Proposal for a Master 2 intership

Dancing bees: when clusters turn liquid

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Context Collective motion is a fascinating observation where the ensemble of agents, such as bacteria, fish or birds can be seen as a single living object that can deform, flow and merge only based on the self-propelled motion of each agent and their short or long-range interactions. A wealth of approaches has been developed over the years to model such systems including discrete and continuous strategies.

In this new project, we focus on an original system that has barely been studied in the frame of mechanics and not at all in terms of rheology: a honeybee cluster. When a colony divides, the queen bee and thousands of worker bees swarm out of the hive and hang outside for hours to days. The bees form a cohesive structure similar to a liquid drop hanging on a wire (Fig. 1). An additional general observation from beekeepers is that, when a swarm is collected, it can flow like a viscous liquid.



Figure 1: A natural swarm of bees clinging to a tree branch.

Objective The main question of this project is : How bees collectively decide to remain as a solid assembly or to flow as a liquid ? We will use approaches coming from the physics of complex fluids and crowds to characterize the mechanical properties of this living material while the cognitive state of the bees will be varied.

Methodology The proposed methodology consists in experiments and theory. The student will complete a dedicated bead rheometer in order to measure the mechanical response of bees under stress. The bead will be equipped with a small camera in order to capture both the macroscopic properties of the bee cluster and the microscopic reorganization at the scale of single bees. The student will calibrate the bead rheometer on passive anisotropic particles before to perform measurement on bees, weather permitting.

Follow-up This project has secured funding; we are proposing a funded Ph.D. position at FAST, starting in October 2027.

References:

[1] M. V. A. Martinez, E. Clement, J. Arlt, C. Douarche, A. Dawson, J. Schwarz-Linek, A. K. Creppy, V. Skultety, A. N. Morozov, H. Auradou, W. C. K. Poon (2020) "A combined rheometry and imaging study of viscosity reduction in bacterial suspensions", *Proc. Natl. Acad. Sci. U.S.A.*, 2020, 1912690117. DOI: 10.1103/PhysRevX.10.021004.
[2] A. Ganesh, C. Douarche, H. Auradou (2025) "Active Saffman-Taylor Viscous Fingering", *Phys. Rev. Lett.* 134, 128301. DOI: 10.1103/PhysRevLett.134.128301.
[3] R. Larrieu, P. Moreau, C. Graff, P. Peyla, A. Dupont (2023) "Fish evacuate smoothly respecting a social bubble? *Sci. Rep.* 13 (1), 10414.