Proposal for a Master 2 internship

Dancing bees: when clusters turn liquid

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Collective motion is a fascinating observation where the ensemble of agents, such as bacteria or fish, 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 paste.

Figure 1: A. Natural bee swarm (diameter 15cm). B. Oil drop on fibers of radius 350 μm and 600 μm (E. Lorenceau).

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. The experiment is similar to a bead rheometer to measure the effective 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. This work will be setup in the Laboratoire FAST in Orsay under the supervision of Carine Douarche and Hugo Perrin. Once the device is ready, experiments on bees will be performed in Toulouse in collaboration with Aurore Avarguès-Weber in the Centre de Recherche sur la Cognition Animale (CRCA).

References:

[1] M. V. A. Martinez, E. Clément, J. Arlt, C. Douarche, A. Dawson, J. Schwarz-Linek, A. K. Creppy, V. Skultéty, 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.