The Physics of Soft and Biological Matter

Self-organisation of swimming bacteria in confined geometries

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Long range interactions between objects are often mediated by the surrounding fluid. In sedimenting passive colloids, for instance, particles generate flows that in turn influence their motion, leading to complex dynamics. While the same principle should apply to active suspensions of microswimmers, it has remained unclear whether explicit hydrodynamic interactions play a role in collective behaviour.

To study this problem we focus on dense bacterial suspensions for which there are known to be large-scale flows. At high concentrations, rod-like cells align at the cellular scale like liquid crystals but interactions with the surrounding medium lead to the formation of turbulent macroscopic structures such as jets and swirls.

We show that such patterns can be stabilised and controlled by confining the suspension into different geometries. Experimental work includes single vortices in flattened drops, ordering of vortex lattices into ferromagnetic-like structures and large-scale circulation in microfluidic race tracks.

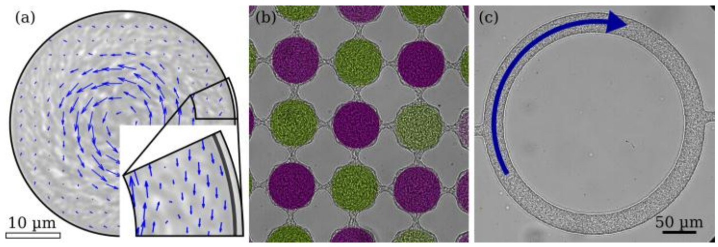

Figure: bacterial steady flows in three experimental setups. (a) Flatten drops of *B. subtilis* suspension surrounded by oil self-organizes into a single spiral vortex. (b) A lattice of vortices (coloured area, 50μm in diameter) form a antiferromagnetic pattern. Purple (resp. green) discs represent clockwise (resp. counter-clockwise) circulation. (c) A dense suspension shows spontaneous circulation in a large circular track. All experiments are done in 25μm height chambers.