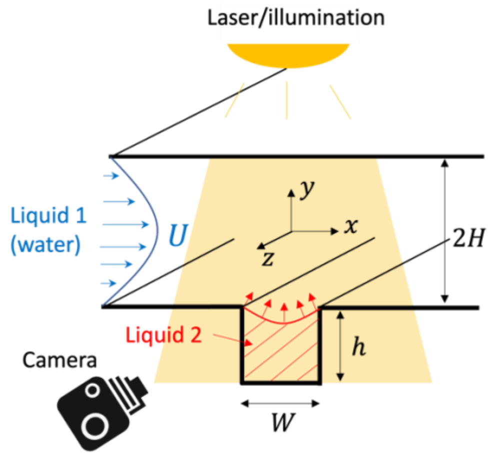
Project 1: Study of multiphase mass transfer between a cavity and an external shear flow

Name of the graduate program (Master 2): Modelling and Applications in Mechanics (Master MAM) or Fluid Mechanics and Energetics (Master MFE)
Laboratory for the research internship: Fluid Mechanics and Acoustics Laboratory (LMFA)
Principal Investigator: Julien LANDEL (julien.landel@univ-lyon1.fr).



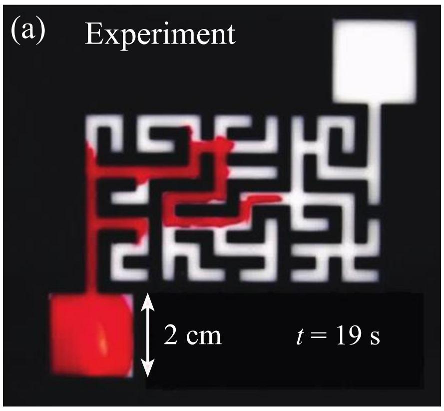
Description
This project will investigate the fluid mechanics related to the cleaning of undesirable viscous liquid substances on solid surfaces with complex geometry. As shown in the figure, a viscous liquid substance (liquid 2) is confined in a surface cavity. An external shearing liquid flow (liquid 1, the cleaning liquid) induces convective-diffusive mass transfer between the two phases to extract liquid 2 and 'clean' the cavity. The objective of this project is to obtain experimental data to ultimately (and beyond this project, which is part of a broader research framework) establish and validate models of fundamental physical phenomena.

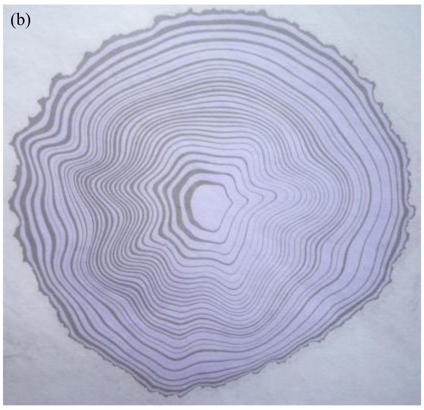
Initially, the phenomenology will be studied by exploring parameter space related to geometry (shape and size of the cavity), liquid properties (rheology, viscosity, miscibility), flow properties (laminar/turbulent), and mass transfer properties (Péclet number). A rich phenomenology is expected, with interfacial instabilities and topology changes over time affecting mass transfer. In the second phase, mass transfer will be measured to determine the Sherwood number over time and identified regimes. The experimental study will utilize dye and tracer imaging techniques, as well as spectrophotometry for mass transfer. The intern will also learn image analysis for processing and interpreting the results.

Bibliography
- Landel, J. R., Wilson, D. I. (2021) "The fluid mechanics of cleaning and decontamination of surfaces". *Annual Review of Fluid Mechanics* 53, 147-171.
- Etzold, M. A., Landel, J. R., Dalziel, S. B. (2022) "Three-dimensional advective–diffusive boundary layers in open channels with parallel and inclined walls". *International Journal of Heat and Mass Transfer* 153, 119504. (Author accepted manuscript)
- Landel, J. R., Thomas, A. L., McEvoy, H. and Dalziel, S. B. (2016) "Convective mass transfer from a submerged drop in a thin falling film". *Journal of Fluid Mechanics* 789, 630-668. (arXiv)

Project 2: Confinement effects in surfactant-driven Marangoni flows

Name of the graduate program (Master 2): Modelling and Applications in Mechanics (Master MAM) or Fluid Mechanics and Energetics (Master MFE)
Laboratory for the research internship: Fluid Mechanics and Acoustics Laboratory (LMFA)
Principal Investigator: Julien LANDEL (julien.landel@univ-lyon1.fr).





Description
Recently, we have observed that surfactants deposited on liquid films can cause complex flows in confined areas. Surfactants are molecules typically found in soaps, but also in other substances. They can alter the surface tension between two phases, such as a liquid phase (water) and a gas phase (air). When the concentration of surfactants at an air-water interface is non-uniform, this creates a Marangoni tension, which leads to the spreading of the surfactants to even out their concentration. In most liquids, there is a trace of endogenous surfactants at very low concentrations, due to natural contamination. These endogenous surfactants can interact with exogenous surfactants locally deposited on the interface and alter the Marangoni-driven spreading. This can lead, for example, to flows capable of solving a maze (see photo to the left and our award winning video, Temprano-Coleto et al. Phys. Rev. Fluids, 2018), or it can be at the origin of the Japanese art of Suminagashi (right picture, also Mcnair et al. J. Fluid Mech. 2024). The aim of this project is to obtain experimental data to, ultimately (and beyond this project, which is part of a broader research framework), validate models describing the interactions between endogenous and exogenous surfactants in confined geometries.

Initially, experimental tests will be conducted to reproduce the art of Suminagashi in order to determine the key parameters. In the second phase, measurements of the spreading dynamics and the equilibrium reached over long times will be made, to compare the experimental data with existing models. The experimental study will use imaging techniques with dyes and tracers. The intern will also learn image analysis for the processing and interpretation of the results.