Wakefield around a dust particle in streaming plasmas and dynamics of the dusty plasmas in external magnetic field

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Complex plasmas in an external magnetic and electric fields are investigated by means of computer simulation and experimentally. We present results for streaming plasmas and for magnetized non-ideal plasmas.

Streaming complex plasmas are routinely generated in high energy density facilities (e.g., the tokamak edge), industrial setups, and in experiments on fundamental dusty plasma research [1, 2]. We present our results on the induced charge density distribution of the plasma constituents around dust particle. The subsonic, sonic, and supersonic regimes are considered taking into account the non- Maxwellian distribution of the flowing ions. In contrast to the wake potential, the density decays strongly monotonically in the plasma wake and does not exhibit an oscillatory pattern or trailing maxima. Therefore, the picture of an ion focusing effect creating a separated ion region downstream was not confirmed. We have computed the dipole moment of the deformed screening cloud as the function of the Mach number, where Mach number is defined as the ratio of the ion streaming velocity and the ion sound speed.This quantity is of central importance for the simplified analytical models describing dust particles interaction in streaming plasmas (in an external electrical field) [3].

Furthermore, the effects resulted from competition between an external magnetic field and gas induced friction in non-ideal magnetized two-dimensional dusty plasma were revealed by the Langevin dynamics computer simulation. We found that the presence of the friction leads to the disappearance of a collective oscillation mode—related to the cyclotron frequency of the dust particles—and decreasing in the dominant mode. Moreover, new interesting observation is made: at lower friction rates, an increase in the magnetic field strength leads to an increase in the main peak in the Fourier transformation of the velocity autocorrelation function, while at higher friction rates the opposite is true [4].

To study the dust particles dynamics in partially magnetized complex plasmas, the experiments on dust particles rotation in the DC glow discharge in an external magnetic field were performed. In these experiments, the dust particles rotation direction is shown to depend on the angle between the magnetic field induction and electric field. Particularly, for the first time, the rotation due to the radial component of the magnetic field was observed. A simple analytical model describing the experimental observations is presented [5].

[1] R. A. Quinn, J. Goree. Particle interaction measurements in a Coulomb crystal using caged-particle motion // Phys. Rev. Lett. – 2002. – Vol. 88. – P. 195001.
[2] S. K. Kodanova et al. Dust particle evolution in the divertor plasma // IEEE Transactions on Plasma Science. – 2016. – Vol. 44. – P. 525.
[3] T. S. Ramazanov, Zh. A. Moldabekov, and M. T. Gabdullin. Multipole expansion in plasmas: Effective interaction potentials between compound particles // Phys. Rev. E. – 2016 – Vol. 93 – P. 053204.
[4] K. N. Dzhumagulova, R. U. Masheeva, T. S. Ramazanov, and Z. Donkó. Effect of magnetic field on the velocity autocorrelation and the caging of particles in two-dimensional Yukawa liquids // Phys. Rev. E – 2014. – Vol. 89 – P. 033104; P. Hartmann, J. C. Reyes, E. G. Kostadinova, L. S. Matthews, T. W. Hyde, R. U. Masheyeva, K. N. Dzhumagulova, T. S. Ramazanov et al., Self-diffusion in two-dimensional quasimagnetized rotating dusty plasmas // Phys. Rev. E – 2019. – Vol. 99 – P. 013203
[5] A.R.Abdirakhmanov, Zh.A. Moldabekov, S.K. Kodanova, M.K. Dosbolayev, T.S. Ramazanov, Rotation of dust structures in a magnetic field in a DC glow discharge, submitted for publication (2019).