# The Effect of Inlet Pulsations on Primary Atomization of Liquid Jets

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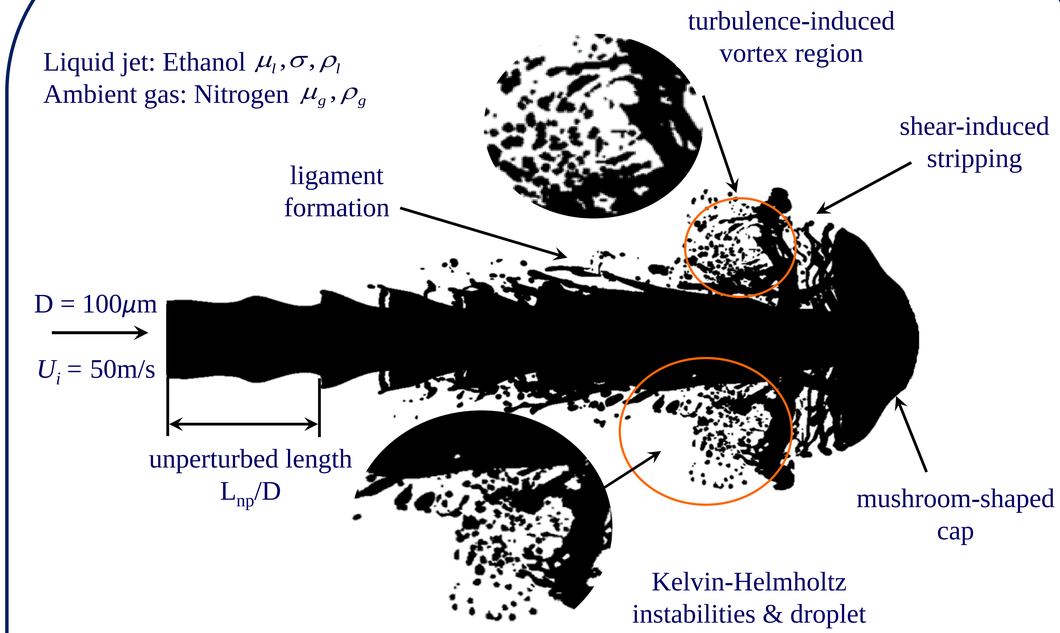
This work was supported by the College of Engineering and Applied Science at the University of Cincinnati

## Primary Atomization: Liquid Jet Injection




**Schematic of liquid ethanol jet injection in stagnant $N_2$ environment**

## Objectives

- Elucidate the physics underlying the primary atomization of liquid jets.
- Investigate the effect of inlet pulsations on the atomization process.
- Identify the reliability of numerical predictions using uncertainty quantification techniques (UQ) and sensitivity analyses.

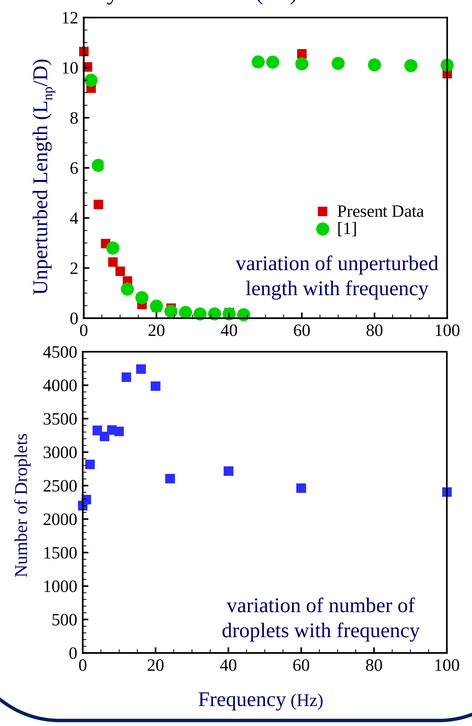
## Validation

**Physical Properties**

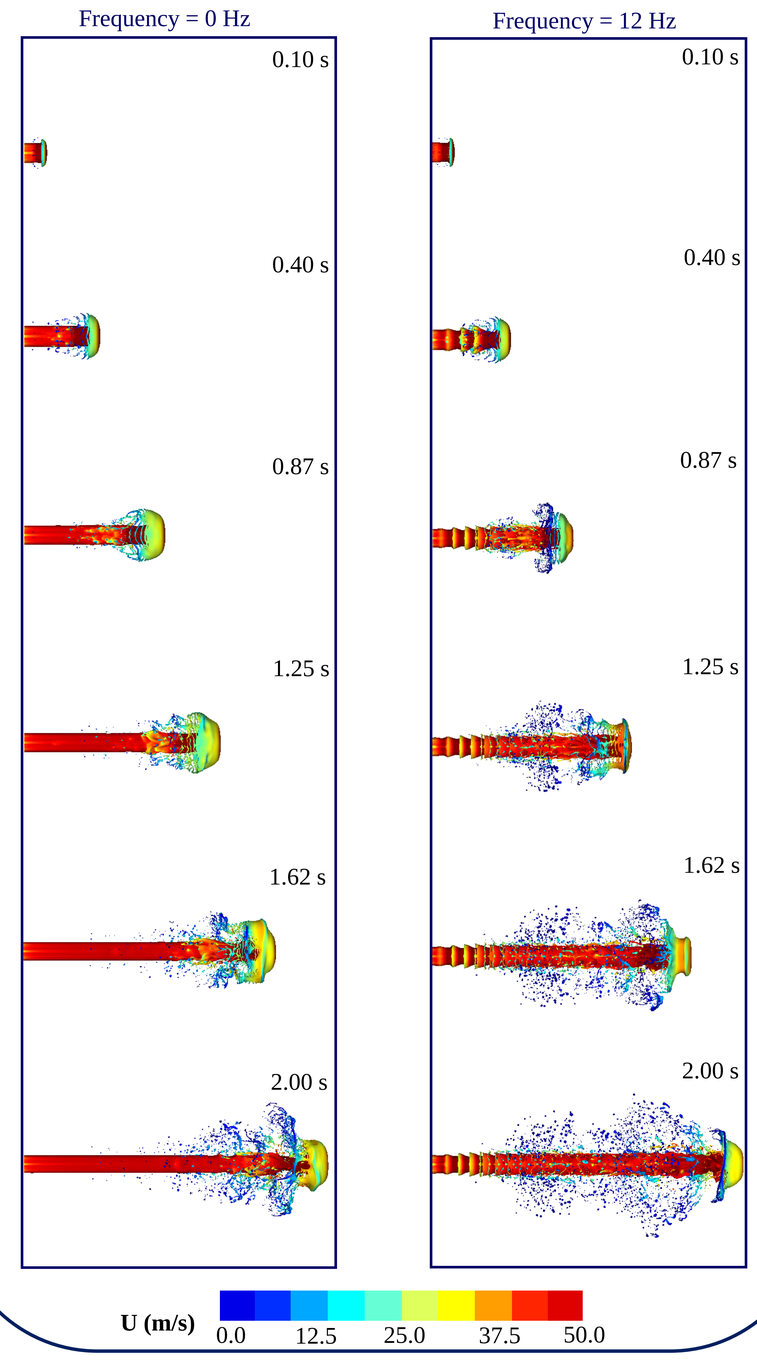
| | Ethanol | Nitrogen |
|---|---|---|
| Density, $\rho$ (kg/m$^3$) | 848 | 34.5 |
| Viscosity, $\mu$ (Pa·s) | 2.87 x 10$^{-3}$ | 1.97 x 10$^{-5}$ |
| Surface Tension, $\sigma$ (N/m) | 0.03 | N/A |

**Relevant Non-Dimensional Parameters**

| | |
|---|---|
| Weber number (We) | 287.5 |
| Reynolds number (Re) | 1477 |




## Detailed Flow Physics




## Methodology

Incompressible, variable-density, Navier-Stokes equations

$$\rho(\partial_t \mathbf{u} + \mathbf{u}\cdot\nabla\mathbf{u}) = -\nabla p + \nabla\cdot(2\mu \mathrm{D}) + \sigma\kappa\delta_s \mathrm{n}$$

$$\partial_t \rho + \nabla\cdot(\rho\mathbf{u}) = 0$$

$$\nabla\cdot\mathbf{u} = 0$$

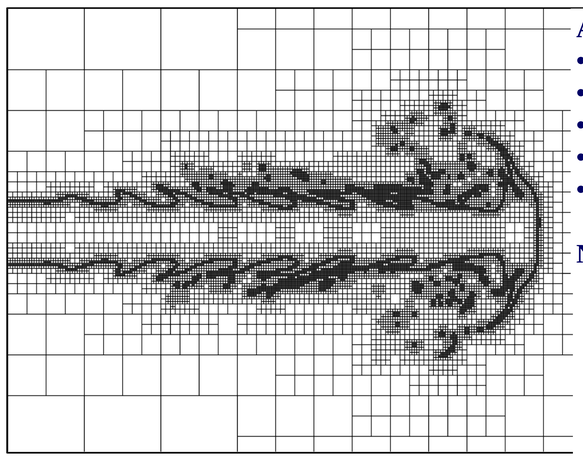
Volume of Fraction (VOF) used for interface capturing

$$\rho(c) \equiv c\rho_1 + (1-c)\rho_2$$

$$\mu(c) \equiv c\mu_1 + (1-c)\mu_2$$

Advection of volume fraction:

$$\partial_t c + \nabla\cdot(c\mathbf{u}) = 0$$



**Adaptive Mesh Refinement (AMR)**

- Gradient and value based refinement
- Cells without AMR = 671million
- Cells with AMR = 1.61 million
- Total reduction = 99.76%
- Min. cell size = 2 μm

**Non-Dimensional Parameters**

$$We = \frac{\rho_g (u_l - u_g)^2 D}{\sigma}$$

$$Re = \frac{\rho_l u_l D}{\mu_l}$$

References:

[1] Yang, X. and Turan, A., "Simulation of liquid jet atomization coupled with forced perturbation," *Physics of Fluids*, Vol. 29, 2017.