Hydrodynamic interactions can induce jamming in flow-driven systems

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In the present work, we experimentally study the transport of particles in a quasi-one-dimensional (q1D) periodic potential. We compare the experimental results with simulations based on the Brownian Asymmetric Simple Exclusion Process [1, 2], and we discuss the importance of hydrodynamic interactions (HI) in flow-driven particle transport.

The experimental setup consists of 27 time-shared optical tweezers, which create individual Gaussian potential wells, uniformly distributed in a ring-shape confining up to 27 colloidal particles. We rotate the optical traps at constant angular velocity to create a quasi-sinusoidal traveling potential landscape. Varying the number of particles in the potential landscape allows us to measure the fundamental diagram of the system, which is the colloidal current as a function of the particle density. We find that for different potential landscape barrier heights the particle current density decreases after reaching a maximum value.

We compare the experimental results with simulations, and we attribute the decrease of the current density relationship to the jamming produced by the HI between particles. We explain this phenomenon using the equations of motion that include HI and show that the latter enhances the potential barrier in flow-driven systems. This is opposed to previous observations in force-driven systems, which remark the fundamental difference with our flow-driven system.

[1] Dominik Lips, Artem Ryabov, and Philipp Maass, *Brownian Asymmetric Simple Exclusion Process*, Phys. Rev. Lett. **121**, 160601 (2018).

[2] Dominik Lips, Artem Ryabov, and Philipp Maass, *Single transport in periodic potentials: The Brownian asymmetric simple exclusion process* , Phys. Rev. E **100**, 052121 (2019).