Geo-inspired thin film model flows

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We develop a serie of laboratory-scale model experiments to explore the dynamics and instabilities of liquid thin films inspired by geophysics [1,2]. Laccoliths are pockets of magma whose growth is accompanied by deformations of neighbouring rock layers. Within certain limits, these dynamic formations can be compared to liquid drops covered with a thin elastic membrane. We revisit the classical experiments of free surface drop dynamics, by modifying the boundary condition at the interface.

We have built an experimental setup to observe the spreading and to characterize the typical lengths involved in the problem using the fast checkerboard demodulation technique (FCD) [3]. We inject a fluid of viscosity μ and density ρ through a glass plate on which we deposit a thin millimetric elastic membrane (cf. Fig. 1). This is performed at a constant flow rate Q. Thus, the evolution of the height profile $h(r,t)$ is described by the thin film equation in the lubrication approximation where D and T are respectively the bending stiffness and the tension of the membrane :

$$\frac{\partial h}{\partial t} = \frac{1}{12\mu r}\frac{\partial}{\partial r}\left(rh^3\left(\rho g\frac{\partial h}{\partial r} + D\frac{\partial}{\partial r}(\Delta_r^2 h) - T\frac{\partial}{\partial r}(\Delta_r h)\right)\right) + w(r,t) \tag{1}$$

What is the shape and the dynamics of a fluid pocket trapped under an elastic membrane? How does the coalescence of two neighbouring pockets take place in this configuration? How are dynamic regimes then changed? We first reconstruct the general shape of the elastic drop and exhibit several spreading regimes that evolve following scaling laws (cf. Fig. 1 (right)). We then try to match the shape of each regime to an associated self similar behavior. A numerical analysis is also in progress for a comparison with the experimental dataset obtained.

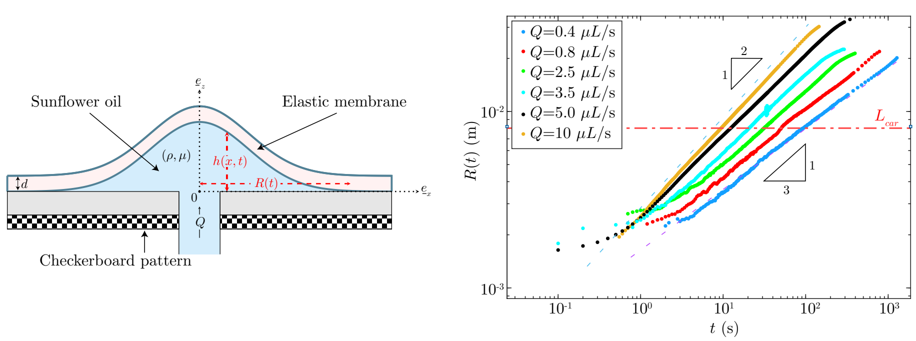

Figure 1. Experimental setup and temporal evolution of the radius $R(t)$ of a droplet for different values of the flow rate Q

References

1. J. Lister & J. Neufeld, Viscously Controlled Peeling of an Elastic Sheet by Bending and Pulling, *Phys. Rev. Letters*, **111**, 1–6 (2013).
2. M. Berhanu, Uplift of an elastic membrane by a viscous flow, *Phys. Rev.*, **99**, 1–10 (2019).
3. S. Wilderman, Real-time quantitative Schlieren imaging by fast Fourier demodulation of a checkered backdrop, *Exp. Fluids*, (2018).