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Study of wave spectra of square-lattice domains in a disordered quasi-two-dimensional binary complex plasma

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A complex plasma consists of weakly ionized gas and microparticles. Those particles are charged negatively while interacting with ions and electrons. In complex plasmas, binary mixture can be introduced as a means to suppress crystallization. With presence of gravity, two types of particles are levitated in the (pre)sheath above the bottom electrode, forming a quasi-two-dimensional (q2D) disordered solid by quenching. Constituent microparticles can be visualized individually with video microscopy and tracked by algorithm. In this talk, we report an observation of domains of square lattice in a q2D binary complex plasma. Wave spectra of such domain are measured and compared with the numerical simulation.

The experiments were performed in a modified Gaseous Electronics Conference (GEC) rf reference cell. Argon plasma was sustained using a capacitively coupled rf discharge at 13.56 MHz with an input power of 20 W. The gas pressure was about 0.65 Pa. The q2D binary complex plasma was composed of monodisperse melamine formaldehyde (MF) and polystyrene (PS) microparticles.

In the experiments, one sees a few domains of square lattice with various sizes embedded in the amorphous binary mixture. The largest domain is made of approximately 80 particles. To identify the collective dynamics of such square lattice, we compute the longitudinal and transverse component of the wave spectra using Fourier transformation. The results are shown in the upper panels in Figure 1 [1].

To compare with the experiment, Langevin dynamics simulations of a binary mixture were carried out, where the non-reciprocal interactions between different types of particles were modeled with a point wake Yukawa potential [2,3]. The experiment shows good agreement with the simulation where the wake charge is set to 20% of the particle charge, as shown in the lower panels in Figure 1.

Furthermore, we study the influence of the wake charge model on the dispersion relations in the simulations. As results, with the increase of the wake charge, the frequency for the longitudinal component decreases, while the transverse component increases.

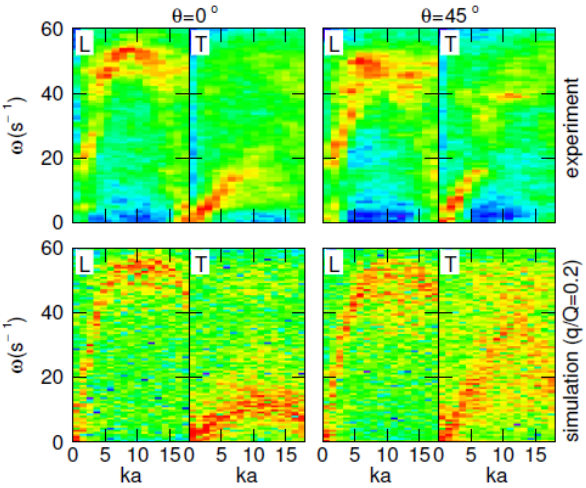

Figure 1 Phonon spectra of the q2D binary complex plasma for experiment and simulation.

For summary, this talk reports on a study of domains of square lattice embedded in a disordered q2D binary complex plasma. We focus on the phonon spectra for longitudinal and transverse component of the in-plane mode. We expect that the presented results will stimulate further studies of phonon spectra in binary complex plasmas.

References

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