DROPLET DYNAMIC ON VERTICAL BUNDLE OF FIBERS

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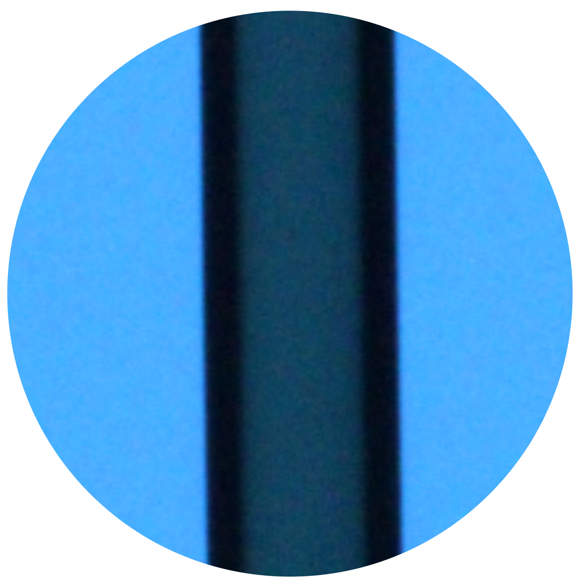
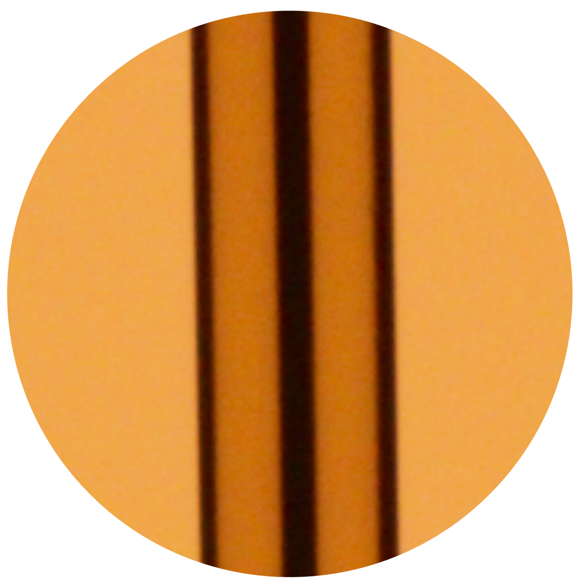
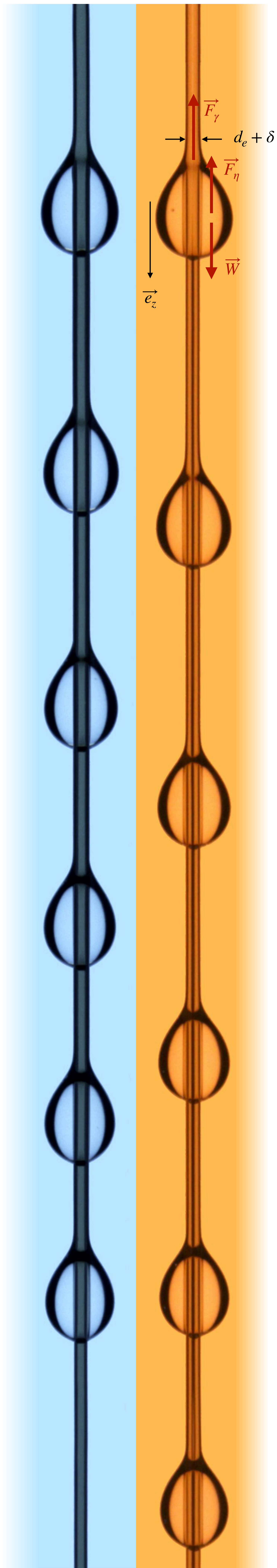
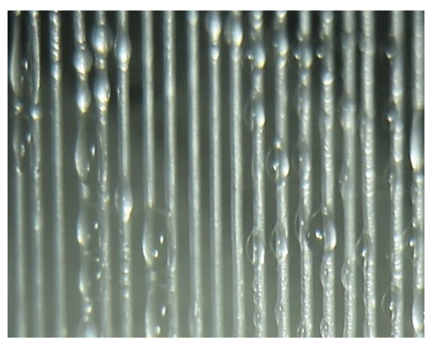






Motivation



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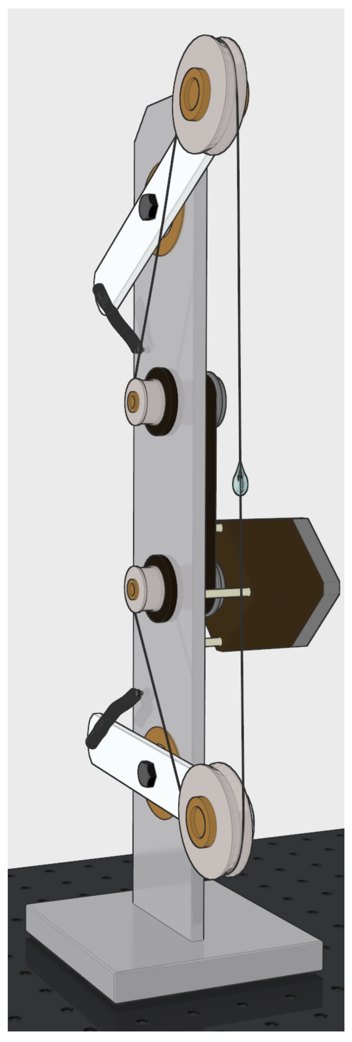
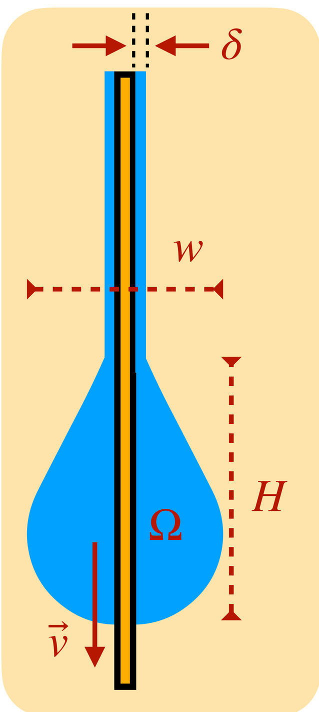
@DenisDoukhan

Capturing freshwater from **fog** using structures like **cloud nets** can make a significant contribution in arid regions. We propose a **biomimetic** approach to enhance the efficiency of these structures by exploring the impact of **grooves** on water droplet transport along **vertical fibers**.

Experimental Set Up





Volume Ω
Speed $\vec{v}$
Geometry H & w
Film Thickness δ

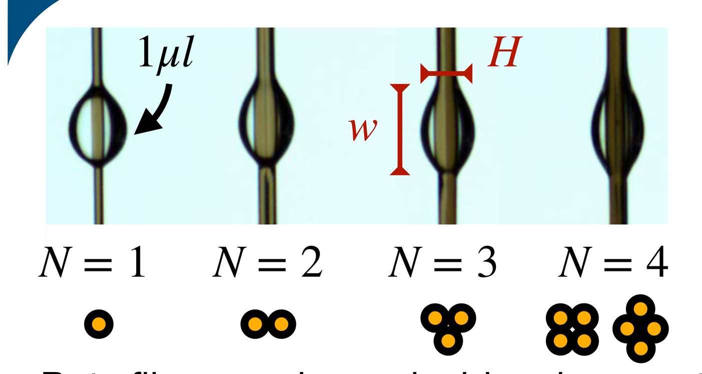
Variables

Fiber Diameter: d: $80\,\mu m \to 280\,\mu m$

Fiber number: $n = 1 \to n = 4$

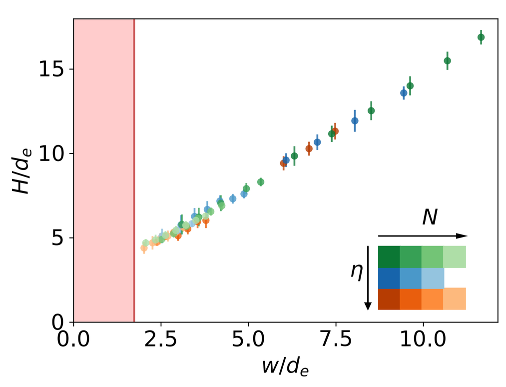
Silicone Viscosity: $\mu = 10\,\text{cSt} \to \mu = 50\,\text{cSt}$

Droplet Shape



But fibers volume inside drop not preserved so we introduce the effective diameter d_e:

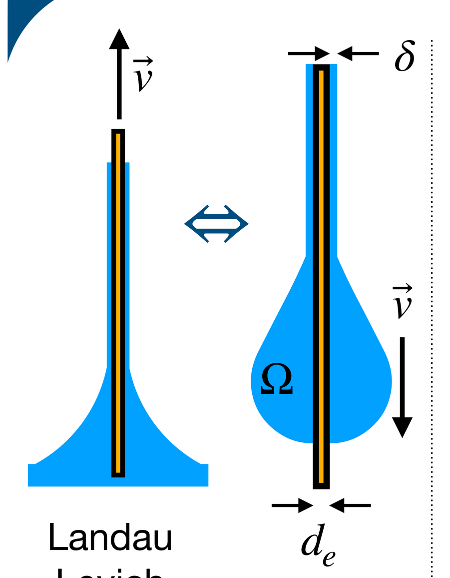
$\longrightarrow d_e$



If we normalise by the effective diameter d_e , drop geometry is independent of N

Substructure doesn't affect droplet shape

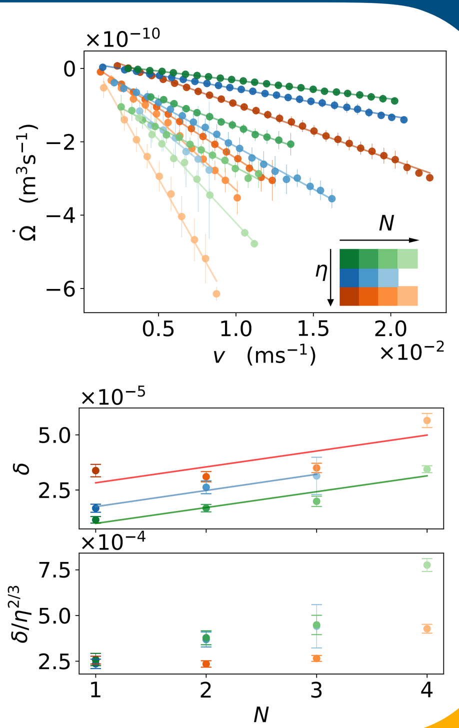
Film Thickness



$\delta \propto Ca^{2/3} = (\eta v/\gamma)^{2/3}$

- Mass conservation
  $\dot{\Omega} = -\pi d_e \delta v$
- Film thickness
  $\delta = -\frac{\dot{\Omega}}{v}\frac{1}{\pi d_e}$
- Verification
  $\hookrightarrow LL : \delta \propto \eta^{2/3}$

$$\frac{\delta}{\eta^{2/3}} = -\frac{\dot{\Omega}}{v}\frac{1}{\pi d_e \eta^{2/3}}$$



Substructure leads to thicker liquid film

Model

$$\sum F = ma_z$$

$$W - F_\gamma - F_\eta = \rho\Omega\ddot{z}$$

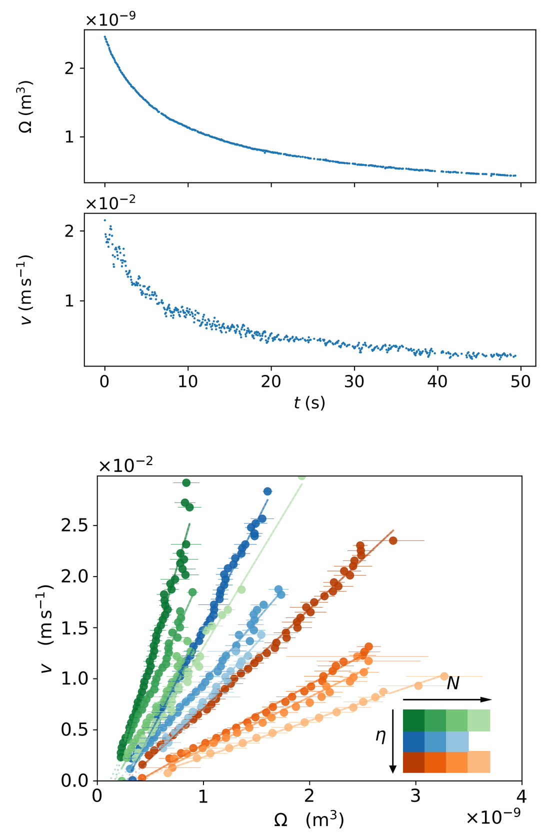
$$\rho g\Omega - \pi\delta\gamma - \eta d_e \xi \dot{z} = \rho\Omega\ddot{z}$$

Neglecting inertia $(\text{We} \sim 10^{-6})$ and writing $\dot{z} \to v$

$$v = \frac{\rho g}{\xi d_e \eta}\Omega - \frac{\pi\gamma\delta}{\xi d_e \eta}$$

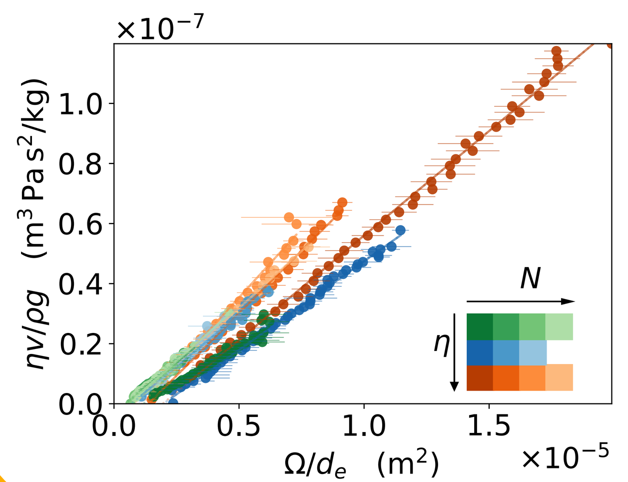
$\longrightarrow$ Residual volume

$$\Omega_0 = \frac{\pi\gamma\delta}{\rho g} \approx 0.1\mu L$$

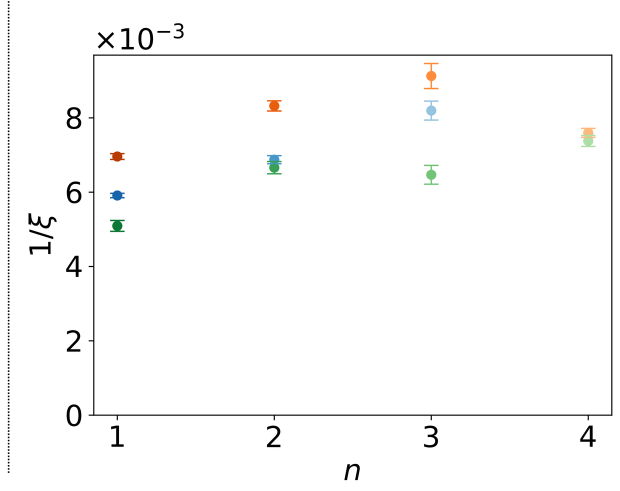


Dissipative factor

$$\left(\frac{v\eta}{\rho g}\right) = \frac{1}{\xi}\left(\frac{\Omega}{d_e}\right) - \frac{\gamma\pi}{\xi\rho}$$

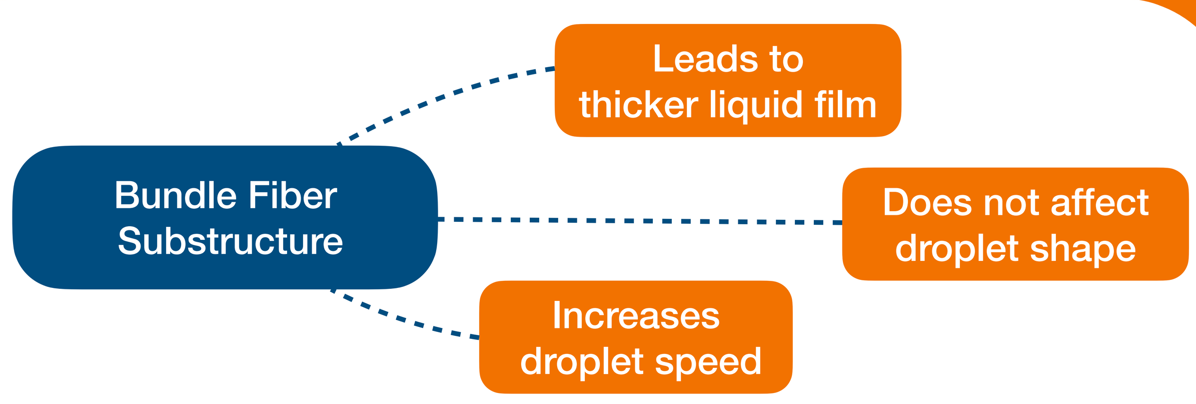


Dissipation decreases with N



Substructure increases drop speed

Conclusion



- Low cost manufacturing
- Increases collection time
- Improves subsequent drops dynamics

Informations

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"Droplets sliding on single and multiple vertical fiber"
M. Leonard, J. Van Hulle, F. Weyer, D. Terwagne, and N. Vandewalle
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