Theory of dust particle charging in multicomponent humid air plasmas

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The paper examines the charging of micron-sized dust particles in a multicomponent plasma of humid air and H_2O:O_2:N_2 gas mixtures at various gas ionization rates by an external ionization source. The dust particle charge was determined using a kinetic model of ion-molecular processes, encompassing over 600 reactions for electrons, negative and positive ions, including hydrated ions containing up to 12 water molecules. It was found that, despite the negligible electron number density far from the dust particle in an undisturbed plasma, the charge of dust particles in humid air is determined by the electron flux when the gas ionization rate exceeds a critical value. This leads to relatively high dust particle charges, comparable to those in electropositive gases. The influence of the gas ionization rate and its composition on the dust particle charge was studied. The main attention is paid to the analysis of analytical methods for estimating the charge of dust particles at elevated gas pressures under conditions of applicability of the diffusion-drift approximation, which began to be developed by Gunn in the paper [1] and were continued by Fuchs in [2], etc. (a more detailed review of these papers is given in the paper [3]). A comparative analysis of the data obtained in numerical calculations with the results of analytical theories of particle charging showed the limited applicability of the latter.

[1] Gunn R 1954 *J. Atmos. Sci.* **11**(5) 339–347
[2] Fuchs N A 1963 *Geofis. Pura Appl.* **56**(1) 185–193
[3] Vysotskii D V, Trushkin N I, Filippov A V and Cherkovets V E 2025 *Plasma Phys. Rep.* **51**(7) 800–812