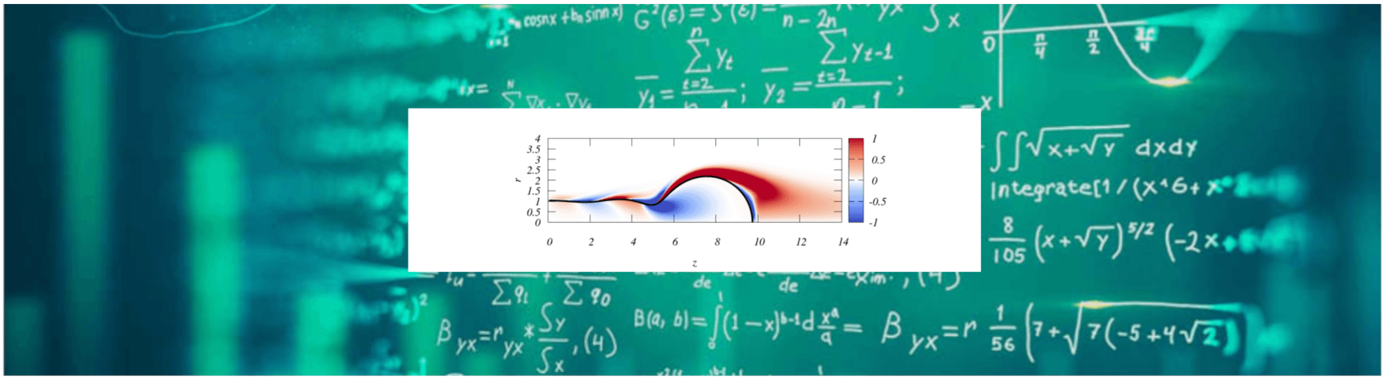


Written on 08 December 2020 4 minutes of reading

News

Fundamental Research

Physical Sciences | Transfer and transport physics | Engineering sciences | Fluid mechanics | Systems modeling and simulation

**Better predicting the retraction of a liquid ligament is useful both for IFPEN's research activities and for studies on Covid transmission. Having concluded that the Taylor-Culick velocity was only valid to evaluate the characteristic retraction time for a liquid in an inertial regime, researchers at IFPEN have proposed a velocity that is valid in a viscous regime.**

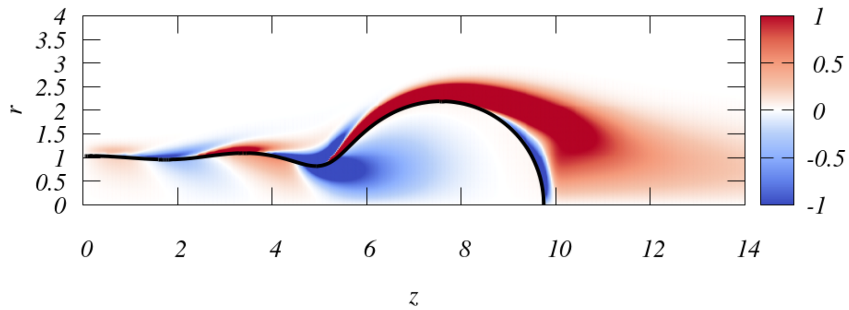
## From COVID transmission to liquid jet atomization: where do droplets come into it?

The retraction of a liquid ligament is a generic process involved **in numerous applications** of interest to IFP Energies nouvelles, be it in the atomization of a liquid jet (engine application) or droplet fragmentation in turbulent flows (processes, water treatment).

The final mechanism driving droplet formation is generally the result **of liquid ligament pinch-off** [1], a problem also encountered in the COVID-19 pandemic in terms of virus transmission via saliva projections [2].

## How can liquid retraction be predicted?

The principal challenge in all these applications is to predict whether the liquid will retract in a single spherical entity (its equilibrium shape) or break up into multiple droplets. A simple way of making such a prediction is **to compare the characteristic ligament retraction time with the characteristic time for the appearance of capillary waves** responsible for pinch-off (figure).




Goutte axisymétrique se rétractant. Les contours de vorticité illustrent l'apparition d'ondes capillaires.

## The Taylor-Culick velocity, its validity qualified by new research

Until very recently, the characteristic retraction time had been estimated via the so-called Taylor-Culick velocity [3,4], whether the liquid was highly viscous or, conversely, highly inertial. IFPEN conducted numerical and theoretical research, with contributions from a post-doctoral researcher and scientific visitor Professor Edson Soares, a specialist in fluid mechanics and the rheological characterization of complex fluids. The research demonstrated that this velocity **was only valid in an inertial regime** and for sufficiently long periods of time.

## Viscous regimes: a decreasing retraction velocity over time

Researchers also proposed a self-similar solution - for which the shape of the droplet remains “similar” over time - in viscous regimes. This solution provides a retraction velocity that, unlike the Taylor-Culick velocity, is not constant but **decreases over time**. The ligament can then take an infinite amount of time to relax and return to its equilibrium position!

This research was the subject of two publications [5, 6] singled out in the editors’ selection.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[1] Villermaux, E. (2020). *Fragmentation versus cohesion*. Journal of Fluid Mechanics, 898.
[2] Abkarian, M., & Stone, H. A. (2020). *Stretching and break-up of saliva filaments during speech: A route for pathogen aerosolization and its potential mitigation*. Physical Review Fluids, 5.
[3] Taylor, G. I. (1959). *The dynamics of thin sheets of fluid. III. Disintegration of fluid sheets*. Proceedings of the Royal Society of London. Series A. Mathematical and Physical Sciences, 253(1274), 313-321.
[4] Culick, F. E. C. (1960). *Comments on a ruptured soap film*. Journal of applied physics, 31(6), 1128-

1129.
[5] Pierson, J. L., Magnaudet, J., Soares, E. J., & Popinet, S. (2020). *Revisiting the Taylor-Culick approximation: Retraction of an axisymmetric filament*. Physical Review Fluids, 5.
[6] Deka, H., & Pierson, J. L. (2020). *Revisiting the Taylor-Culick approximation. II. Retraction of a viscous sheet*. Physical Review Fluids, 5.

Retraction of a liquid ligament in viscous and inertial regimes: research at IFPEN revisits theoretical predictions
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