ON THE THEORY OF DUST IONIZATION WAVES IN THE GAS DISCHARGE COMPLEX PLASMA

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The theory is developed for the dust ionization waves (DIW) that have been recently observed in the experiment [1]. DIW is a novel type of the waves involving spatial oscillations of the dust particles that can be observed in complex plasma under microgravity conditions. In contrast to the well-known dust acoustic waves (DAW), propagation of DIW is due to the oscillations of electron–ion recombination rate on the dust particle surface rather than to the compressibility of the dust cloud. The set of governing equations include the momentum and continuity equations for the dust particles, the balance equation for cold ions, the Boltzmann distribution for the hot electrons, and the Poisson equation. The momentum equation includes the contributions from the dust cloud compressibility, the electric field, the dust particle friction against neutrals with the damping frequency ν, and the dust particle–plasma interaction in the form [2]. Solution of these equation accounts for the observed key properties of DIW. In particular, it is shown that the DIW and DAW modes are unified by the resulting dispersion relation and form a junction at the excitation frequency $\omega = \omega_d$. Both modes can be realized if the excitation frequency exceeds the frequency lower bound ω_d. The DIW mode wave number $k = k_d\tilde{\omega}(\tilde{\omega}^2 - 1)^{-1/2}$, where the constant k_d is defined by the system properties and $\tilde{\omega} = \omega/\omega_d$, is weakly dependent on ω. The DIW phase velocity increases with ω, and it is much greater than the DAW velocity. The DIW damping length $2\tilde{\omega}^3/\tilde{\nu}k_d$, where $\tilde{\nu} = \nu/\omega_d$, can be orders of magnitude larger that that for DAW. Hence, DIW can be externally excited but DIW self-excitation is impossible. Instead, under proper conditions, DAW can be self-excited, otherwise, it is difficult to observe DAW. The estimates for ω_d and k_d correlate with the corresponding experimental values [1].

This research is supported by the Russian Science Foundation, Grant No. 20-12-00365.

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