles.

Fachvortrag P 8.2 Tue 11:00 KI 1.174

Investigation of spatial-dependent particle growth using a new imaging RCE technique — •Sebastian Groth, Franko Greiner, and Alexander Piel — Institute of Experimental and Applied Physics, Kiel University, Germany

Under certain circumstances nanometer-sized particles grown in a reactive argon-acetylene plasma form quite homogeneous monodisperse particle clouds. The size evolution of these clouds can be investigated via random point measurements using a commercial RCE or by simple spatially resolved imaging diagnostics [1]. Nevertheless there are various scenarios like sheath growth, void growth or localized growth, where an inhomogeneous size evolution of nanodust clouds is observed. To describe these phenomena in situ quantitatively as a function of space and time a new imaging diagnostic has been developed that measures all four Stokes vector components to determine spatially resolved the particles' size and optical properties. Corresponding to the optical setup the diagnostics are named Imaging Rotating-Compensator-Ellipsometer (I-RCE). We present this newly developed diagnostics and demonstrate its advanced capabilities on different growth scenarios.

Supported by the Deutsche Forschungsgemeinschaft within the SFB-TR24, project A2.

[1] F. Greiner et al., Plasma Sources Sci. Technol. **21**, 065005 (2012)

P 8.3 Tue 11:25 KI 1.174

Coupled modes in the absence of the mode-coupling instability — John K. Meyer, •Ingo Laut, Sergey K. Zhdanov, Volodymyr Nosenko, and Hubertus M. Thomas — Institut für Materialphysik im Weltraum, Deutsches Zentrum für Luft- und Raumfahrt, Wessling

The mode-coupling instability (MCI) is a much examined instability in two-dimensional complex plasma crystals which is based on the nonreciprocal, wake-mediated interactions [1]. When the transverse vertical and the longitudinal wave modes intersect, an instable hybrid mode is formed that leads to the melting of the crystal. It was believed that such a coupling of modes is possible only when the modes do intersect.

Here we report an experimental observation of coupling of the transverse vertical and longitudinal wave modes in the absence of MCI [2]. A new large diameter rf plasma chamber was used to suspend the plasma crystal. The observations are confirmed with molecular-dynamics simulations.

[1] L. Couëdel, S. Zhdanov, A. V. Ivlev, V. Nosenko, H. M. Thomas, and G. E. Morfill, Phys. Plasmas **18**,, 083707 (2011)
[2] J. K. Meyer, I. Laut, S. Zhdanov, V. Nosenko, and H. M. Thomas, accepted for publication in Phys. Rev. Lett.

P 8.4 Tue 11:40 KI 1.174

Laser heating of finite binary mixtures in complex plasmas — •Frank Wieben, Tobias Kramprich, and Dietmar Block — Institute of Experimental and Applied Physics, Kiel University, Germany

Complex plasmas, plasmas containing microparticles, are excellent model systems to study the thermodynamic properties of Yukawa systems. In recent experiments laser heating methods proved to be perfect tools to investigate phase transitions in monodisperse 2D and 3D particle ensembles. The melting temperature of finite clusters strongly depends on the total number of particles and the exact configuration of the system. As simulations on the melting of 2D binary Coulomb clusters suggest, the melting temperature in systems containing two species of different sizes and charges also depends on the mixing- and charge-ratio. However, up until recently there has been no experimental access to 2D binary mixtures since particles of different sizes leviate in separated layers. By combining particles of different materials 2D binary mixtures can be generated [1]. In this contribution experimental and simulation results on the heating of finite binary particle systems ($N \approx 100$) are presented. The melting and relaxation behavior of these two-component systems show a strong dependance on the mixing ratio. This work was supported by the Deutsche Forschungsgemeinschaft DFG in the framework of SFB TR 24 Greifswald Kiel, Project A3b and of Research Grant BL555/3-1.

[1] Wieben et al, Phys. Plasmas **24**, 033707 (2017)

P 8.5 Tue 11:55 KI 1.174

effect of discharge polarity reversal on the wave propagation in flowing complex plasma under microgravity condition — •Surabhi Jaiswal, Mikhail Pustylnik, and Sergey Zhdanov — DLR, oberpfaffenhofen, Germany

We presented an experimental investigation of effect of discharge polarity reversal on the wave structure generated in a flowing complex plasma at lower pressure. Experiment has been performed under microgravity conditions on board the International Space Station by using PK-4 facility, which ensured particle levitation inside the chamber up to desired volume. On changing the polarity, direction of dust cloud as a whole has been reverse however direction of associated wave structure remain unchanged with a small shift in the trajectory during polarity reversal. Generation of new crest in between the existing crest and merging of wave crest have been observed. Hilbert transform technique is used to understand the local variation of frequency, wave number and velocity of the crest. A model has been developed to understand the appearance of additional crest and variation in phase speed.

P 8.6 Tue 12:10 KI 1.174

String fluid instability in a complex plasma in a direct current discharge under microgravity — •Mierk Schwabe, Sergey Zhdanov, Mikhail Pustylnik, and Hubertus Thomas — Institut für Materialphysik im Weltraum, Deutsches Zentrum für Luft- und Raumfahrt (DLR), Münchener Str. 20, 82234 Weßling

The PK-4 Laboratory is a Russian-European laboratory for studies on complex plasmas on board the International Space Station ISS. Its heart consists of a direct current plasma tube with 3 cm diameter and a total length of 85 cm. Microparticles of various sizes can be injected into the plasma. Here, we report on an instability formed in the microparticle cloud in which waves form. The plasma was driven in polarity switching mode * the DC electric field was quickly switched, and the microparticles were trapped in the center of the discharge. The polarity switching causes the ions and electrons of the plasma to stream around the microparticles, and the ions form wakes in downstream direction of the microparticles, which in turn attract other microparticles and lead to the formation of microparticle strings. Here, we report on the formation of waves in such a string fluid. We study the dispersion relation of the waves, demonstrate that they are not ordinary dust acoustic waves, and hypothesize on the excitation mechanism of the instability.