

Droplet deformation decomposition in a turbulent flow

I. Roa Antúnez^a, M. C. Renoult^a, C. Dumouchel^a and J. C. Brändle de Motta^a

Droplet deformation and breakup are important phenomena in the atomization process due to their impact in the final distribution of droplet size. For many applications such as spray painting, coating or fuel injection, it is desirable to be able to obtain appropriate fragmentation sizes. Turbulence is one of the main mechanisms through which secondary breakup occurs. Several authors relate the turbulent droplet breakup to a resonant mechanism reached by their free oscillations, even for low turbulence levels, which gives the ground for this study.

The oscillations of a single, initially unperturbed, spherical liquid droplet subject to a homogeneous and isotropic turbulent medium are investigated. The problem is approached via direct numerical simulation of the two-phase flow Navier-Stokes equations for an ensemble of droplets with different characteristic values, such as density and viscosity ratios. The database of single droplets is obtained using the in-house interface-resolved solver ARCHER¹. A theoretical framework for the droplet oscillations for each individual mode using a spherical harmonic decomposition is considered², following the deformation of the surface from its initial state until shortly before its breakup. In figure 1 we show an evolution of the amplitude coefficients of mode 2 before the break.

This approach relates the droplet small-perturbation amplitude deformation with the turbulent medium parameters and characteristics, allowing to exhibit how the turbulence excites the different modes leading eventually to breakup. We connect this phenomenon to the linear stability theory and analyse how the droplet lifetime is related to the turbulence statistics for the ensemble of characteristic values.

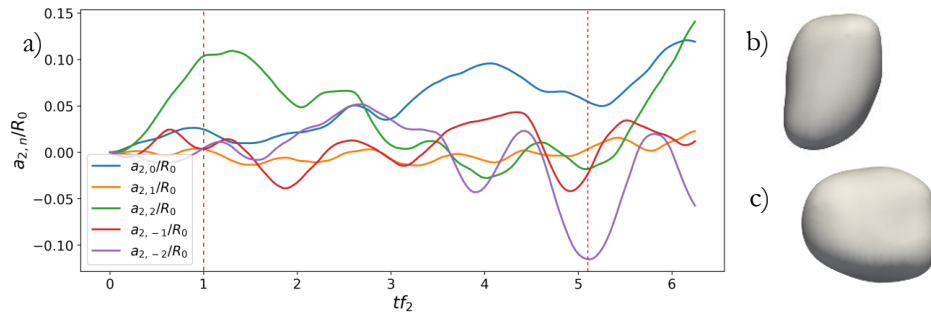


Figure 1: a) Temporal evolution of the amplitude coefficients $a_{2,n}$ for degrees $n=-2$ to $n=+2$, where R_0 is the initial radius of the droplet, t is time and f_2 corresponds to the theoretical angular frequency associated to mode 2. b) Snapshot of the droplet at $tf_2 = 1$. c) Snapshot of the droplet at $tf_2 = 5.1$.

^a Normandie Univ, UNIROUEN, INSA Rouen, CNRS, UMR6614-CORIA, 76000 Rouen, France

¹ Cheron et al., *29th Conference on Liquid Atomization and Spray Systems* (2019).

² Perrard et al., *Journal of Fluid Mechanics*, **920** (2021).