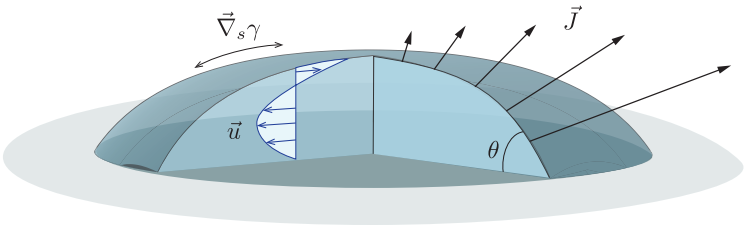
Chair: Physics of Fluids group

Mysterious Ring in Evaporating Drops: Experiments

Description

Evaporating droplets might seem like dull systems, but there is a lot going on inside them that often escapes our eyes. The evaporation process involves a complex interplay between dissipated energy and mass that drives flows inside such droplets. Such flows can have a crucial effect on the deposition patterns left behind once the liquid phase evaporates completely, which has a tremendous interest for applications as spray coating, pesticide administration, and ink-jet printing industries.
In these applications, the objective is to control the deposition of colloidal particles dispersed in the liquid phase. Unfortunately, this objective becomes often very challenging. For example, in ink-jet printing, it is desirable to have a very homogeneous deposition of the ink (often made of colloidal particles). However, due to the complex interplay of the different components of the ink, complex flows can arise as a consequence of interfacial Marangoni flows (see fig. 1a), which lead to a heterogeneous deposition of the colloids in the droplet. Very surprisingly, the colloids aggregate forming a ring!

a)



b)

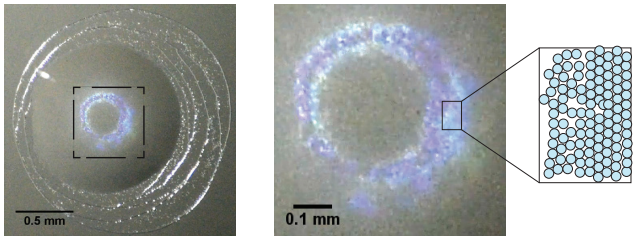


Figure 1: (a) Sketch of a sessile evaporating droplet, showing a classical flow profile $\vec{u}$, evaporation flux $\vec{J}$ and surface tension gradient $\vec{\nabla}_s\gamma$ (b) top view images from Thayyil *et al.* [1] of colloidal Marangoni rings containing 1 micrometer-sized silica particles.

Assignment

The project, should you choose to accept it, will be to reproduce such *Marangoni rings* experimentally for different liquid compositions and environmental conditions. Once you succeed on this, you will make use of different experimental techniques involving microscopy (fluorescence microscopy, laser scanning confocal microscopy, scanning electron microscopy, etc) to further analyze its formation and structure.

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References

[1] Lijun Thayyil Raju, Christian Diddens, Yaxing Li, Alvaro Marin, Marjolein N Van Der Linden, Xuehua Zhang, and Detlef Lohse. Evaporation of a sessile colloidal water–glycerol droplet: Marangoni ring formation. *Langmuir*, 38(39):12082–12094, 2022.