Pattern formation in photo-controlled bioconvection

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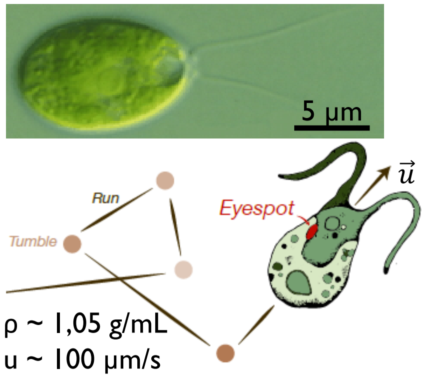
1. Introduction

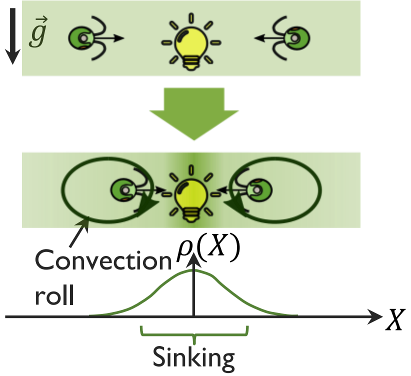
The photosynthetic micro-algae *Chlamydomonas Reinhardtii* (CR) display the ability known as phototaxis to detect and move towards optimal light intensities. We attract and accumulate CR cells beneath a light beam in a petri dish. Because they are denser than water, this creates density gradients from which macroscopic convection flows called bioconvection flows arise. We study the associated visible concentration patterns.

2. *Chlamydomonas Reinhardtii*



$\rho \sim 1{,}05$ g/mL
$u \sim 100$ µm/s
Blue-green light sensitive
Phototactic drift $\overrightarrow{v_{drift}} \propto \vec{\nabla} I_{light}$

3. Principle of the experiment



Coupling between convection & phototaxis

4. The Rayleigh number

$$Ra \sim \frac{convection}{diffusion}$$

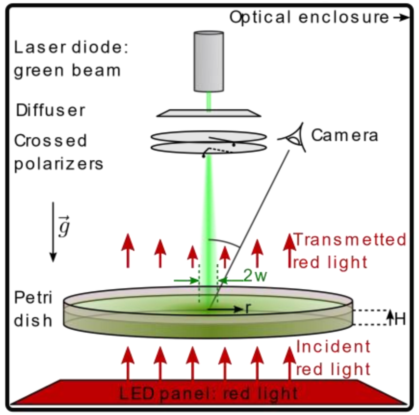
$$\tau_{conv} \sim \frac{\eta}{(\rho(c)-\rho_0)gH}$$

$$\tau_{diff} \sim \frac{H^2}{D}$$

$$\boldsymbol{Ra} \sim \frac{\boldsymbol{\rho_0 g \beta H^3 c}}{\boldsymbol{D\eta}}$$

With $\beta = \frac{\rho(c)-\rho_0}{c\rho_0}$

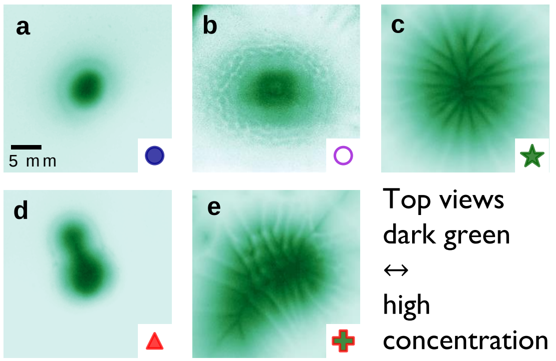
5. Experimental setup



Control parameters
Rayleigh number ***Ra***, Light beam width ***w***

6. Experimental results

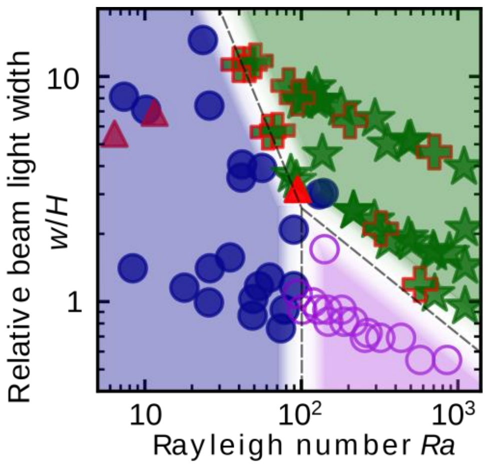
From symmetric to more complex patterns



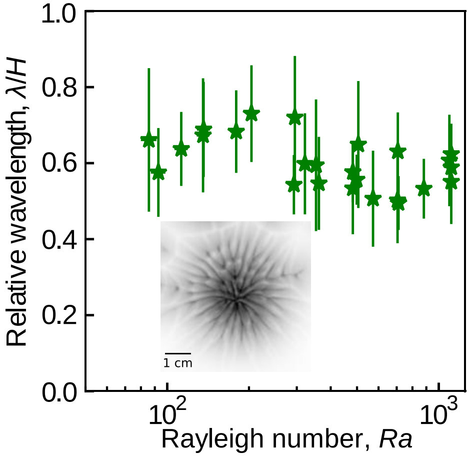
Top views
dark green ↔ high concentration

Main instability : a. round
Secondary instabilities : b. waves of concentration c. dendrites, d-e. directional growth : pure (d) or mixed with dendrites (e)

Photo-bioconvection patterns phase diagram



Wavelengths of dendrites instabilities



7. Conclusion & perspectives

The spatial organization of cells results from the coupling between macroscopic convection flows and phototaxis

Unexpected breakings of the initial radial symmetry of the problem when increasing the beam width

Future imaging of the flow field in a 2D geometry