NEW APPROACH TO THE THEORY OF VOID BOUNDARY FOR THE RF DISCHARGE COMPLEX PLASMA

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We treat the 3D cloud of dust particles formed in the low-pressure rf discharge under microgravity conditions. A space close to the center of rf discharge free from the dust particles is termed void. In recent studies, location of the void boundary is associated with the loss of balance of the forces acting on dust particles. However, the results of both the analytical approaches and numerical simulation are incompatible with experimental data. We propose a new approach that implies onset of an instability at the void boundary. In the fluid approximation, the particle dynamics is defined by the Euler equation, where the particle pressure gradient and the electric and ion drag force are taken into account. These forces are calculated based on the ionization equation of state [1]. Stability analysis yields the threshold condition for instability development $(Zv_M^2/3\nu c_s)(3\gamma-2)(\gamma-1)^{-1}\nabla\ln n_e > 1$, where $v_M^2 = T_e/M$, T_e and n_e are the electron temperature and number density, Z and M are the particle charge and mass, respectively; ν is the damping rate of a particle due to the neutral drag, c_s is the dust acoustic sound velocity, and γ is a function of the particle dimensionless electrostatic potential defined in [1]. Proposed approach provides a first interpretation of the following experimental regularities: (a) existence of a cusp of the particle number density at the boundary [2], (b) decrease of the boundary particle number density with the increase in argon pressure [2], and (c) the void size is significantly larger in experiments with neon as compared to argon.

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1. Zhukhovitskii D.I. // Phys. Plasmas. 2019, V. 26. No. 6. P. 063702.
2. Naumkin V.N., Zhukhovitskii D.I., Molotkov V.I., *et al.* // Phys. Rev. E. 2016. V. 94. No. 3. P. 033204.