Spatio-temporal correlations across the melting of Wigner molecules

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We present responses of a small number of Coulomb-interacting particles confined in two-dimensional geometries, across the crossover from their solid- to liquid-like behavior. Here, irregular confinements emulate the role of disorder on such 'melting'.

Focusing first on the thermal melting, where zero-point motion of the particles are frozen out, we explore signatures of a hexatic-glass like behavior. While static correlations, that investigate the translational and bond orientational order, resemble hexatic-like behavior at low temperatures, dynamics of particles slows down considerably. Using density correlations we probe intriguing inhomogeneities arising from the interplay of the confinement and long-range interactions. The relaxation at multiple time scales show stretched-exponential decay of spatial correlations in irregular traps. Temperature dependence of characteristic time scales, depicting the structural relaxation of the system, show similarities with those observed for the glassy systems. Our results indicate that some of the key features of supercooled liquids emerge in confined systems with lower spatial symmetries.

Subsequently, we extend our studies to include the effects of quantum fluctuations. Our results, using quantum (path integral) Monte Carlo techniques for Boltzmann particles, seem to indicate complementary mechanisms for the quantum and thermal crossovers in Wigner molecules. The phase diagram as a function of thermal and quantum fluctuations are determined using independent criteria. We will also discuss our recent analyses upon including the effects of quantum statistics.