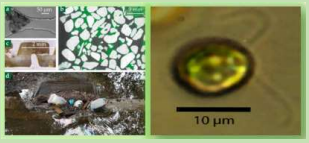
Crowd of Microswimmers-The Study of Upstream

Aya AlAli, Salima Rafai
Liphy Laboratory
alaliaya129@hotmail.com, salima.rafai@univ-grenoble-alpes.fr

When a suspension of particles suspended in a liquid passes through a small opening,clogging can occur. This phenomenon poses significant challenges in various engineering systems as it impairs performance and limits process efficiency. More generally, jamming problems arise in extremely diverse situations, and nowadays they are studied in the context of crowd dynamics. Crowds are a common occurrence in nature, ranging from birds and fishes to ant colonies.

1-Introduction:

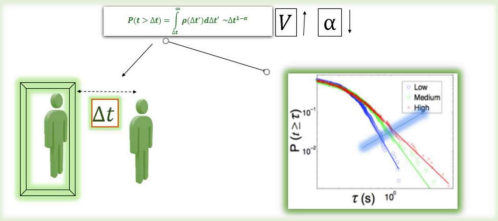
Our primary focus lies on micro-swimmers especially on micro-algae known as Chlamydomonas Reinhardtii and is naturally found in non-saline waters. It possesses a spherical main body measuring 10 micrometers in size, with two equally long flagella attached to it. The motion of the algae is driven by the beating of these flagella that perform a breaststroke-like beating to propel forward, allowing it to explore its surroundings in a quest for food.



Why we use chlamy?
- They are phototactic
- They have spherical shape(Modeling)
- They have means of locomotion(breaststroke,low Reyonalds number)

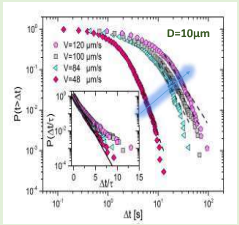
2-Faster is Slower Effect(Bibliography):

One particular aspect of collective motion studied in this field is Evacuation, where a cluster of particles attempts to escape through an opening. Recent Studies showed that as the desired velocity of the crowd to exit increases, the blocking time at the exit also increases. In other words, the faster the crowd wants to exit, the longer it takes for the process to complete. This behavior follows a power law tail in the survival function.



Faster is Slower effect observed in all systems in humans ,sheep and granular systems.

Our team (AlAlam et al., 2022) conducted recent research to investigate whether Faster is Slower effect is observed in microalgae. This was achieved by varying the constriction diameter during the study.



Transition from flowing to clogging state!!!

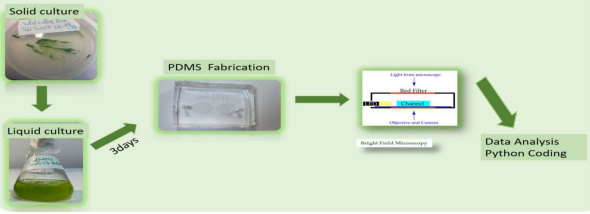
Faster is Slower effect also observed on MicroAlgae!!!

3-Objective:

- Effect of an obstacle on the evacuation.
- Effect of cell adhesion inside the crowd.
- Measurement of density fluctuation.

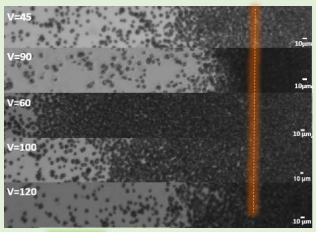
4-Method:

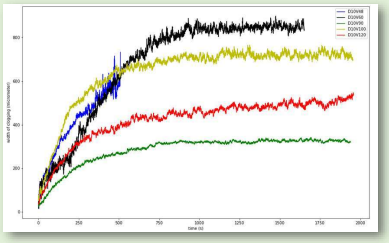
Before proceeding with cell culture, it is crucial to consider the sterility of the environment.
We use an incubator with regulated conditions. The cells are received as a green paste and spread on petridish. We harvest the solid culture and dilute it in 50 mL of TAP to create a "mother solution". The suspension is incubated for three days. The experimental protocol begins by preparing PDMS channels. The PDMS channels are attached to the microscope glass on the experimental day, A white LED is positioned opposite the constriction to induce ballistic motion directly towards it. Recording starts when the LED is turned on, causing the Chlamydomonas Reinhardtii to accumulate at the entrance and form a crowd.



5- Results:

Using scikit-image (skimage) and matplotlib libraries in Python we focused on analyzing the dynamics of the clog before the constriction,upstream portion of the videos in order to understand the downstream dynamics to gain insights into the cause of"Faster is Slower effect" behavior. Specifically, we aimed to determine if there is a relationship between the size of clogging and the velocity in data with the same constriction diameter but varying velocities.



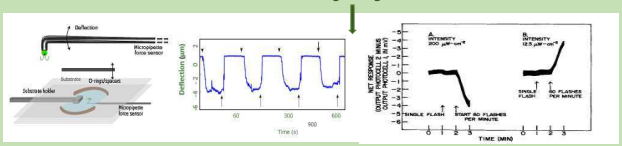


No Relation between velocity and size of clogging!!!!!

6-Conclusion and Perispectives:

- Consistent increase in width until it reached a stable plateau, without any clear relationship between width and velocity changes.
- Changes in density at narrow parts of the channel, highlighting the importance of understanding density patterns in uncovering the factors behind the "faster is slower" effect.
- Understanding density fluctuation can be understood either by :

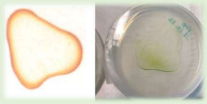
Altering the light

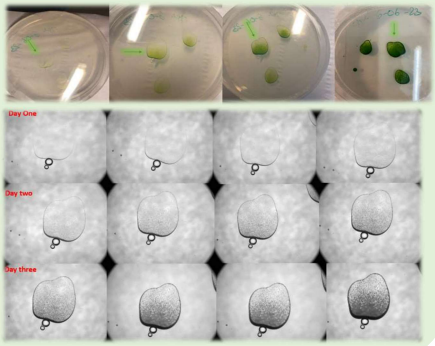


Putting an obstacle.

7-Coffee Ring Effect:

When coffee is spilled and dries on a surface, it often leaves behind a ring-shaped stain,the same intersiting phenomenon is observed on chlamy cells.





Maybe by this cell-cell interaction and dynamics in the downstream can be understood(chlamy growing form bottom to top).

8-References:

Edouardo AL ALAM. "Active jamming of microswimmers at a bottleneck constriction". In: PHYSICAL REVIEW FLUIDS. 2022.
Marvin Brun-Cosme-Bruny. "Nage de suspensions actives en milieu complexe." In: 2019
Kreis et al. "Adhesion of Chlamydomonas microalgae to surfaces is switchable by light". In: Nature Physics volume. 2018
Mary Ella Feinleib. "PHOTOTACTIC RESPONSE OF eHuMYmMoNAs TO FLASHES OF LIGHT-I. RESPONSE OF CELL POPULATIONS". In: Photochemistry and Photobiology. 1975.