Dust Lattice Modes in Complex Plasmas with Inhomogeneous Dust Charges

V.V. Yaroshenko[1,2], A.V. Ivlev[1], and G.E. Morfill[1]

[1]*Max Planck Institute for Extraterrestrial Physics, D-85741, Garching, Germany*

[2]*Institute of Radio Astronomy of the National Academy of Sciences of Ukraine*

Dust lattice (DL) modes arising in strongly coupled dusty plasmas have been extensively studied both theoretically and in many experiments using radio-frequency discharge plasmas in the laboratory and under microgravity conditions. In the laboratory experiments, the highly negatively charged microparticles levitate in the sheath region of the horizontal negatively biased electrode where there is a balance between the gravitational and electrostatic forces acting in the vertical direction. There are a few characteristic features of such particle trapping. On the one hand, the complex plasma structures reveal the anisotropy due to vertical supersonic ion flows that lead to the formation of an ion "wake" underneath the suspended microparticles [1]. It turns out that this "wake" effect can induce instabilities in the plasma crystal related to interaction of transverse and longitudinal DL modes close to the point where their branches intersect [2]. On the other hand, the charge of the microparticles caused by the electron and ion currents onto the grain surfaces strongly depends on the vertical particle position in the sheath region [3]. This introduces anisotropy of the system related to a vertical profile of the equilibrium particle charge. We study the influence of both factors: the particle-wake interaction and vertical charge inhomogeneity on coupling of the transverse and longitudinal DL modes in a one-dimensional horizontal particle string. It is found two different ways of the reconnection of the dispersion curves in complex plasmas. When a particle string is suspended at a level where the particle charge is increased, the transverse and longitudinal branches become confluent in such a way, that there is a considerable frequency gap in the vicinity of the intersection point, in which both DL modes are evanescent. This type of reconnection between the two types of DL waves can be considered as a kind of the linear mode conversion. Conversely if the particles levitate at that part of the sheath where the equilibrium charge is reduced, a confluence of the transverse and longitudinal branches occurs separately in the long-wavelength and short wavelength ranges, thus leading to the gap in the wavenumber domain, and resultant instability of the hybrid mode. Using the typical complex plasma parameters, it is found that this instability could be of importance at gas pressures below of a few tens Pa. The experimentally observed spontaneous excitations of DL waves that occur in complex plasmas when the gas pressure is decreased below a critical value (e.g. in [4] at pressures below 5 Pa) can be a manifestation of the discovered DL mode instability.

[1] F. Melandsø and J. Goree, Phys. Rev. E **52**, 5312 (1995).
[2] A. Ivlev and G. E. Morfill, Phys. Rev. E **63**, 016409 (2000).
[3] A. Ivlev, U. Konopka and G. E. Morfill, Phys. Rev. E **62**, 2739 (2000).
[4] A. Samaryan, B. W. James, S. V. Vladimirov, and N. F. Cramer, Phys. Rev. E **64**, 025402 (2001).