Leidenfrost droplets : spontaneous rotation and self-propulsion

Supervisors : Sébastien Michelin (LadHyX) & Denis Bartolo (ENS Lyon)

Contact : sebastien.michelin@ladhyx.polytechnique.fr & denis.bartolo@ens-lyon.fr

This project in hydrodynamic modeling will aim at explaining a phenomenon that was experimentally discovered just a few months ago, despite several centuries of observations [1] : the spontaneous rotation of levitating evaporating liquid droplets, and their resulting motion over solid surfaces.

This internship can take place either in LadHyX (Ecole Polytechnique) or in the Physics department of ENS Lyon.

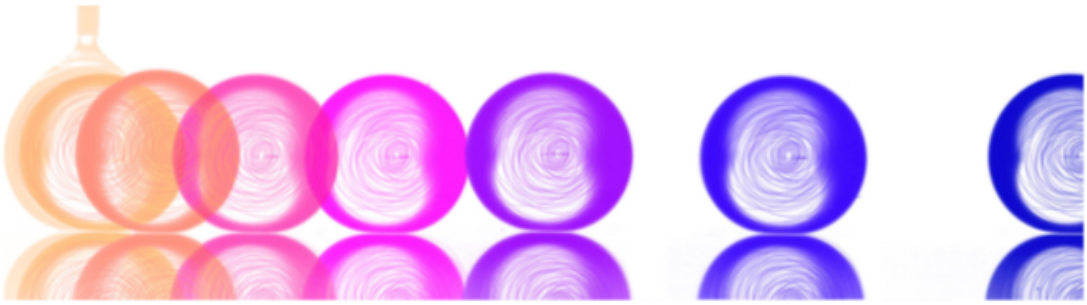

FIGURE 1 – Below a critical radius, a levitating droplet breaks its azimuthal symmetry and self-propel [1].

We all have already witnessed the rapid motion of water droplets deposited on the bottom of a hot pan (try the experiment at home the result is spectacular !). For several centuries now, the explanation seemed clear and well understood. A liquid droplet released near a hot surface can levitate on a vapor film if the surface temperature is greater than the boiling temperature of the liquid (Leidenfrost effect). The vapor flux generated at the base isolates thermally and mechanically the liquid from the solid substrate. This phenomenon is associated with a large mobility of the levitating droplet : a vapor film lubricates the contact with the solid surface, providing them with a mobility akin to that of air hockey pucks levitating on the air-blowing table.

In a recent publication, Bouillant *et al.* unveiled an unexpected phenomenon : below a critical size, the droplets do not passively hover the vapor film but instead actively roll in random directions.

This spectacular phenomenon, illustrated on the picture above, does not have a theoretical explanation yet. We propose to remedy this and more generally describe quantitatively the spontaneous symmetry-breaking that would allow an isotropic evaporation of the liquid to generate a net torque and force on the liquid droplet. To this end, we will analyze theoretically the dynamics of the lubricating film and how it can pilot the dynamics of the droplet.

References

[1] A. Bouillant, T. Mouterde, P. Bourrianne, A. Lagarde, C. Clanet & D. Quéré, "Leidenfrost wheels", 2018, *Nat. Physics*