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Influence of Cavitation on Textural Atomization

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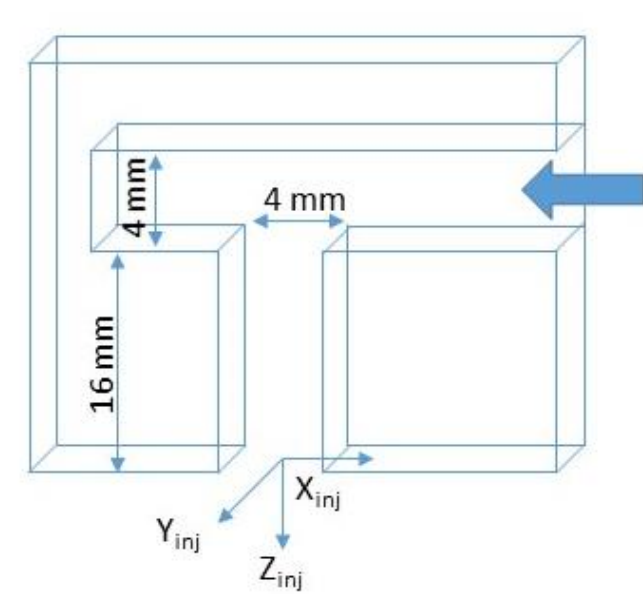
Abstract

Textural atomization designates the production of liquid drops from the peeling off of liquid gas interfaces. This mechanism is usually observed in the near nozzle region and is often associated with a significant level of turbulence in the flow issuing from the injector. Cavitating internal flows are known to promote the level of turbulence of the issuing flow [1] and indeed textural atomization processes have been reported on such flows [2]. This work characterizes the textural atomization of a flow issuing from a so-called 2D atomizer in which cavitation develops as the flow rate increases. The experimental work shows visualizations of the flow inside the discharge orifice and the textural atomization process in the near nozzle region. Internal velocity fields obtained by LDV measurements are presented. A multi-scale analyzing tool [3] is applied to describe the textural atomization process. This analysis reports an evolution of the textural atomization liquid structures and of their deformation as cavitation effects increase. It also opens a way to the prediction of the droplets produced by the textural atomization process whose diameter distributions have been measured and are also presented.

Objectives

1. To characterize the textural atomization in cavitating flow conditions
2. To describe the evolution of the liquid structures developing in the textural atomization
3. To explore a possible connection with the diameter distribution of the produced droplets

Experimental Work

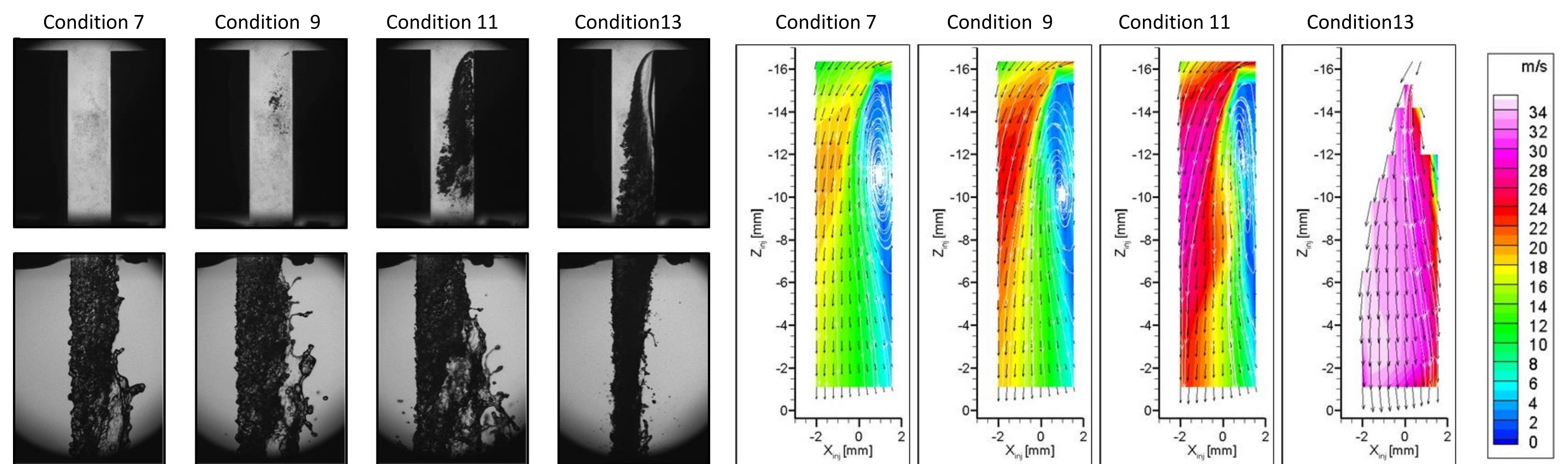


- 2D atomizer from A. Sou [4]
- Transmission images show four cavitation regimes
- LDV measurements show that the cavitation zone is associated with high recirculation except for the last cavitation regime
- The textural atomization process shows ligaments
- The ligaments strongly depend on the cavitation regime

Condition	7	8	9	10	11	12	13
Q_v (l/min)	2.4	2.6	2.85	3.3	3.45	3.75	4.35
$Re = V_q h / \gamma$	9090	9850	10800	12500	13070	14200	16290
V_q (m/s) = Q_v / A_0	10	10.8	11.9	13.8	14.4	15.6	17.9
$V_{cav, side}$ (m/s)	4.28	4.55	4.80	7.44	8.22	9.88	11.7
$We_g = \rho_g V_q^2 t / \sigma$	1.72	2.02	2.43	3.25	3.55	4.20	5.52
$CN = (p_{amb} - p_v) / (0.5 \rho_l V_q^2)$	1.98	1.68	1.4	1.05	0.95	0.81	0.61

Water in air
 $\sigma = 0.07$ N/m
 $\rho_g = 1.204$ kg/m³

$\gamma = 1.1 \cdot 10^{-6}$ m²/s
 $p_v = 2339$ Pa
 Injector thickness (h) = 1 mm

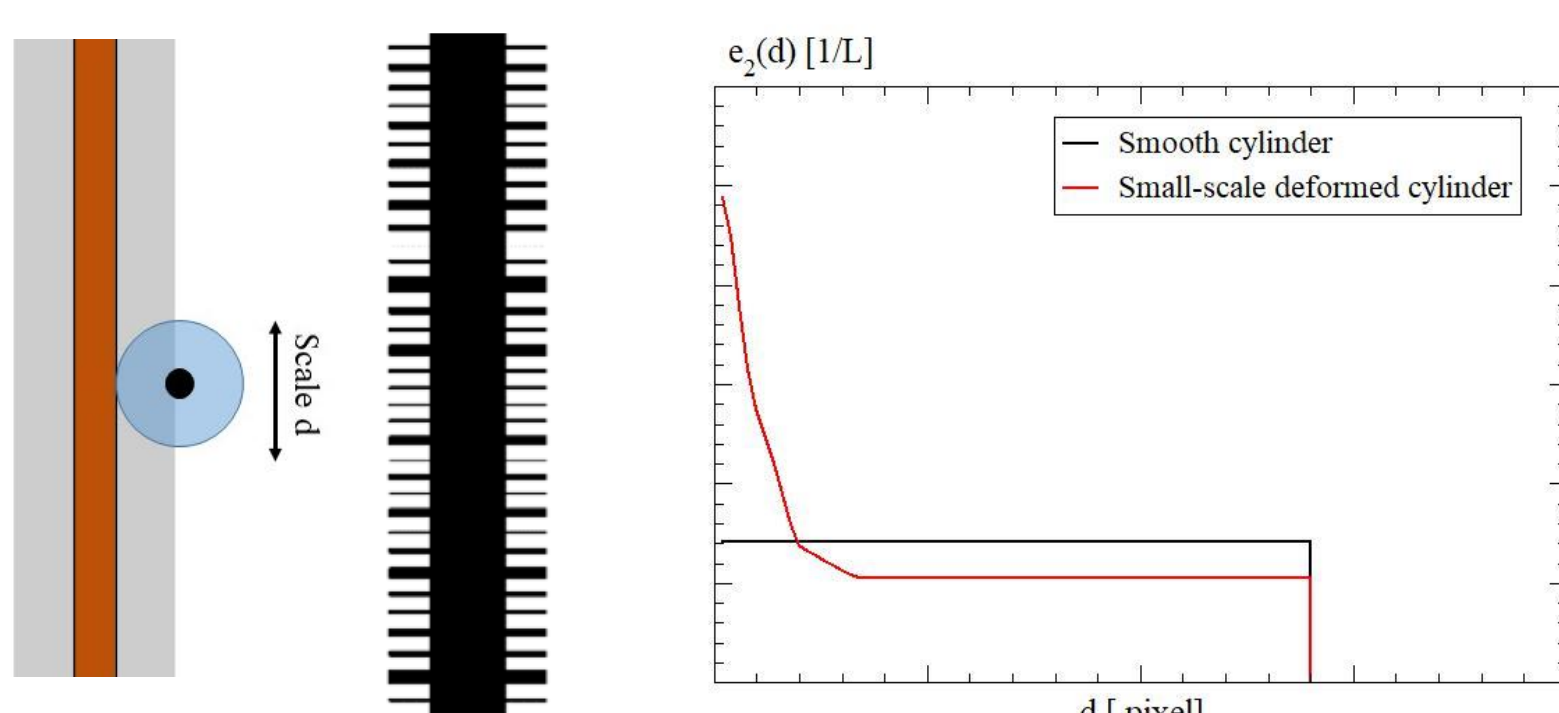


Multi-Scale Analysis

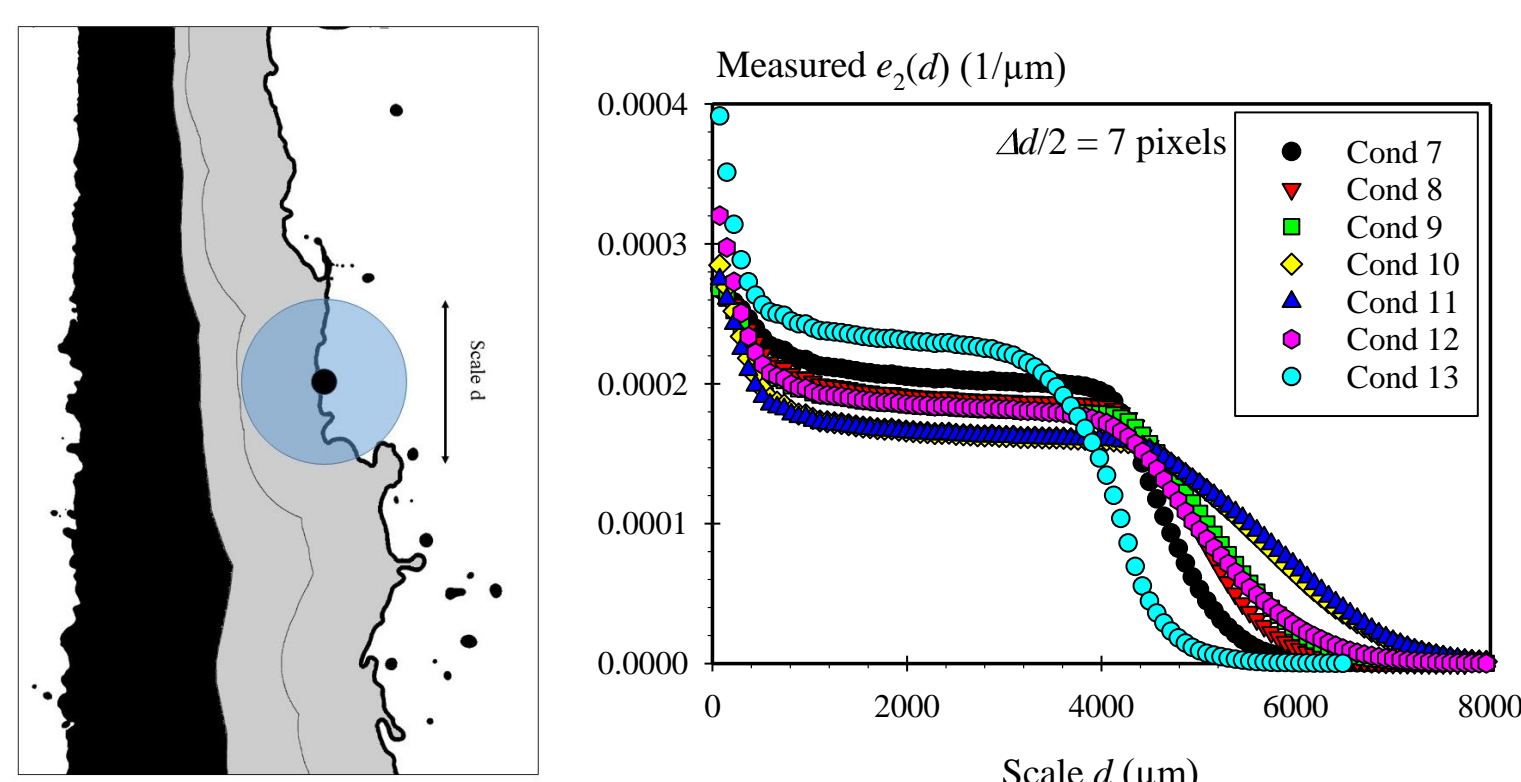
- Measurement of the scale distribution $e_2(d)$
- It is defined by:

$$e_2(d) = \frac{\text{Perimeter of the eroded system at scale } d}{2 * \text{Total Surface Area}}$$

- For a smooth cylinder, it is a step function
- For a deformed cylinder, it is depending on the scale



- Application on the cavitating side only
- The scale distribution is mathematically separated in two parts to isolate the textural structure scale distribution $e_{2,1}(d)$ [5]

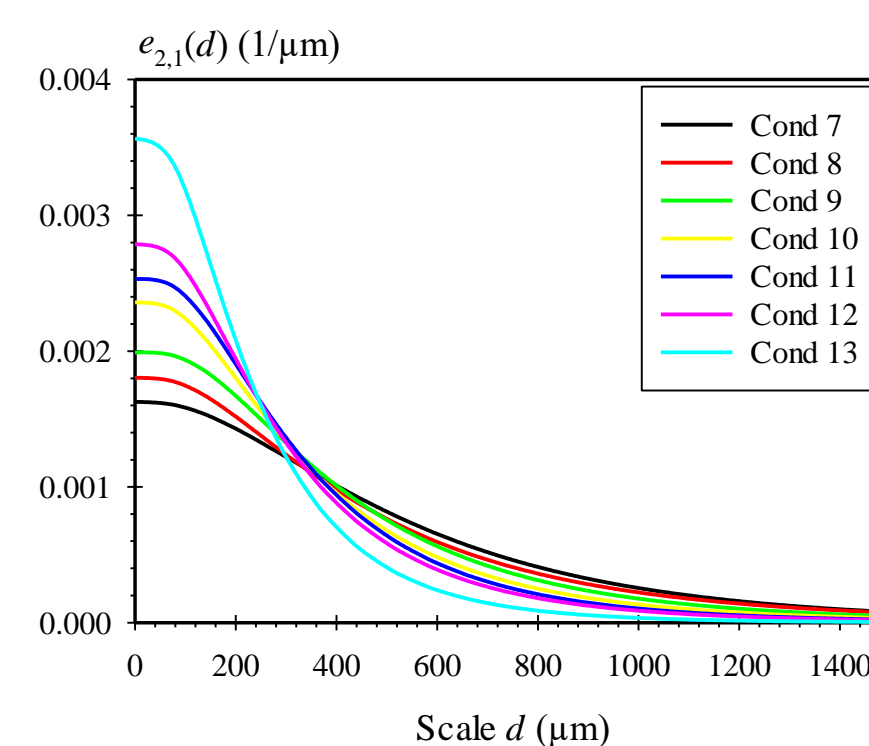


$$e_2(d) = \beta_e e_{2,1}(d) + (1 - \beta_e) e_{2,2}(d)$$

$$e_{2,1}(d) = \frac{1}{D_{q_1}} \left(\frac{\alpha_i}{q_i} \right)^{1/q_i} \Gamma \left(\frac{\alpha_i}{q_i} \right) \frac{\alpha_i}{q_i} \left(\frac{d}{D_{q_1}} \right)^{q_i} \Gamma \left(\frac{\alpha_i + 1}{q_i} \right)$$

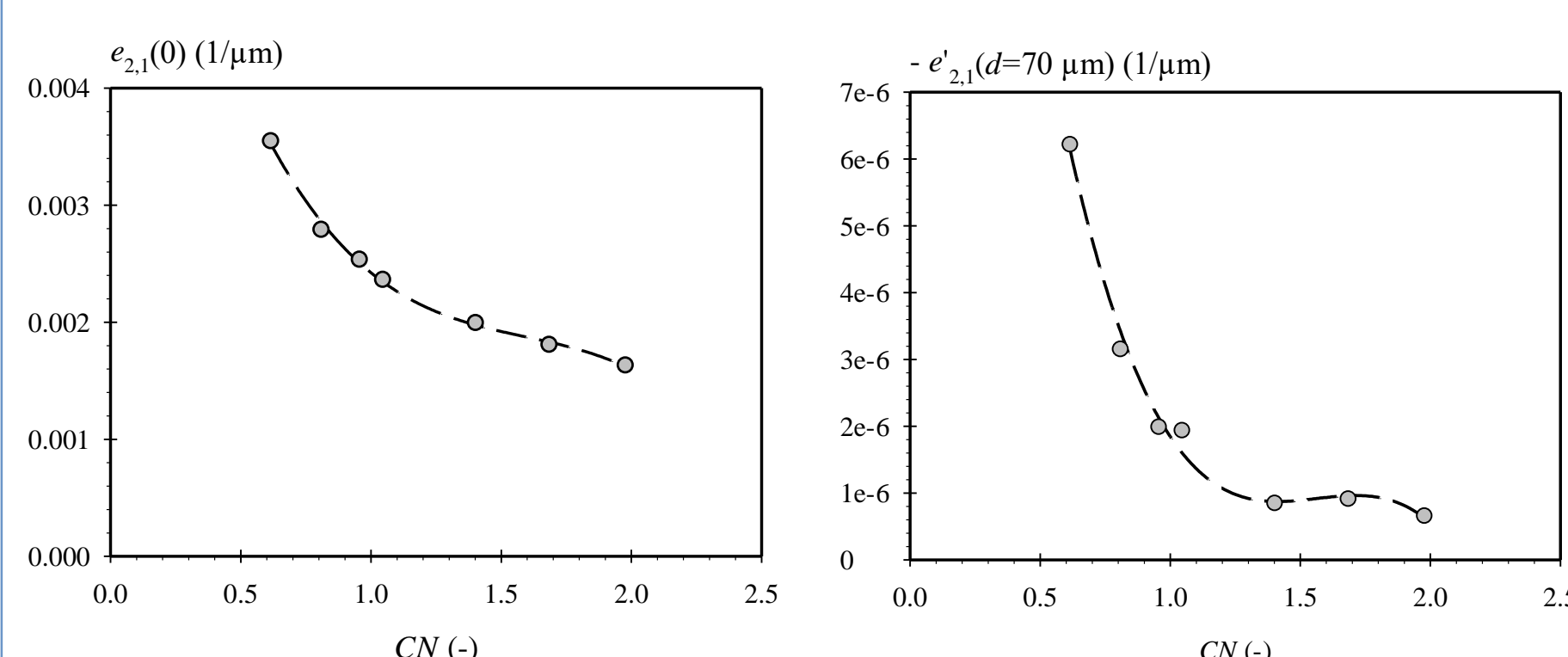
Textural Atomization Scale Distribution

- The scale distribution $e_{2,1}(d)$: the textural atomization

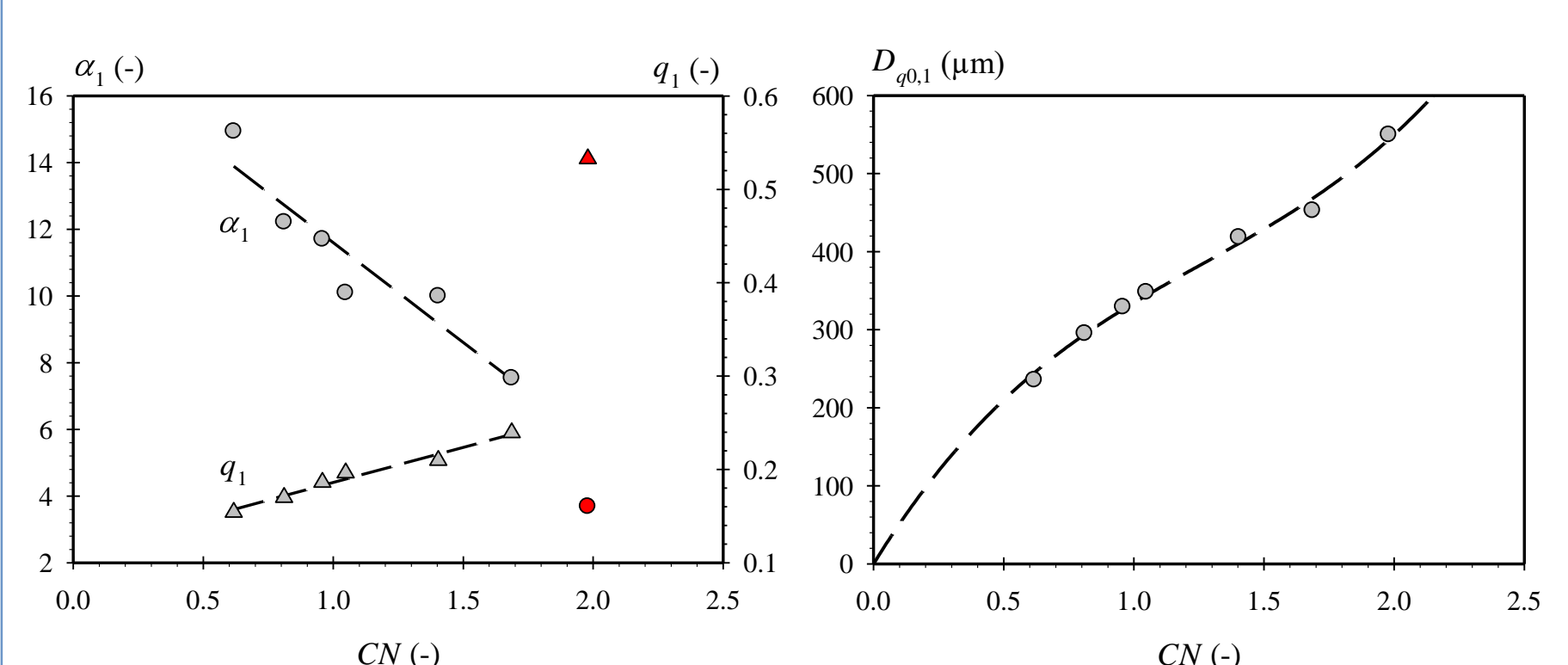


As CN decreases:

- the interface length per unit surface increases: the atomizing structures are thinner (left)
- The atomizing structures are more and more deformed at small scales (right)

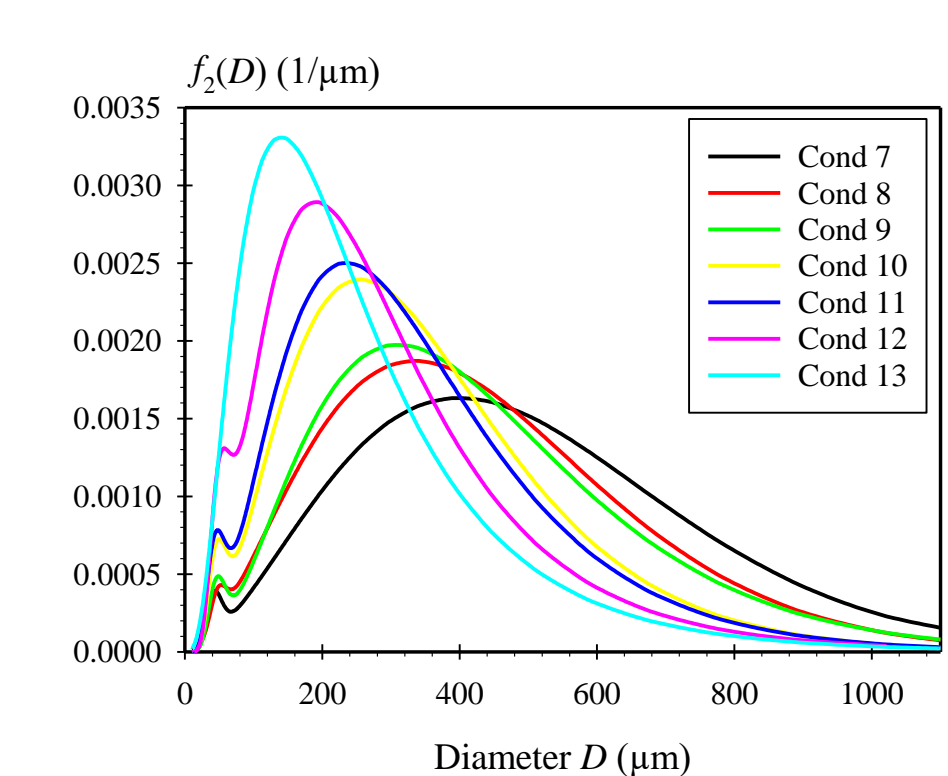


- The $e_{2,1}(d)$ parameter evolutions indicate a modification of the perturbation size distribution

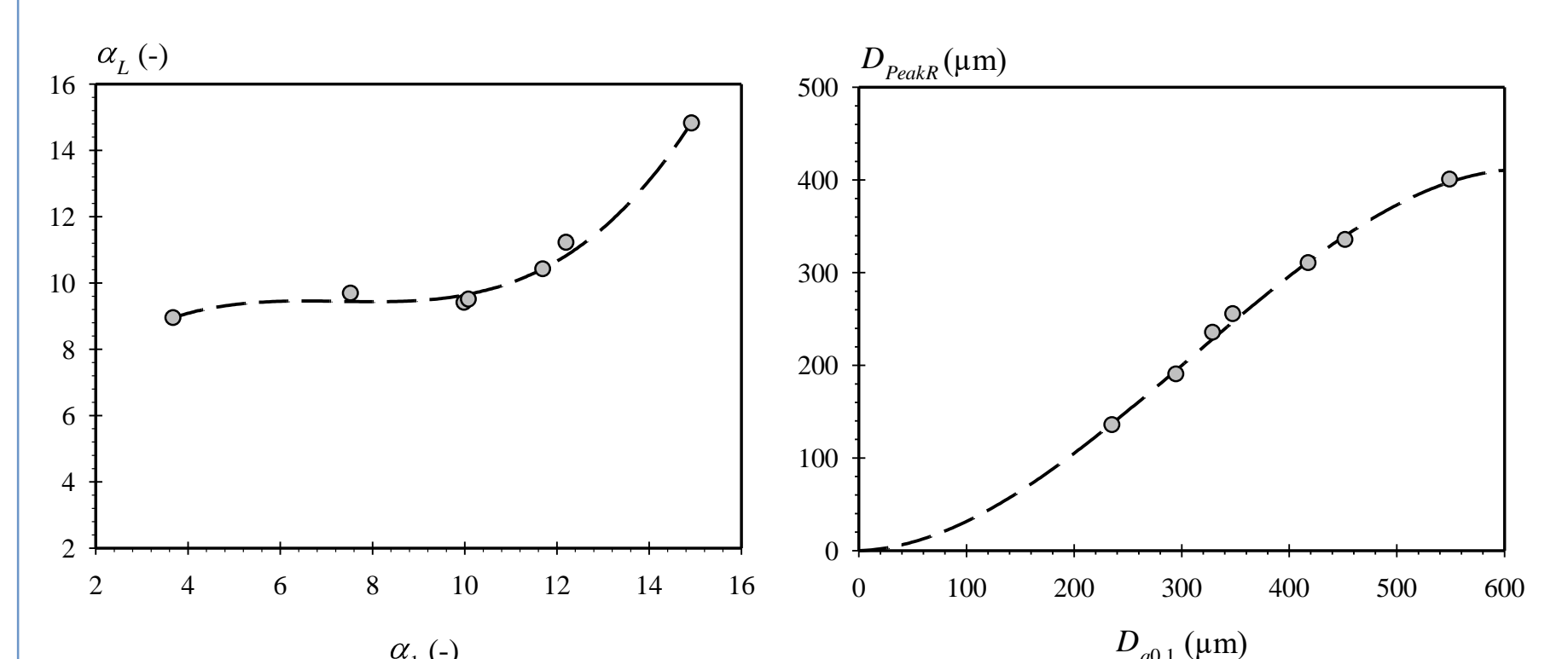


Drop Size Distribution

- Surface-based diameter distributions of initial drops are measured on images [6] and mathematically represented by a combination of two 3-parameter Gamma distributions [7]



- Correlations between $e_{2,1}(d)$ and $f_2(D)$ parameters are established



Conclusions

- The multi-scale analysis of the liquid-gas interface provides a quantified representation of the structures involved in the textural atomization process
- These structures depend on cavitation
- A correlation between the textural perturbations and the initial spray droplets is recognized

Contact

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