Lattice constant mismatch induced superlattices in tightly confined Yukawa solids

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Solids under different geometrical constraints exhibit rich dynamical behaviors and structures. Examples include the substrates with different atomic lattices, or substrates with flat surfaces. The former is related to epitaxy, where the topography of substrates is intentionally designed to manipulate the structure, facing, and/or orientation of stacking lattice. It could lead to the formation of superlattice, composed of two or more stacking atomically thin layers with mismatch lattice constant and/or lattice orientation [1].

Despite the simple appearance, the flat boundary suppresses the normal motions of the particles, align particles, and induces the formation of layers in parallel with the boundary up to the correlation length [2-4]. Particles in each layer are triangularly packed. These effects have been directly demonstrated experimentally by colloidal particles in a water solution or charged dust particles in the plasma [2,5].

Therefore, it is intriguing to ask a question from a fundamental view: Can a superlattice be formed under the structure heterogeneity caused by the symmetry breaking from the presence of confinement boundaries?

In this work, through Langevin-type molecular dynamic simulation, the above issues are unraveled using mesoscopic 3D Yukawa crystal confined in a narrow gap with a pair of parallel reflective boundaries as a platform. The system allows the formation of 16 to 15 layers in the tight gap by decreasing κ (the ratio of the mean Wigner-Seitz radius to the Debye length). It is found that, the intralayer interparticle distance a of the two outmost layers are different from the nearly constant a of the rest layers. The above difference increases with decreasing κ. This leads to the formation of superlattices with different types of Moiré patterns either with or without the misorientation of the intralayer triangular lattice for the first and the second outmost layers and the absence of superlattice for other inner adjacent layers.

References

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