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COLLECTIVE BEHAVIORS IN BACTERIAL SYSTEMS

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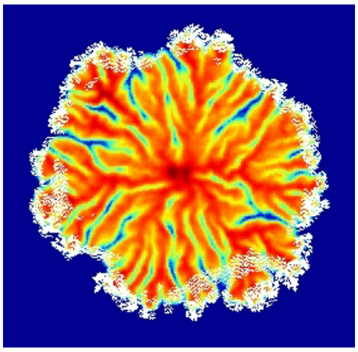
ABSTRACT

Bacterial colonies provide simple examples of biological systems in which complex behaviors occur over a wide range of scales. The microscopic level is that of a single bacterium (of the order of a few micrometers), the mesoscopic level that of vortices and jets (tens of micrometers) [1], and the macroscopic level that of the colony itself (centimeters).

I will give a brief summary of basic experimental facts, and review a hydrodynamic model of bacterial colonies [2-4], developed in collaboration with Thierry Passot (Observatoire de la Côte d'Azur, Nice, France). This macroscopic model [2] describes a colony as a complex fluid, made of a mixture of bacteria and water. It generalizes classical reaction-diffusion equations, and is able to capture dynamical behaviors at the macroscopic and mesoscopic levels. Simulations [3] qualitatively reproduce experimental colony shapes and show a non-trivial interaction between the stability properties of the colony boundary and the dynamics inside the colony.



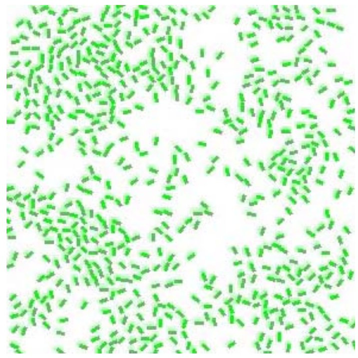
Numerical simulation of the model presented in [2], illustrating how the velocity field (white arrows) of the complex fluid made of bacteria and water affects the dynamics of the colony boundary.

The review paper [4] summarizes these results and puts this work in the more general context of how collective behaviors may emerge from interactions between individuals.

The main focus of the rest of the talk will be to explore how *local* interactions at the microscopic level may affect macroscopic behaviors in bacterial systems [5]. The approach taken will be to use molecular dynamics simulations of interacting particles to describe collections of live bacteria. I will first describe the principal computational

issues that arise in these types of simulations, as well as the standard ways to address them. I will then discuss how classical collision rules that conserve energy and momentum may be modified to describe ensembles of live particles.

Finally, I will show results of numerical simulations in which such rules have been implemented. Randomness, included in the form of random reorientation of the direction of motion of the particles, plays an important role in the type of collective behaviors that are observed.



Formation of clusters in a simulation of tumbling, interacting particles.

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