Magnetic microrollers as a platform for active transport

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Transport and mixing at the microscale are difficult due to the absence of inertia and strong wall friction in confined systems, and a wide range of solutions have been proposed to address this challenge. We propose a new strategy that leverages wall friction to achieve these tasks using microrollers.

Micrororollers are micron-sized particles that spin thanks to a rotating magnetic field, **B**, about an axis parallel to the interface (Fig. 1a). When these colloidal particles rotate adjacent to a nearby floor, strong advective flows are generated around them, even quite far away. When a group of these microrollers is driven, the strong hydrodynamic coupling between particles leads to formation of new structures with great potential for microfluidic and bio-medical applications.

Our experimental observations show that uniform suspensions of microrollers form active motile carpets with fast flows above them. By varying the direction of the magnetic field, these active layers can be used for the guided transport of passive cargos at large scales (Fig. 1b) [1].

When the suspension is not uniformly distributed, it undergoes a cascade of instabilities: an initially uniform front of microrollers evolves first into a shock-like structure, which then quickly becomes unstable, emitting fingers of a well-defined wavelength; then the fingertips pinch off to form compact motile structures translating at high speed (Fig. 1c) [1]. These colloidal creatures are self-sustained and form a stable state of the system. Combining experiments, large scale numerical simulations and continuum models, we will explain the predominant role of hydrodynamic collective effects in the development of these colloidal creatures.

We will further show how the nature of the surface underneath and the presence of obstacles affect their individual and collective dynamics [2,3].

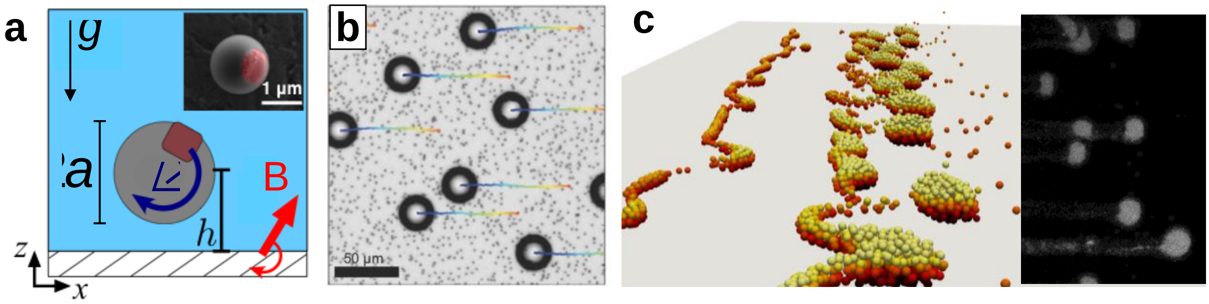

Figure 1: a) Sketch of a microroller rotating above a solid/liquid interface, b) Transport of large cargo particles (20 times bigger than rollers) by a uniform suspension. Colored lines indicate cargo particle tracks. c) Stable clusters emerging from a fingering instability. Particles are colored by speed. Inset : top view of an experiment

References

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