Research internship: Photo-acoustic phenomena in biological active matter

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We propose a research internship (M1 or M2) at the PMMH laboratory (team currently located at the Institut de Physique du Globe) in collaboration with researchers at ENS and Warwick University (UK) on the manipulation of biological active matter by acoustic and optical forces. The goal will be to characterize the dynamics of suspensions of unicellular algae (*Chlamydomonas reinhardtii*), a freshwater algae moving around using flagella (Fig. 1a) when levitated by stationary acoustic waves and illuminated by monochromatic lights in micro-cavities. Indeed, in such setup the acoustic forces focus the motile cells in the pressure nodes of the cavity and create localised aggregates in acoustic levitation, confined in an “acoustic trap” [1] (Fig. 1b-e). We have recently discovered that particles or cells can be ejected from the acoustic trap if illuminated with the proper wavelength [2]. While this second effect is not yet well understood, it probably originates from a complex coupling between acoustic forces and light-absorption by the particles. With *Chlamydomonas*, the photo-acoustic effect can be opposed by the natural tendency of the algae to actively swim towards light (phototaxis) [3]. The competition between these two light-induced effects is expected to lead to interesting spatio-temporal dynamics. In this study we will first characterize the collective behaviour of *Chlamydomonas* when solely confined in the acoustic trap. In a second step, we will study the photo-acoustic effect with non-motile algae (where no phototaxis takes place). Finally, we will characterize the collective dynamics of the motile phototactic algae upon illumination.

Through this research project, the student will use video-microscopy, image analysis and statistical analysis of the experimental data in order to quantitatively characterise the phenomena. For Master 2 students the internship can potentially be followed with a PhD coupling artificial and living active matter manipulated with light and sound.

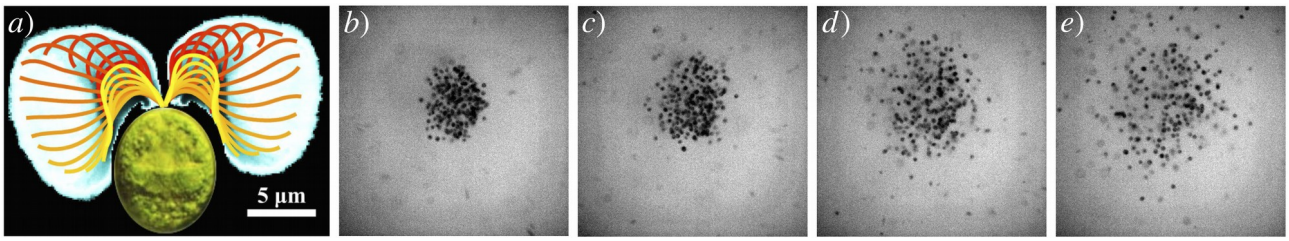

Fig. 1: a) Picture of a *Chlamydomonas* cell with superimposed flagella beating cycle (breaststroke). b-e) Acoustic trapping of a suspension of *Chlamydomonas* cells in a micro-cavity (the stationary sound wave is orthogonal to the field of view). As the acoustic energy injected in the system is decreased (b to e), the aggregate gets less and less confined.

[1] S. Gutiérrez-Ramos, M. Hoyos, J. Ruiz-Suárez, Induced clustering of *Escherichia coli* by acoustic fields, Sci. Rep. 8, 4668 (2018)
[2] G. Dumy, M. Hoyos, and J.-L. Aider, Investigation on a novel photoacoustofluidic effect, J. Acoust. Soc. Am. 142, 2609 (2017)
[3] J. Arrieta, A. Barreira, M. Chioccioli, M. Polin, and I. Tuval. Phototaxis beyond turning: persistent accumulation and response acclimation of the micro alga Chlamydomonas reinhardtii, Scientific Reports 7, 3447 (2017)