Pattern formation in photo-controlled bioconvection

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We attract and accumulate phototactic microalgae *Chlamydomonas Reinhardtii* (CR) around a laser beam. This accumulation creates inhomogeneous buoyancy forces in the suspension which results in macroscopic recirculation flows referred to as bioconvection flows. We study the associated concentration patterns. Spontaneous (without light excitation) bioconvection occurs in suspensions of on average upward swimming organisms only above a critical dimensionless Rayleigh number. This number compares buoyancy-driven convection over diffusion. When using a localized laser beam excitation to attract the algae, bioconvection is triggered far below the critical Rayleigh number. Some studies have focused on the case of a thin light beam [1], [2]. Here we control both the Rayleigh number Ra and the dimensionless beam width R_b/H to control bioconvection patterns and investigate their phase diagram.

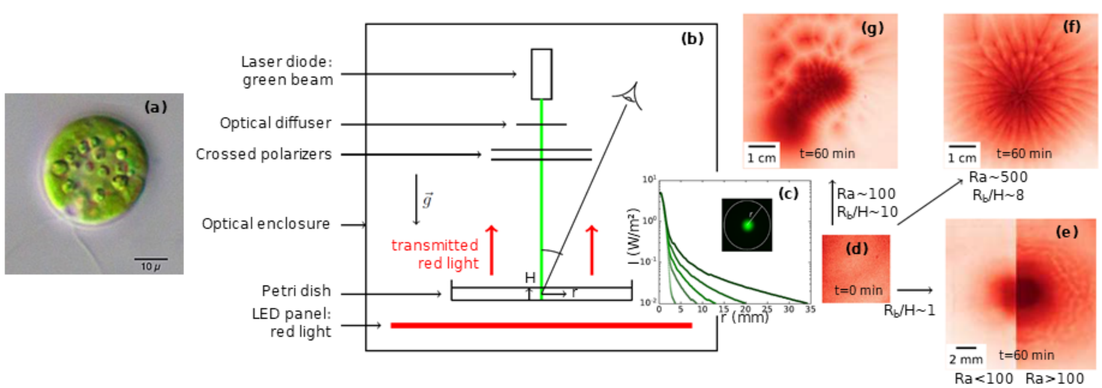

Figure 1. a, *Chlamydomonas* individual cell. **b**, A thin layer of a suspension of CR cells lays in a horizontal Petri dish. A green laser beam points at the center of the Petri dish to attract CR. A red light panel is placed below the Petri dish and the transmitted red light is visualized from the top with a camera to access the concentration field. **c**, Green light intensity radial profiles of different widths. **d**, **e**, **f**, **g**, Top views of the concentration field. Starting homogeneous concentration (d), stationary radially symmetric pattern and travelling waves (e), stationary dendrites (f) and unstationary directional growth (g).

In ref [1], stationary radially symmetric patterns and travelling waves are observed at $R_b/H \sim 1$ (Fig. 1d). Here we show that when the beam width exceeds the suspension depth ($R_b/H > 1$), the concentration field exhibits remarkable and up-to-now unreported symmetry breakings. Stationary dendrites with well-defined wavelength (Fig. 1f) and unstationary directional growth (Fig. 1g) are uncovered. We also analyse theoretically how this depends on the relative importance of convection, and both lateral and possible vertical phototaxes. This study illustrates how the richness of nonlinear physics in active fluids both motivates and helps to understand the behaviour of microorganisms.

Références

1. J. DERVAUX & ET. AL., Light-controlled flows in active fluids, *Nature Physics*, **13**, 306–312 (2017).
2. J. ARRIETA & ET. AL., Light control of localized photobioconvection, *Phys. Rev. Lett.*, **123**, 158101 (2019).