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Synchronization pattern observed in a complex (dusty) plasma

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Complex or dusty plasmas are weakly ionized gases containing micron-size particles called dust particles or microparticles. In a laboratory radio-frequency (rf) plasma these particles are negatively charged. Due to their strong interactions with the plasma and with each other, they can form strongly coupled systems. Complex plasmas are ideal model systems for phase transitions, self-organization and transport processes. We report on the kinematics of dust particles during the early stage of mode-coupling induced melting of a two-dimensional plasma crystal. It was found that the formation of the hybrid mode causes the particle vibrations to partially synchronize at the hybrid frequency. The system self-organizes in a rhythmic pattern of alternating in-phase and anti-phase oscillating chains of particles. Phase- and frequency-locked hybrid particle motion in both vertical and horizontal directions is evidenced. The spatial orientation of the synchronization pattern correlates well with the directions of the maximal increment of the shear-free hybrid mode. Dynamically, a two-dimensional plasma crystal can be seen as an ensemble of coupled nonlinear oscillators. Spontaneous emergence of synchronized signals and spontaneous symmetry breaking are typical behaviors in such large populations of interacting units.