

Energy Physics Group

Laboratoire Astroparticule et Cosmologie (APC)

UMR 7164

IN2P3, Univ. Paris Diderot, CEA, Observatoire de Paris

**Search for novel sources of
energy for tomorrow**

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Aims and Strategy

- Search for novel sources of energy,
- Observation and understanding of basic mechanisms underlying physical phenomena,
- Modeling and eventually applications in novo energy systems,
- cross-disciplinary research: at the interface of physics, biology and chemistry, research includes also socio-economics aspect.

Scientific discipline & Activities

Group combines a traditional emphasis in fluid mechanics, heat transfer, and statistical physics with an understanding and application of molecular physics, physical chemistry and biology.

Fields of reserach

1. Hydrodynamics of active matter,
 2. Physics of transport phenomena,
- with final application to Energy Challenges .

- Strong link with the energy industry.

Work Force

- 4 senior researchers (1 professor, 2 associate professors (research affiliates) and 1 CNRS research engineer),
- 4 PhD candidates, one is co-supervised by the WINDEE Institute of the Western University in Canada,
- Small group allows vigorous interaction among its members.

Hydrodynamics of Active Matter

- Understanding & modeling of the behavior of microorganisms.
- Their reaction to different stresses aimed at producing by photosynthesis of biofuels or other bio-molecules of interest.

SYNECHOCYSTIS

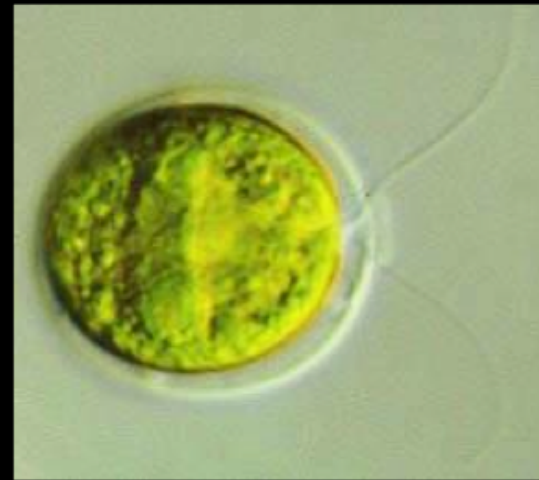
strain : PCC 6803



Diameter : 2-10 μm

CHLAMYDOMONAS REINHARDTII MICROA

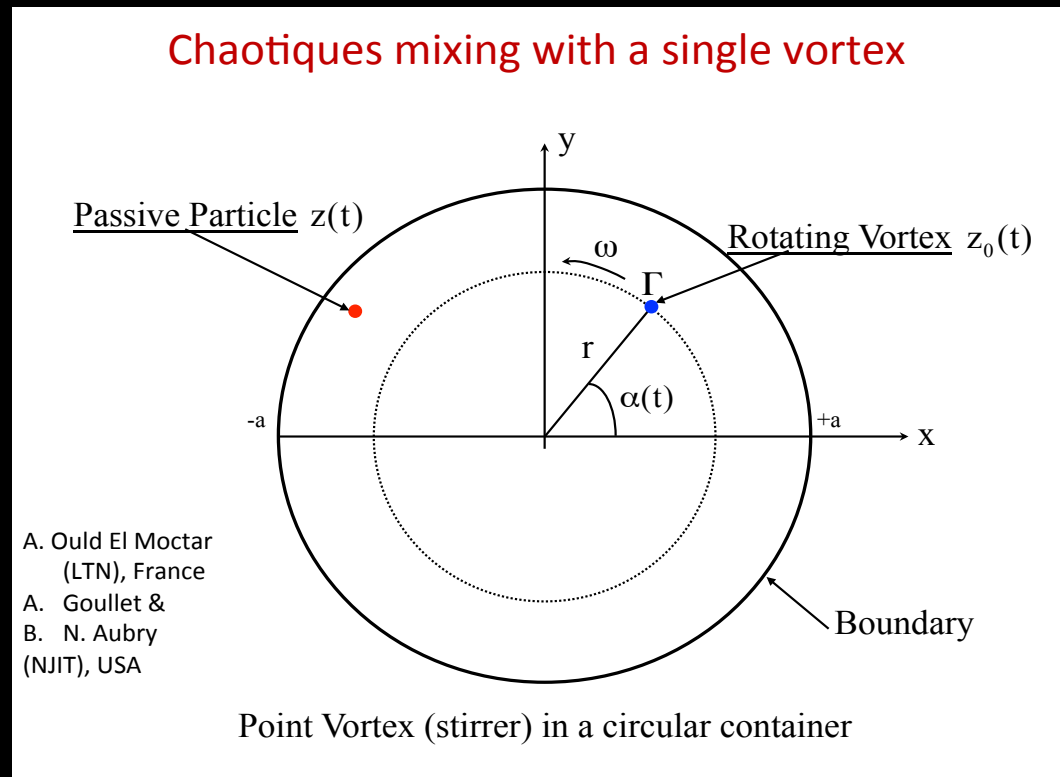
strain : Wstrain : WTS 24 (wild type strain)



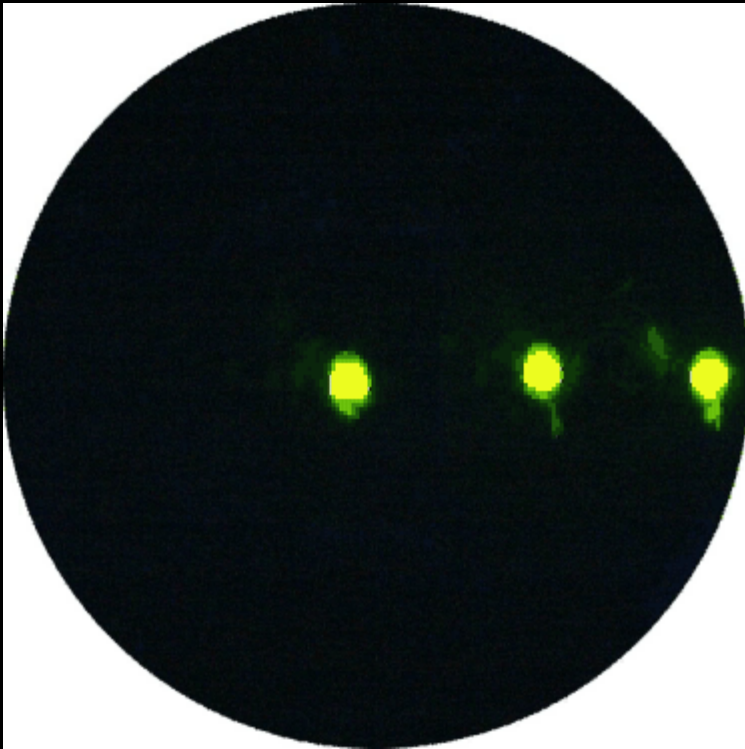
Diameter : 10-25 μm

Physics of transport phenomena

- **Dynamical system approach to heat transfer intensification**

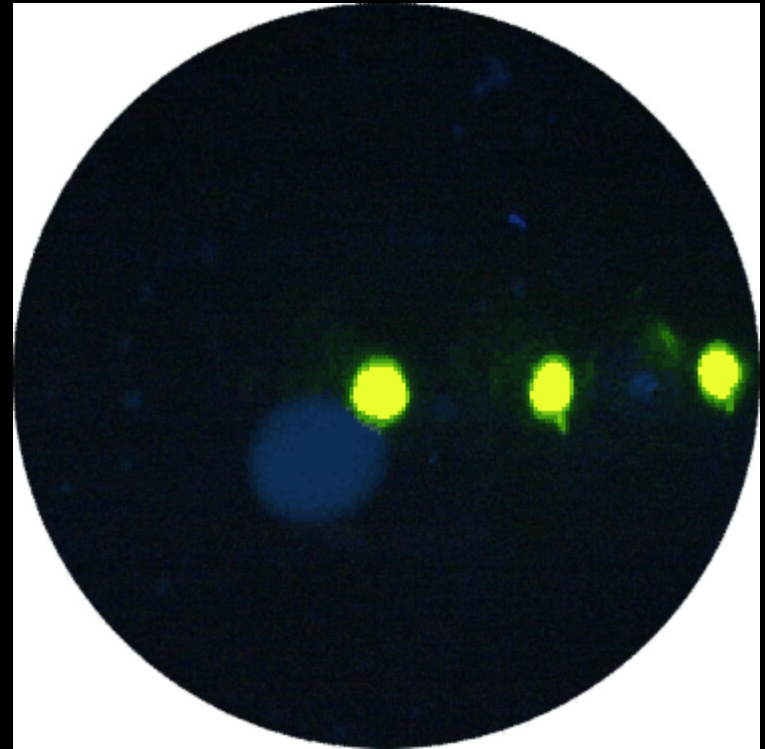


Dual Speed Vortex



$\beta=\pm 1.5$ and $b=0.6$

Rotating protocol: $\pi/2+\pi/4$



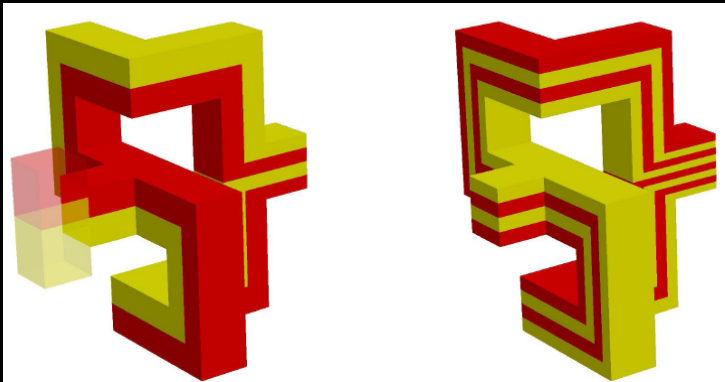
$\beta=\pm 1.5$ and $b=0.6$

Rotating protocol: $\pi/4+\pi/2$

Flux Recombination Reactors

- Baker's transformation.
- Mixing process is induced by the primary flow, while many other techniques are based on a secondary flow action.

Carrière (2007)



Chen and Meiners (2004)

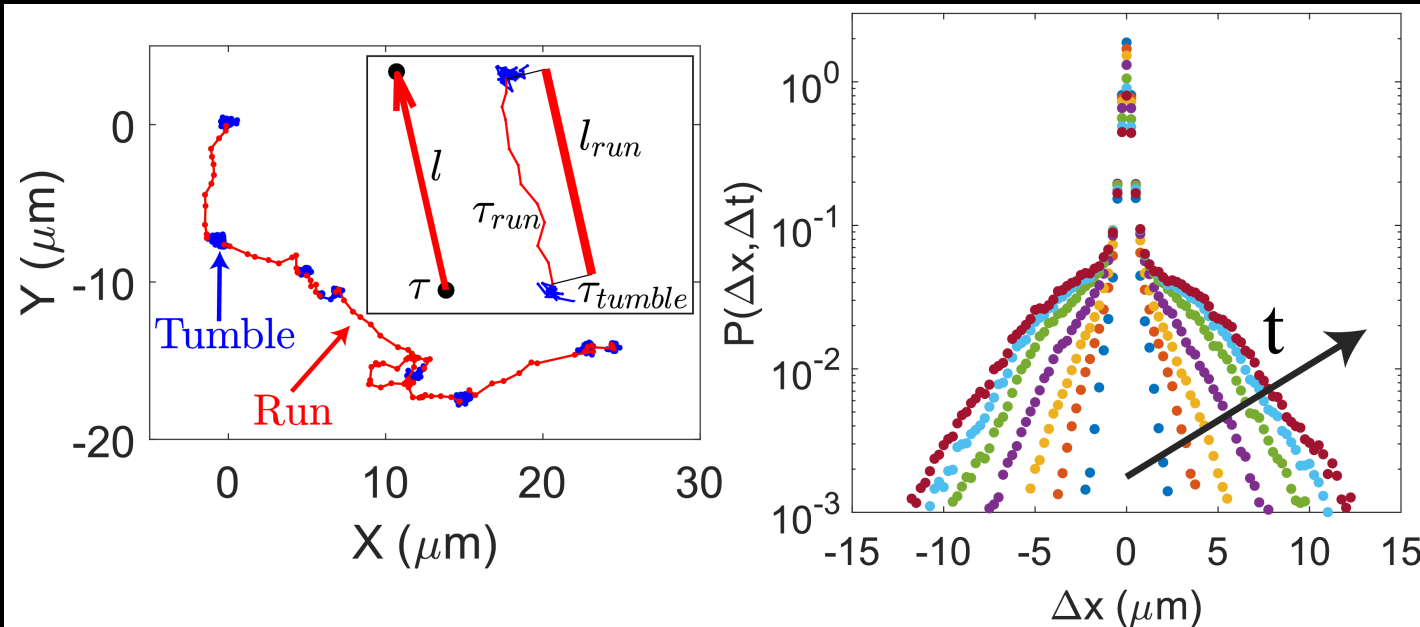


High Light 1

Diffusion during early stages of bacterial colonization

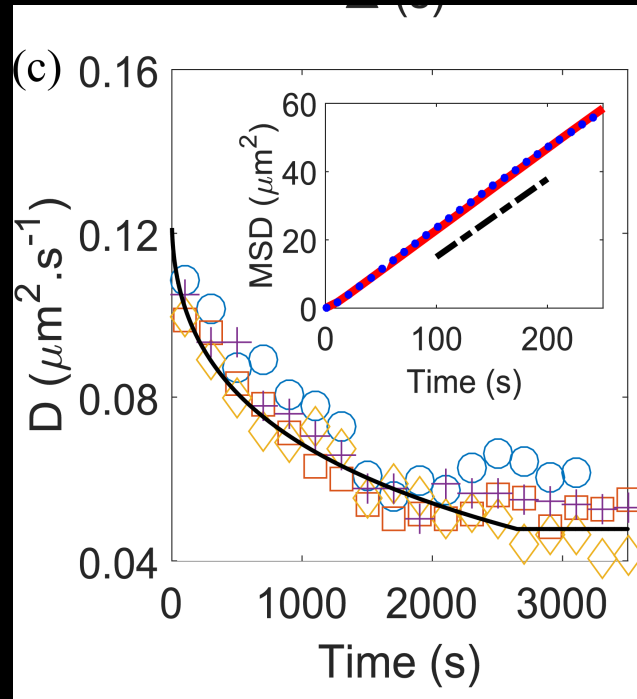


High light 1



Probability distribution of bacterial displacement.

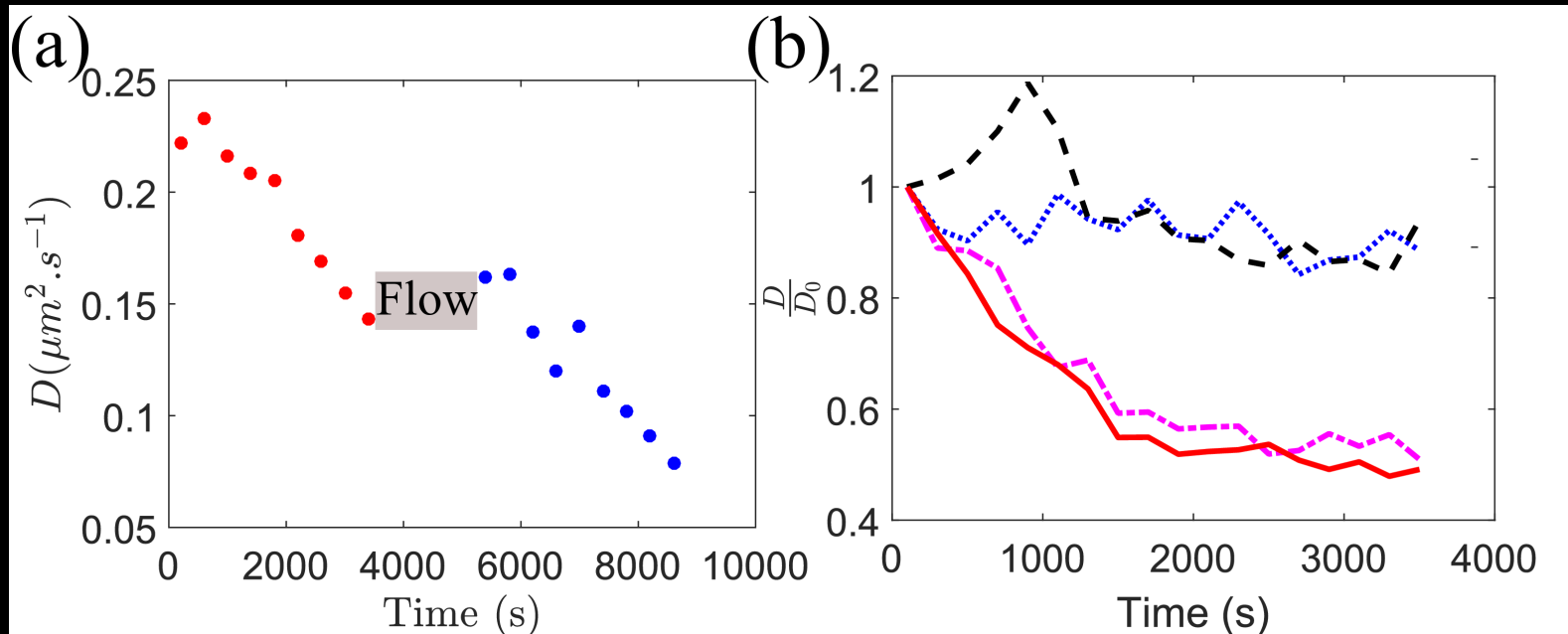
High Light 1



Variation of diffusion coefficient with time

$$D \sim \frac{V_m^2 \langle \tau_{run}^2 \rangle}{4 \langle \tau \rangle}$$

High Light 1



Effect of bacterial population renewal near the surface.

Effect of Expolysaccharides production.

Black : slr1875  sll1581, blue : sll0923  sll5052, red : Wild Type and, pink : sll1581.

High Light 2

Biofaçade

In Vivo, Algo House (XTU) et Plant House (MU), avec l'accueil de la résidence jeunes chercheurs et la biofaçade, donnant sur le Bd du Général Jean Simon



Publications (2013-17) and out-reach

- 40 articles in peer-reviewed journals,
- 27 articles in proceedings of Int Conferences and invited talks,
- Coordination of the Interdisciplinary Energy Research Program of the USPC: 11 laboratories and 90 research scientist from 6 establishments of Sorbonne Paris Cité University.

SWOT analysis

- *Strengths*
 - Attractiveness of the field of investigation: energy,
 - High visibility and international recognition of the group in its fields of research,
 - Leadership of the group in the interdisciplinary energy research.
- *Weaknesses*
 - Reduced number of permanent researchers in the group that is not compatible with its ambition.
- *Opportunities*
 - Large international collaboration network of the group,
 - Importance of the energy as a challenge to the humanity.
- *Threats*
 - Lack of funds for fundamental research. Most of the institutional research funds are directed to the technological research.

Future Projects

- Understanding and modeling of microorganism motility, mechanisms of microorganism interaction with solid surface and biofilm formation, and in general microorganism colonization.
- Dispersion of *C. reinhardtii* in the fluid flow in order to propose new mechanisms for separation (harvesting) of the microorganisms from suspension.

Future strategy

- In bio-solar energy:
 - Investigation and design of optimal configuration of PCM storage to maintain the acceptable temperature range in the photobioreactor for building application,
 - Study of adaptation of microorganisms and their colonization in the PCM-integrated photobioreactor,
 - Conduct field-testing of the prototype design.

Future strategy

- Research on thermoacoustics will concern:
- Acoustical characterization of thermoacoustic core (regenerator with hot and cold heat exchangers) at high acoustic levels in the presence of temperature gradient,
- Matching conditions between the different elements of the device: regenerator and heat exchangers, thermoacoustic core and acoustic load,
- Phenomenological analysis, numerical simulation and experimental studies of different thermal flows that occur as consequences of thermoacoustic heat pumping in each element of the thermoacoustic machine.