STUDY OF FUNDAMENTAL PROCESSES IN STRONGLY COUPLED DUSTY PLASMAS BY THE TIME-AVERAGED CORRELATIONAL ANALYSIS

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We present here the results of theoretical analysis of the time-averaged correlation functions for displacements and velocities of interacting particles in strongly coupled systems.

One of the important experimentally unsolved problems in complex plasmas is a spatial structure of the wake field (a result of interaction of microparticles with a plasma flow). Since the wake is formed behind the particle downstream the ion flow, a flow-aligned particle chain in a plasma-sheath is a convenient structure for studying the wake-mediated interaction between particles. In this work, we present a new contactless technique for studying pair interactions in complex plasmas based on measuring the time-averaged correlations of displacements and velocities of strongly interacting particles, which can be relatively easily measured in experiments with grains in different non-ideal systems. We propose the simple analytic relationships for determination of the gradients of inter-grain forces as well as of external fields, knowing only the values of the above correlates. Numerical simulations show that the proposed approach is effective to study the wake of dust particles. We also propose a new simple criterion (developed on the basis of correlation approach) that makes it possible to detect a violation of the symmetry of the pair interaction in strongly coupled dissipative systems.

A simple analytical model(based on the above-mentioned approach) for description of sources of additional kinetic energy in systems of particles with a nonreciprocal interaction was developed. The theory yields the satisfactory results for a qualitative analysis of the features of dust dynamics in an anisotropic complex plasma. Unlike the theoretical models proposed earlier to explain the anomalous heating in the systems of particles with a nonreciprocal interaction, our model allows to predict not only the kinetic energy growth for grains in laboratory RF discharges, but also an increase of their kinetic temperature in the direction of an ion flow as well as a difference in the energy distribution between the degrees of freedom. To verify the theory, we carried out numerical simulations of vertically aligned chains and extended layered structures with a nonreciprocal model of interaction that is similar to interaction due to an effect of the ion focusing in a laboratory complex plasma.

We consider the phenomenon of coupling (condensation) of dust particles into self-confined particle pairs in an anisotropic plasma medium with an ion flow. On the basis of the correlational approach, we show that a self-confined pair of particles exists even if their total kinetic energy is much greater than the potential well depth for the pair state. This phenomenon occurs due to velocity correlation of particles, which arises with the non reciprocity of interparticle interaction. We obtain the stability conditions of the pair (bound) state depending on the interaction parameters and particle kinetic energy. It was shown that the breakup of the particle pair is very sensitive to the ratio of particle charges; for example, it is determined by the influence of the upper particle on the ion flow around the lower one.