

Self-oscillating synchronematic colloids

Scientific Achievement

This study provides a fundamental framework to understand how self-oscillating colloidal particles synchronize hydrodynamically leading to collective oscillatory states.

Significance and Impact

At the microscale, self-oscillating units, which transform constant energy inputs into oscillatory states, are highly dissipative. In this work, experiments, simulations, and theory demonstrate modes of synchronization and cooperation of micron-sized self-oscillators. Our work offers design and control of materials whose functions emerge from collective dynamics rather than individual parts, such as communicating nanorobots and oscillating networks for computing.

Research Details

- A Stokesian Dynamics simulation framework coupled to an electrostatic model was developed to compare the outcome of the experiments with hydrodynamically accurate simulations of particles close to a wall.
- A simplified mathematical model based in the weakly-coupled oscillator theory was developed to provide simpler expressions to scale simulations up to tens of thousands of particles. The model provided a more fundamental framework to understand the mechanisms of synchronization and collective frequency increase.

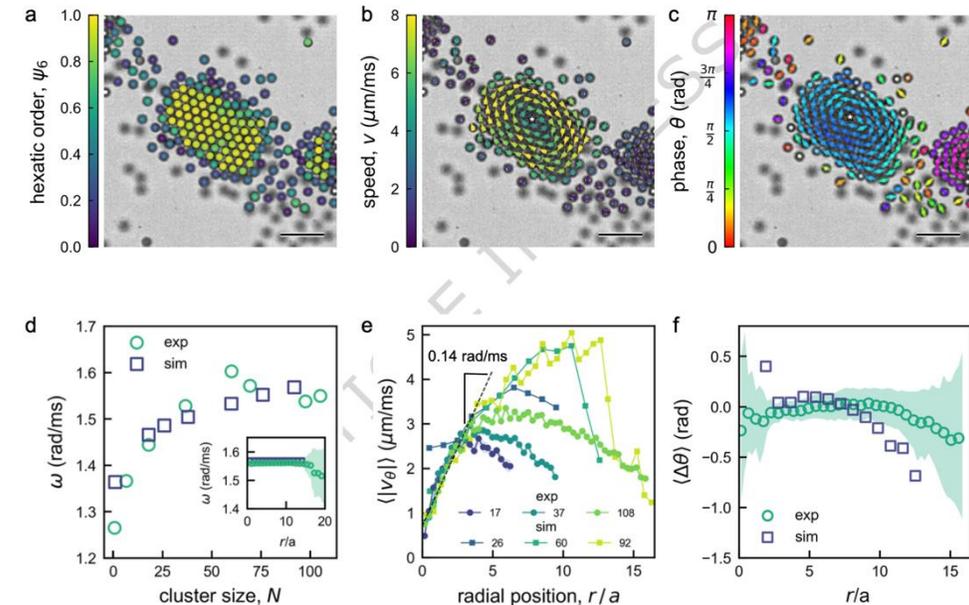


Figure: Synchronization of active crystals. (a) In crystal clusters, particles are tightly bound together and (b) particles at the edge of the cluster move faster. (c) For separated clusters, all particles are synchronized. (d) Increasing the number of particles increases the collective frequency of oscillation of the cluster, a purely hydrodynamic effect. (e) Linear velocity increases with increasing distance from the particle center. (f) Particles at the edges tend to have a small lag with respect to particles close to the center of the cluster. Eventually, for big sizes, this lag can destabilize the cluster. All figures show a good agreement between experiments (exp) and simulations (sim)



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