Two-dimensional dusty plasma crystals and liquids

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Strongly coupled plasmas - in which the average potential energy per particle dominates over the average kinetic energy - appear in a wide variety of physical systems [1]. Among these systems, dust plasma crystals and liquids realized in low-pressure gas discharges by dispersing mesoscopic grains into the plasma have attracted a lot of attention during the past years. Quasi-two-dimensional (single layer) configurations of dust particles can be created using a horizontal planar electrode arrangement. Here the dust layer is levitated near the sheath edge of the lower electrode due to the balance between gravity and the electrostatic force acting on the grains (which acquire a high negative charge in the plasma). The grain-grain interaction in such systems can be well described through a Yukawa potential, which accounts for the Coulomb repulsion of charged dust particles and for the screening by the embedding plasma.

We describe the experimental realization of the quasi-two-dimensional dust system; summarize the basics of the computer simulation and theoretical approaches capable of their description in the liquid and solid phases. We discuss the properties of the dynamical density and current correlation spectra, generated by molecular dynamics simulations [2,3]. Three different collective excitations develop in the systems: in the liquid phase (i) the compressional (longitudinal) mode exhibits a quasi-acoustic dispersion, (ii) the in-plane shear (transversal) mode is acoustic with a cutoff at finite wave number, and (iii) the out-of-plane transversal mode is of optical nature [4]. Harmonic generation due to nonlinear wave-wave interaction is also observed.

We also address the issues associated with the existence of different structural phases [5] and transport coefficients (e.g. superdiffusive behavior) [6] in the low-dimensional system under study.

[1] G. J. Kalman, J. M. Rommel and K. Blagoev, Strongly coupled Coulomb systems (New York: Plenum Press, 1998)

[2] G. J. Kalman, P. Hartmann, Z. Donkó, and M. Rosenberg, Phys. Rev. Lett. 92, 065001 (2004)

[3] Z. Donkó, G. J. Kalman and P. Hartmann, Submitted to J. Phys. Cond. Matter (2008)

[4] Z. Donkó, P. Hartmann and G. J. Kalman, Phys. Rev. E 69, 065401 (2004)

[5] P. Hartmann, Z. Donkó, P. Bakshi, G. J. Kalman, S. Kyrkos, IEEE Trans. Plasma Sci. 35, 332 (2007)

[6] Z. Donkó, J. Goree, P. Hartmann, Bin Liu, to be submitted to Phys. Rev. E.