Characterization of new radio-frequency setup for studying large 2D complex plasmas

V. Nosenko, J. K. Meyer, S. K. Zhdanov, H. M. Thomas

Institut für Materialphysik im Weltraum, Deutsches Zentrum für Luft- und Raumfahrt (DLR), D-82234 Weßling, Germany

Addressing the growing need for larger complex-plasma systems, a new plasma setup was built at the DLR Institute of Materials Physics in Space [1]. It is based on a relatively large (90 cm in diameter) vacuum chamber where a capacitively coupled radio-frequency (rf) discharge is used to suspend a two-dimensional (2D) cloud of polymer microparticles. The discharge is created between the lower rf electrode and the grounded chamber walls, the particles levitate in the plasma (pre)sheath above the electrode. The new setup was characterized using a variety of diagnostics.

The amplitudes of the rf voltage and current measured using the Solayl Vigilant rf probe were 16−32 V and 9−19 A, respectively, depending on the gas pressure and discharge power. The phase angle between the rf voltage and current was ≈ 70°. Compared to the Gaseous Electronics Conference (GEC) rf reference cell, the present setup is characterized by relatively high current and relatively low voltage. The basic plasma parameters were measured in the bulk plasma 6.5 cm above the center of rf electrode using the Hiden ESPion rf-compensated Langmuir probe. The electron temperature T_e was measured in the range of 0.4−2 eV, depending on the gas pressure and discharge power. The electron density n_e was in the range of 0.5×10^9−3.6×10^9 cm^{-3}. The electron density measurements were corroborated using microwave interferometry technique (Miwitron MWI 2650).

Video microscopy was used to image suspended microparticles. Their coordinates were then calculated in each frame using a Particle Tracking Velocimetry (PTV) technique. The particle velocity fluctuation spectra were calculated and fitted to theoretical dispersion relations to arrive at the particle charge in the range of 2×10^4−$3.6\times10^4 e$ and screening length in the range of 0.9−1.7 mm.

[1] V. Nosenko, J. Meyer, S. K. Zhdanov, H. M. Thomas, AIP Advances **8**, 125303 (2018).