Two dimensional Leidenfrost droplets in a Hele-Shaw cell

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We experimentally and theoretically investigate the behavior of Leidenfrost droplets inserted in a Hele-Shaw cell. As a result of the confinement from the two surfaces, the droplets have the shape of flattened discs and are thermally isolated from the surface by the two evaporating vapor layers.

Experimentally, a specific setup is designed to provide both a reliable control of the temperature of the confining surfaces and a direct imaging of the droplets. We observe that the droplets display capillary azimuthal oscillating modes whatever the confinement or the droplets size. This behavior is reminiscent of an unexplained hydrodynamic instability.
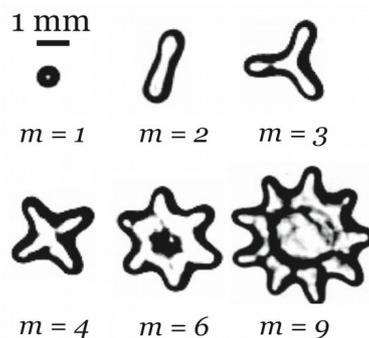
Figure : Top views of the droplets. Examples of different oscillation modes. Here, m holds for the number of spikes of drop, d = 1 mm and the horizontal scale is shown by the black bar.

Using the lubrication approximation we numerically determine the shape of a droplet as a function of its radius. We furthermore find that the droplet thickness tends to zero at its center when the radius reaches a critical value. This prediction is corroborated experimentally, the droplets are unstable above a critical size and a hole grows at their center. The dynamics of the hole growth is twofold and driven by capillarity and inertia. We report a first regime characterized by the liquid reorganization from a flattened disc to a liquid torus with similarities to the burst of micron-thick soap films. In the second regime, the liquid torus expands and thins before fragmentation.
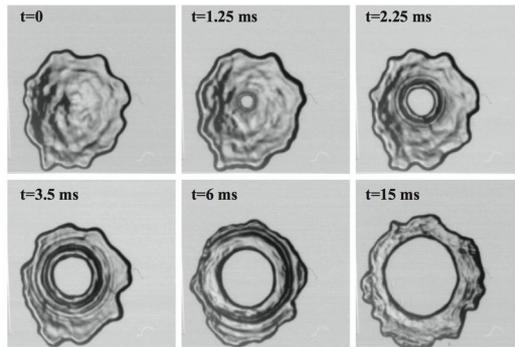
Figure : Image sequence of the hole nucleation and growth

[1] F. Celestini, T. Frisch, A. Cohen, C. Raufaste, L. Duchemin, Y. Pomeau, *Two dimensional Leidenfrost droplets in a Hele-Shaw cell*, Phys. Fluids **26**, 032103 (2014)

[2] C. Raufaste, F. Celestini, A. Barzyk, T. Frisch, *Hole growth dynamics in a two dimensional Leidenfrost droplet*, Phys. Fluids **27**, 031704 (2015)