Bursting bubbles in Basilisk

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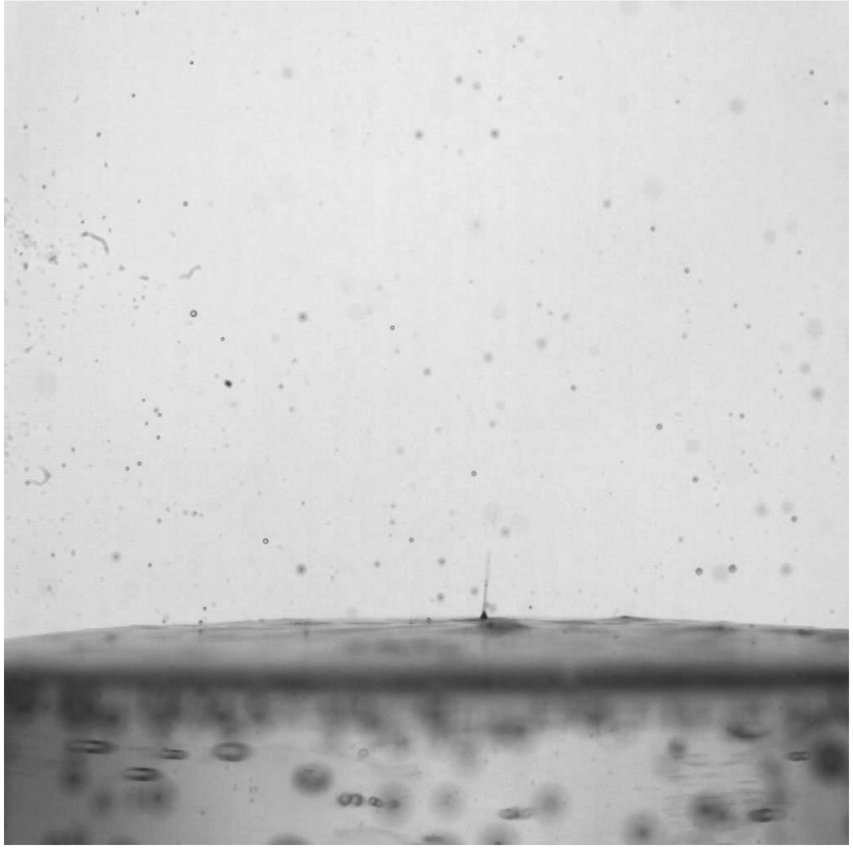
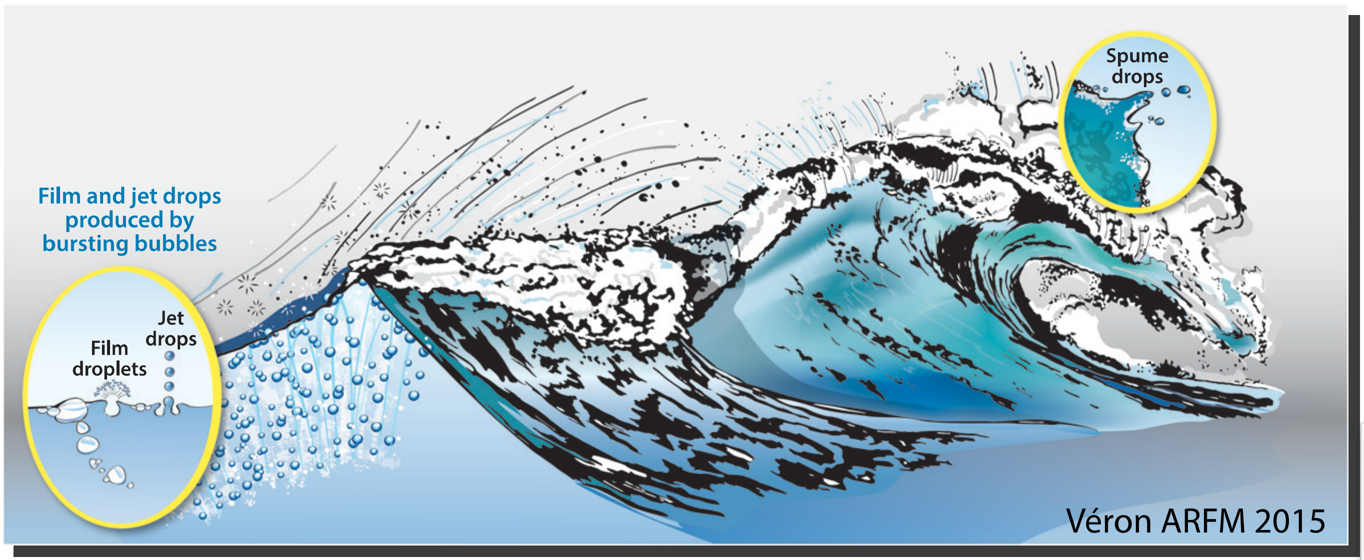
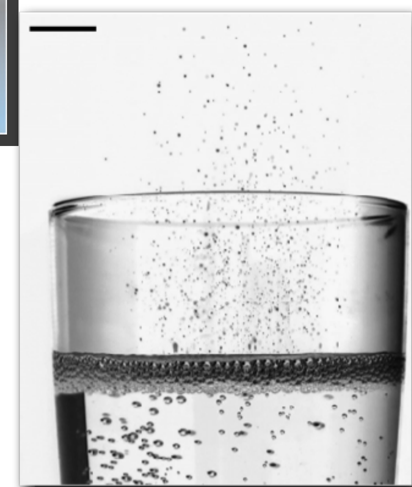
Bursting Bubbles



Context





Estimation of aerosols flux

A bursting bubble

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Outline

- Estimation of the liquid volume transferred to the air
  - Numerical simulation setup
  - Characterization of:
    - Velocity of the ejected droplets
    - Size of the ejected droplets
    - Number of ejected droplets
  - Estimation of the vertical mass flux

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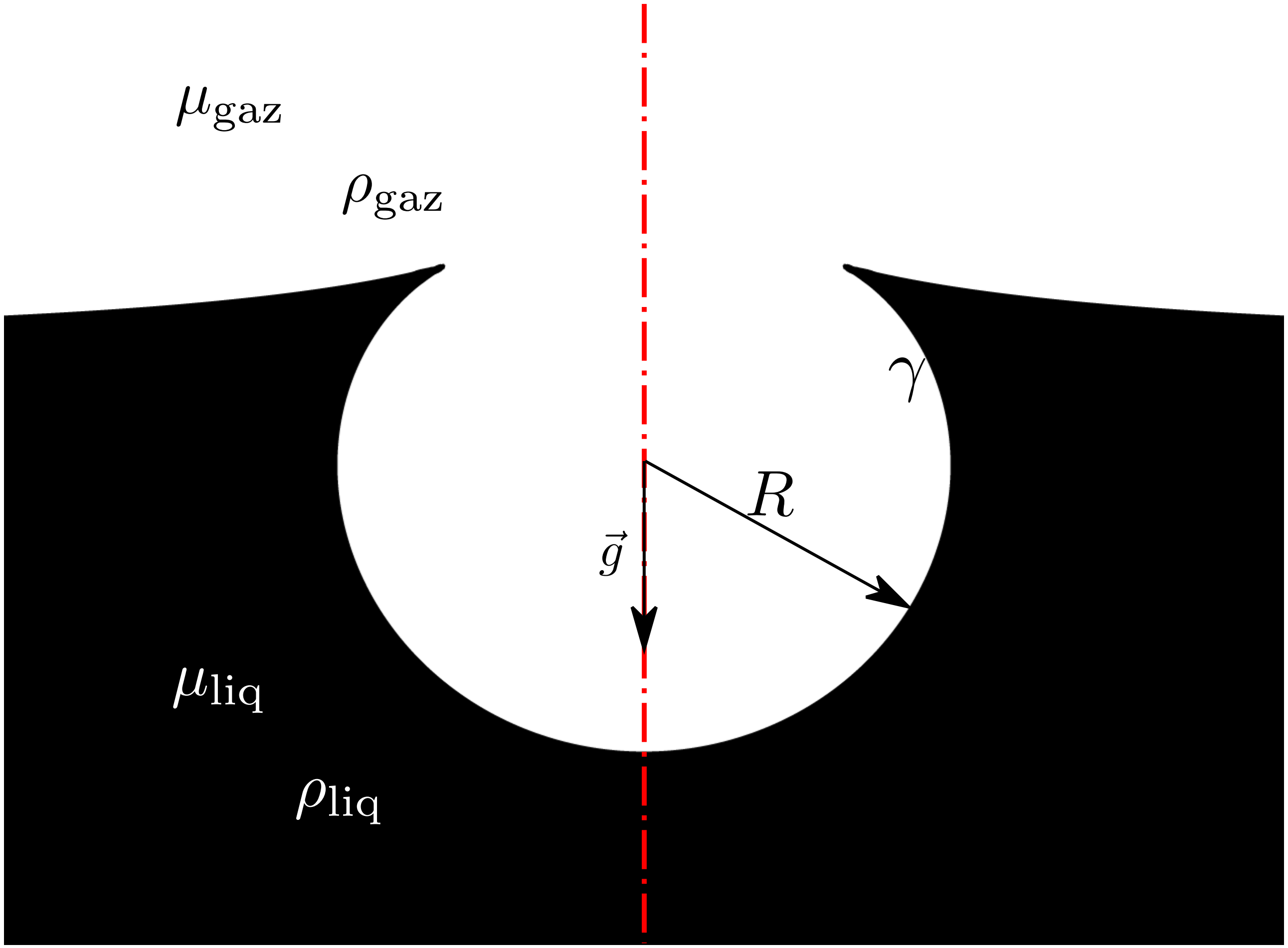
Numerical simulation setup



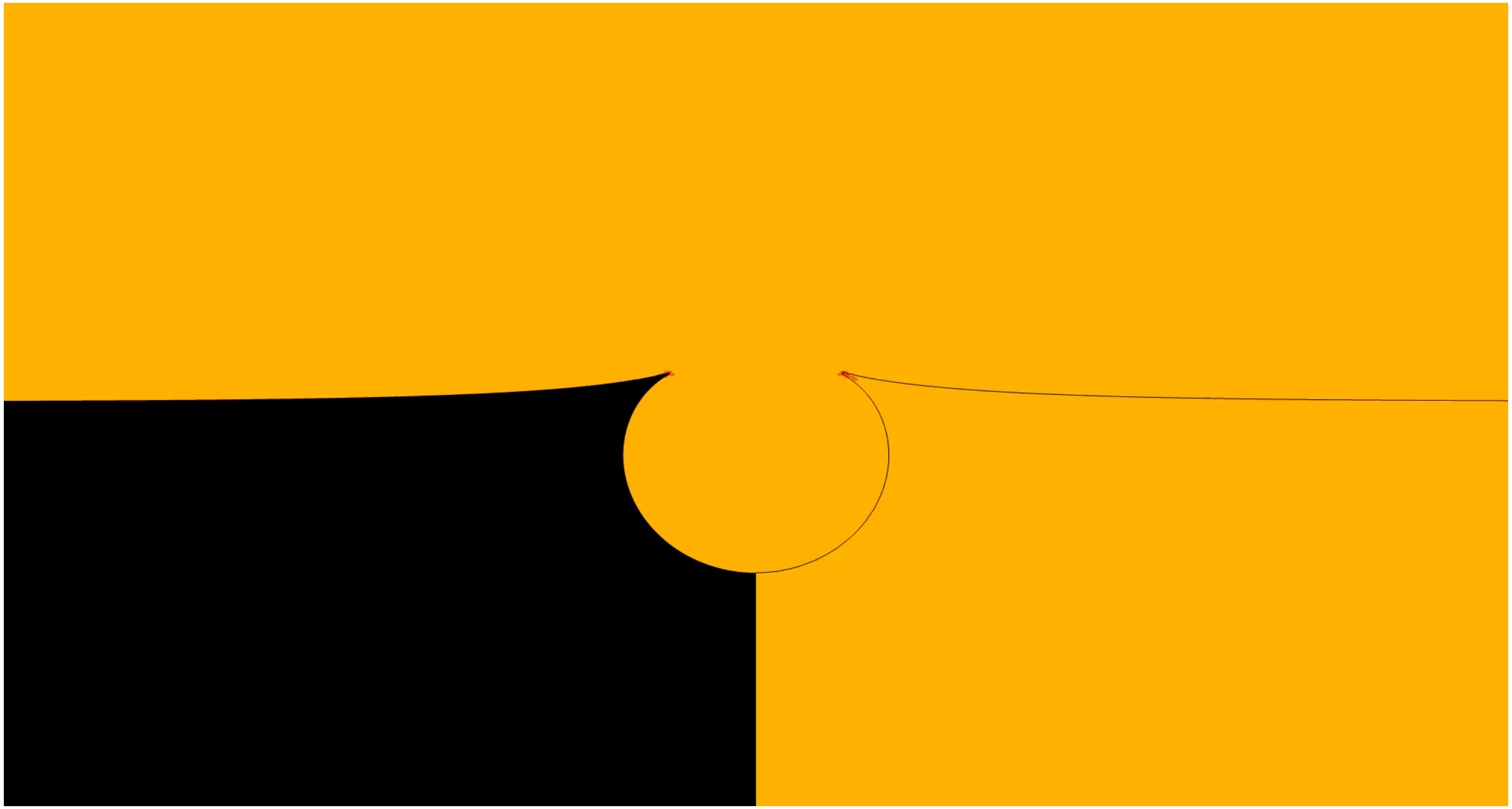
$$\rho_{\text{gaz}}/\rho_{\text{liq}} = 1/998$$

$$\mu_{\text{gaz}}/\mu_{\text{liq}} = 1/55$$

$$\text{La} = \frac{\rho_{\text{liq}}\gamma R}{\mu_{\text{liq}}^2}$$

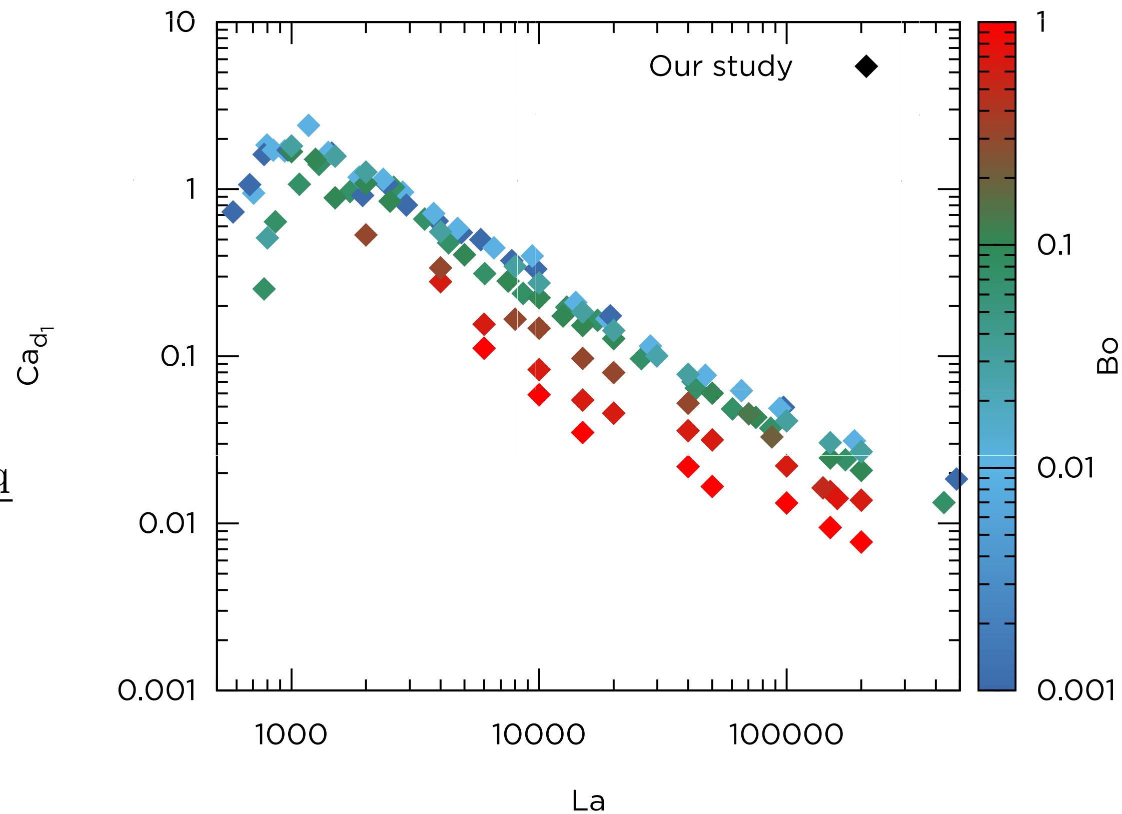
$$\text{Bo} = \frac{\rho_{\text{liq}} g R^2}{\gamma}$$

Simulated bursting bubble



Velocity of the first drop

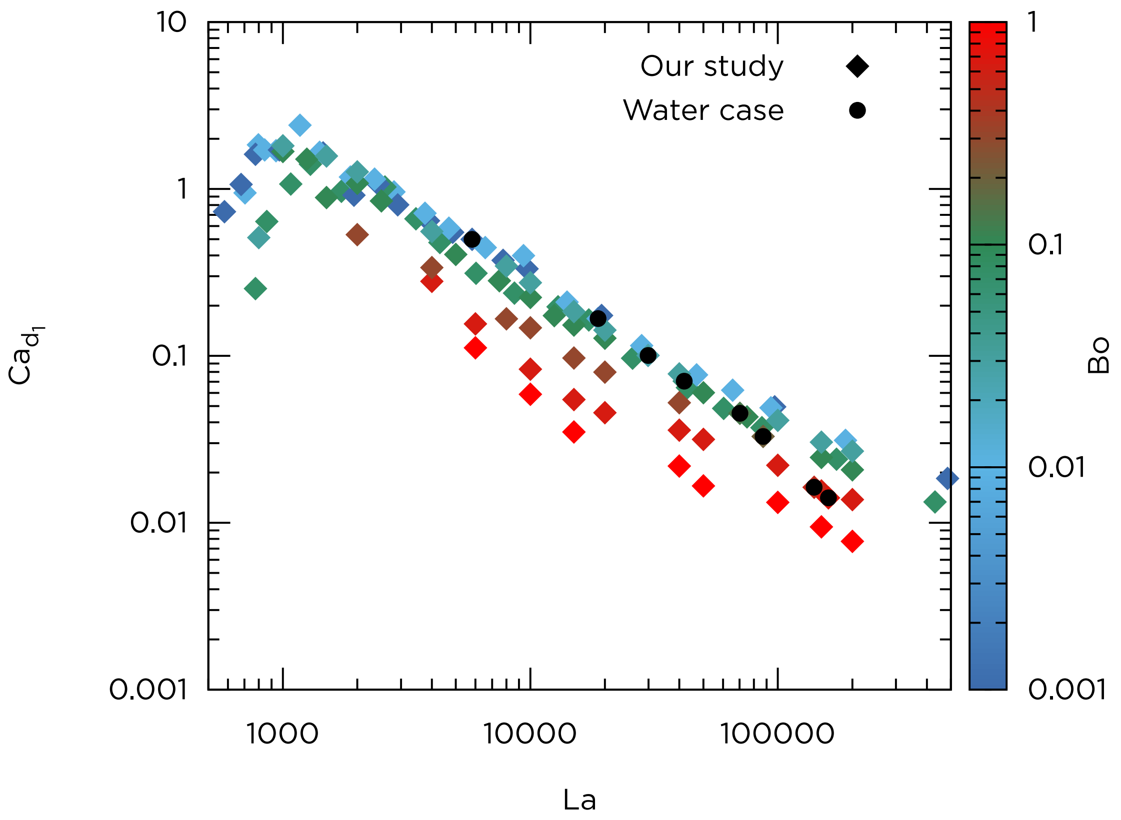
$$\mathrm{Ca}_{d_i} = \frac{v_{d_i}\mu_{\mathrm{liq}}}{\gamma}$$



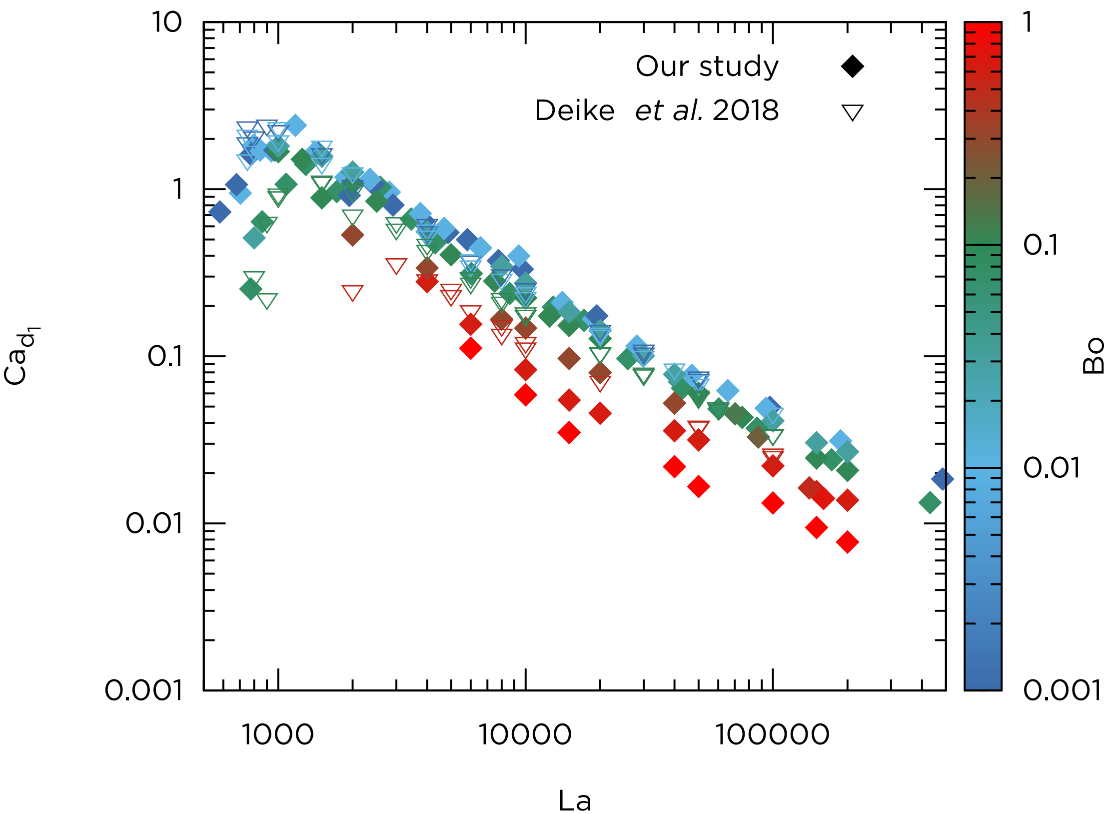
$$\mathrm{Bo} = \frac{\rho_{\mathrm{liq}} g R^2}{\gamma}$$

$$\mathrm{La} = \frac{\rho_{\mathrm{liq}} \gamma R}{\mu_{\mathrm{liq}}^2}$$

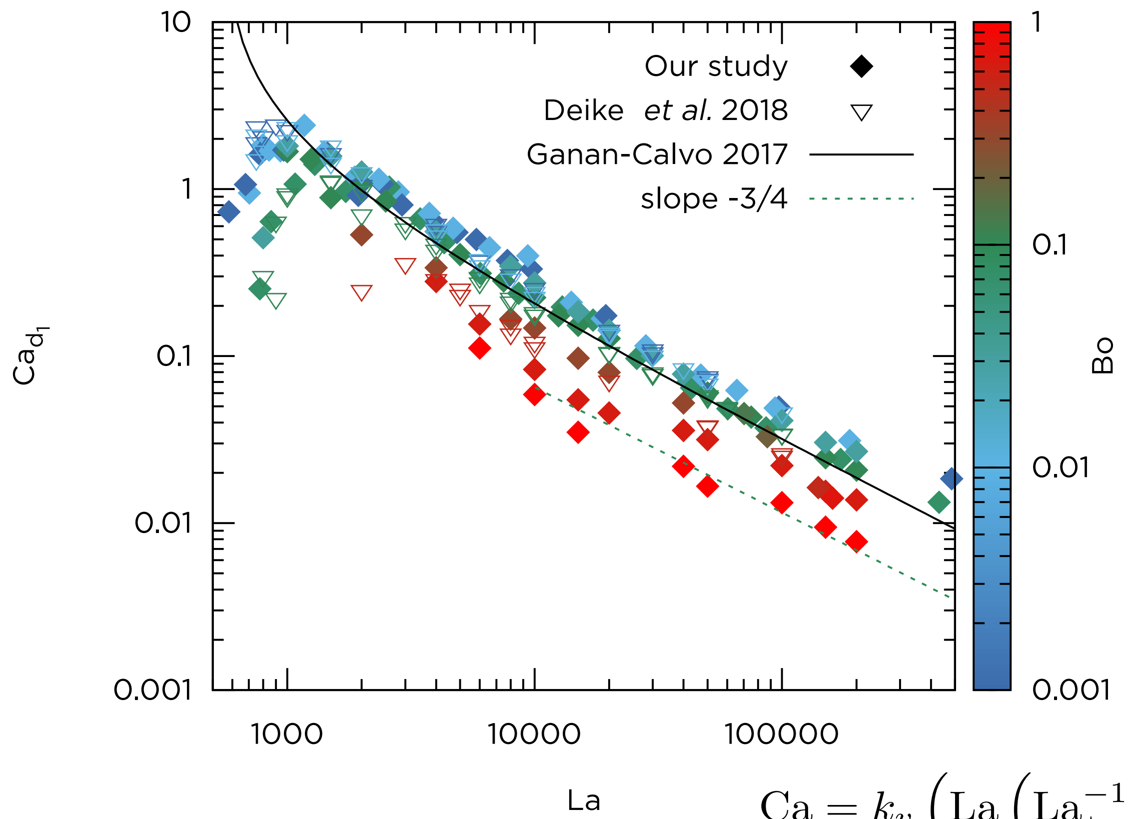
Velocity of the first drop



Velocity of the first drop

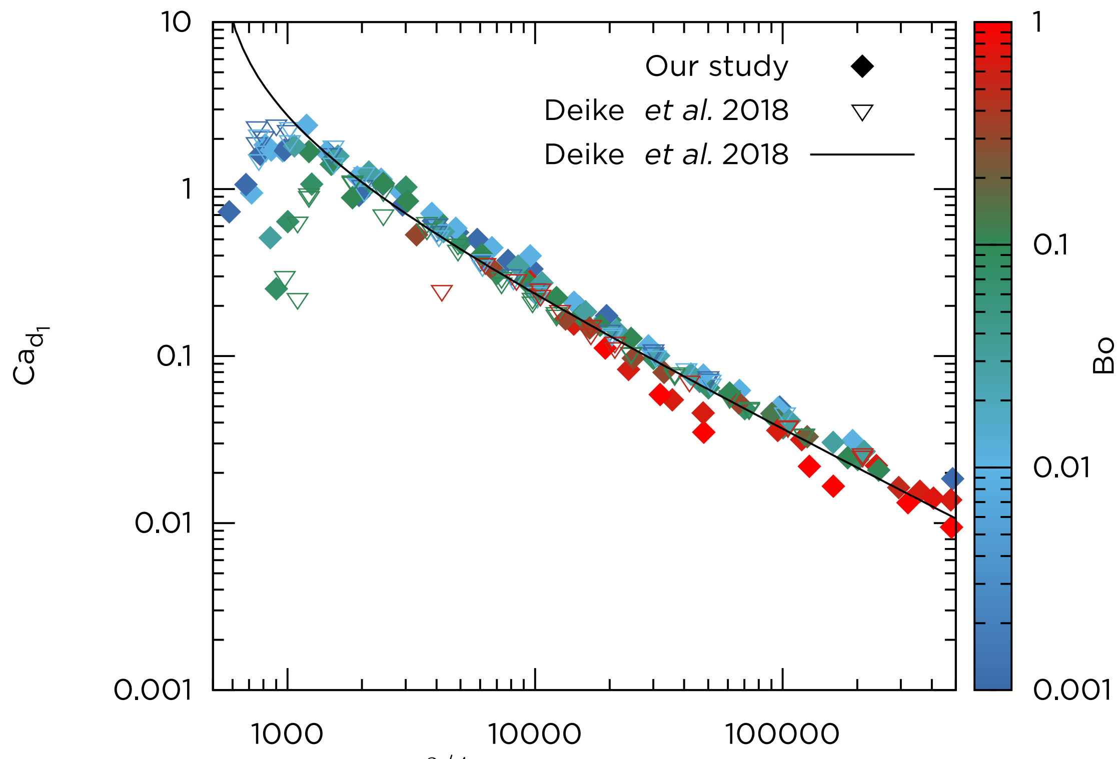


Velocity of the first drop



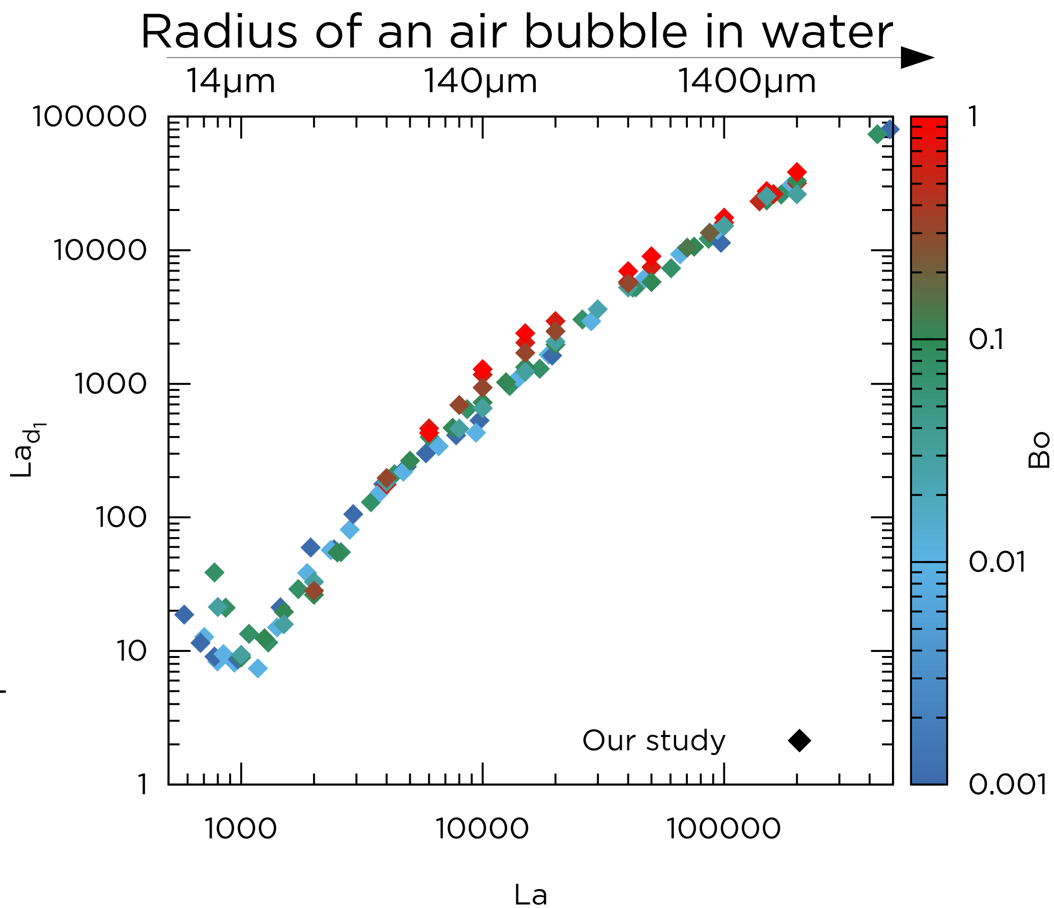
$$\mathrm{Ca} = k_v \left(\mathrm{La}\left(\mathrm{La}_\star^{-1/2} - \mathrm{La}^{-1/2}\right)\right)^{-3/4}$$

Velocity of the first drop



$$\mathrm{Ca} = k_v \left(1+\alpha\mathrm{Bo}\right)^{-3/4} \mathrm{La}^{-3/4} \left(\mathrm{La}_*^{-1/2} - \mathrm{La}^{-1/2}\right)^{-3/4}$$

Size of the first drop

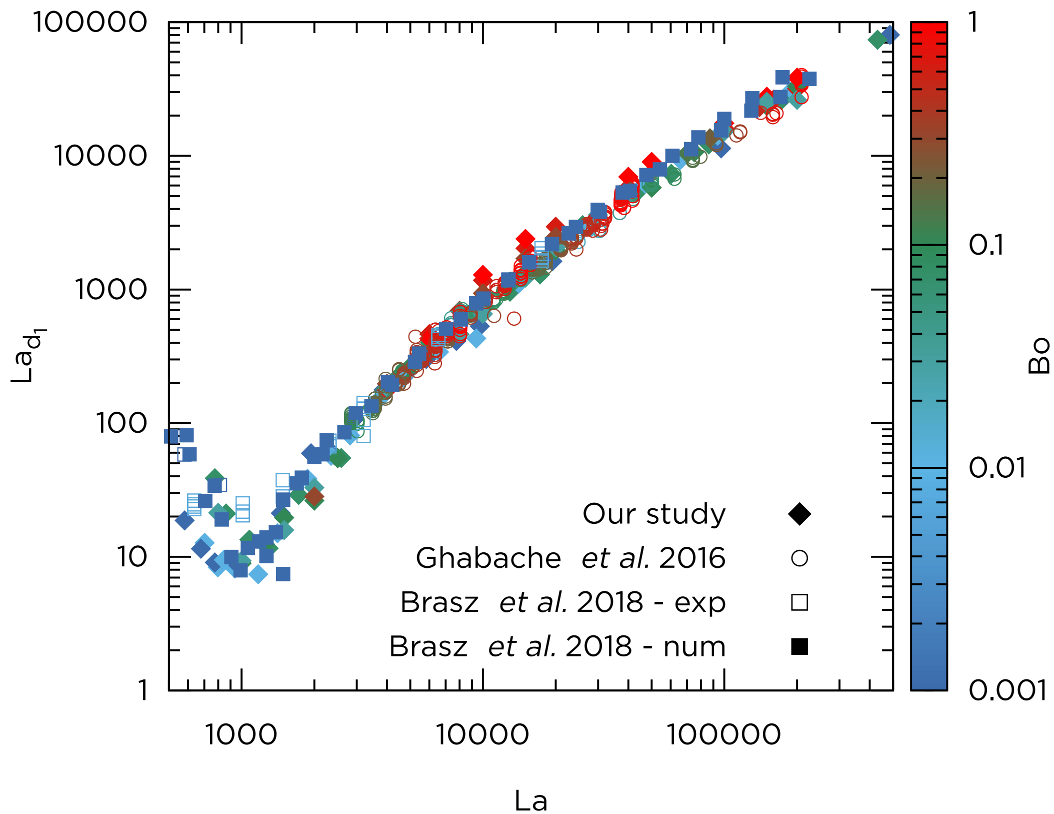


$$\mathrm{La}_{d_i} = \frac{\rho_{\mathrm{liq}} \gamma R_{d_i}}{\mu_{\mathrm{liq}}^2}$$

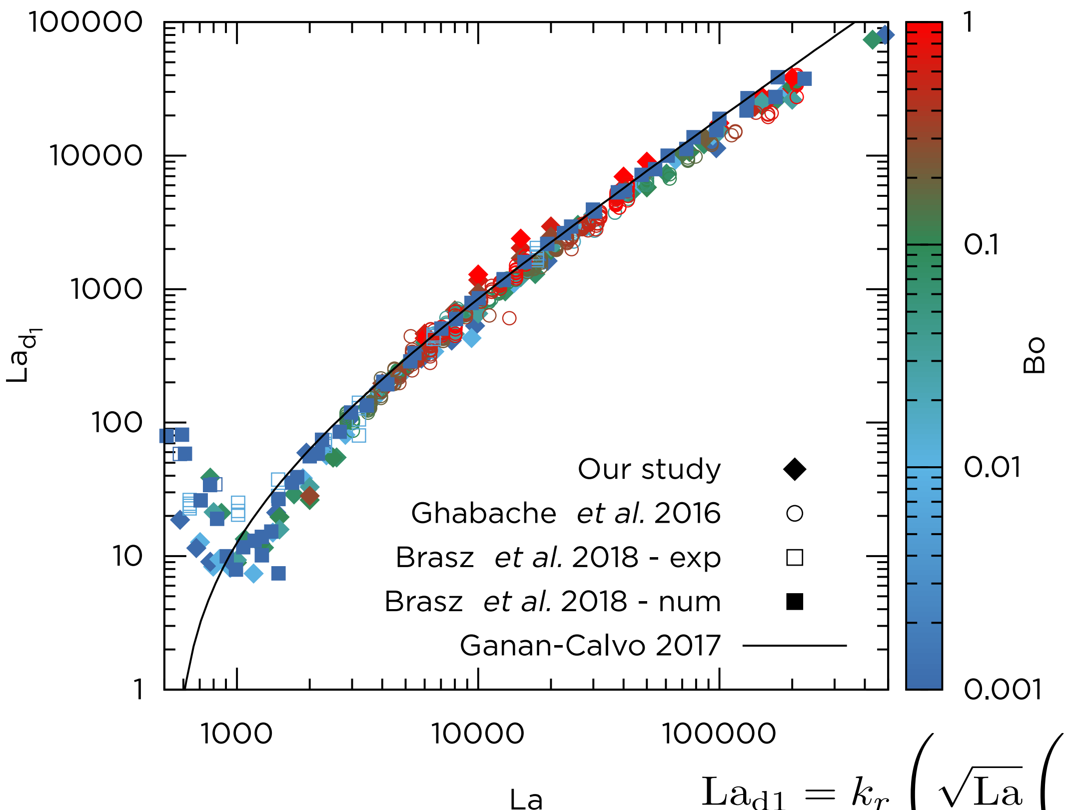
$$\mathrm{Bo} = \frac{\rho_{\mathrm{liq}} g R^2}{\gamma}$$

$$\mathrm{La} = \frac{\rho_{\mathrm{liq}} \gamma R}{\mu_{\mathrm{liq}}^2}$$

Size of the first drop

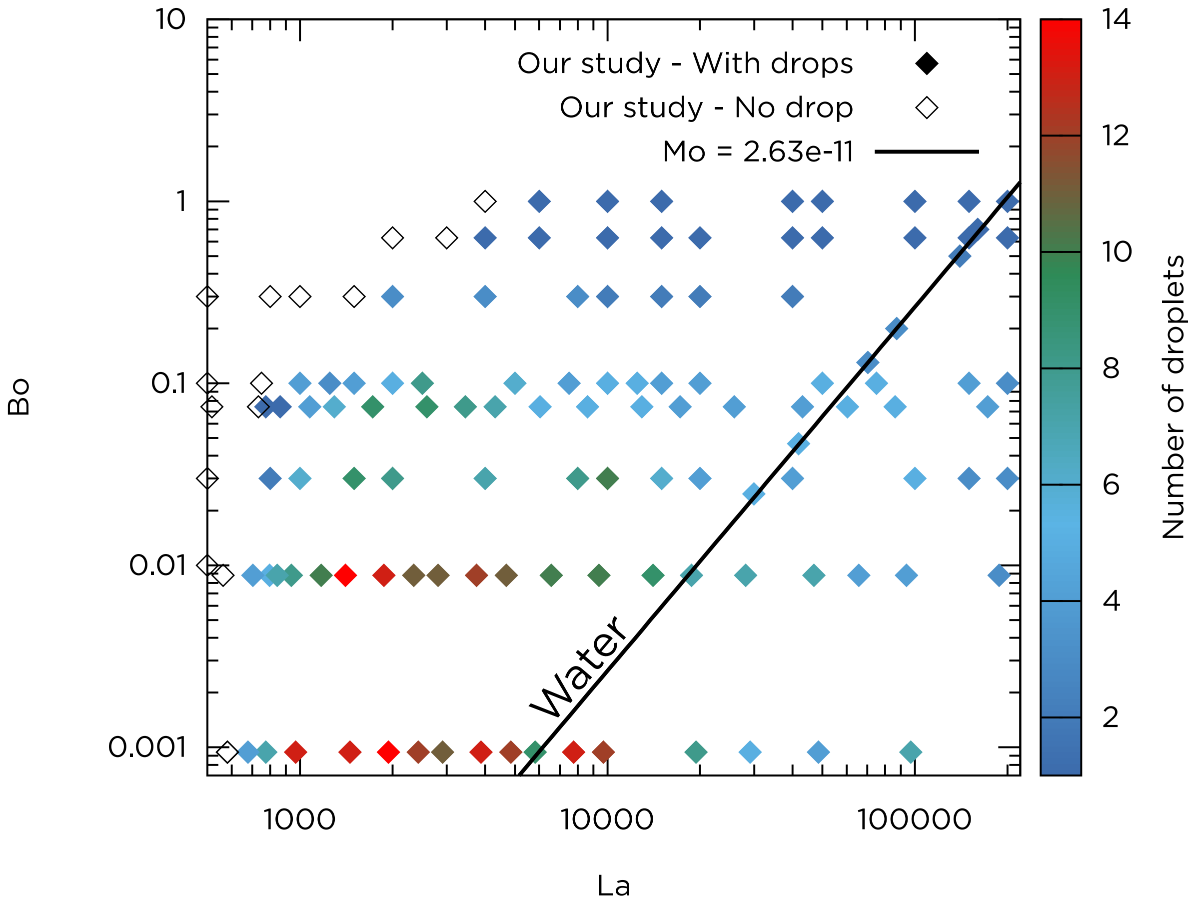


Size of the first drop

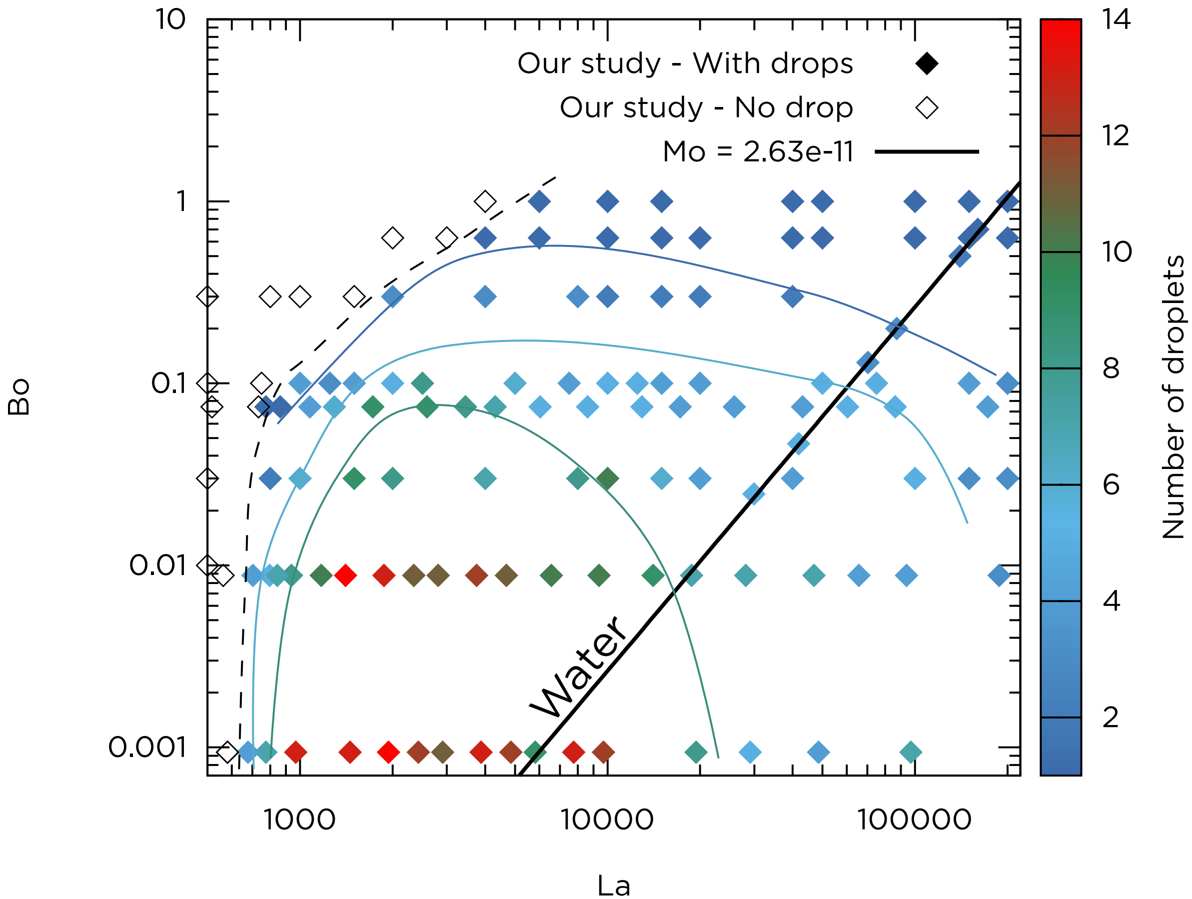


$$\mathrm{La}_{\mathrm{d}1} = k_r \left(\sqrt{\mathrm{La}} \left(\sqrt{\frac{\mathrm{La}}{\mathrm{La}_*}} - 1 \right) \right)^{5/4}$$

Counting the drops



Counting the drops



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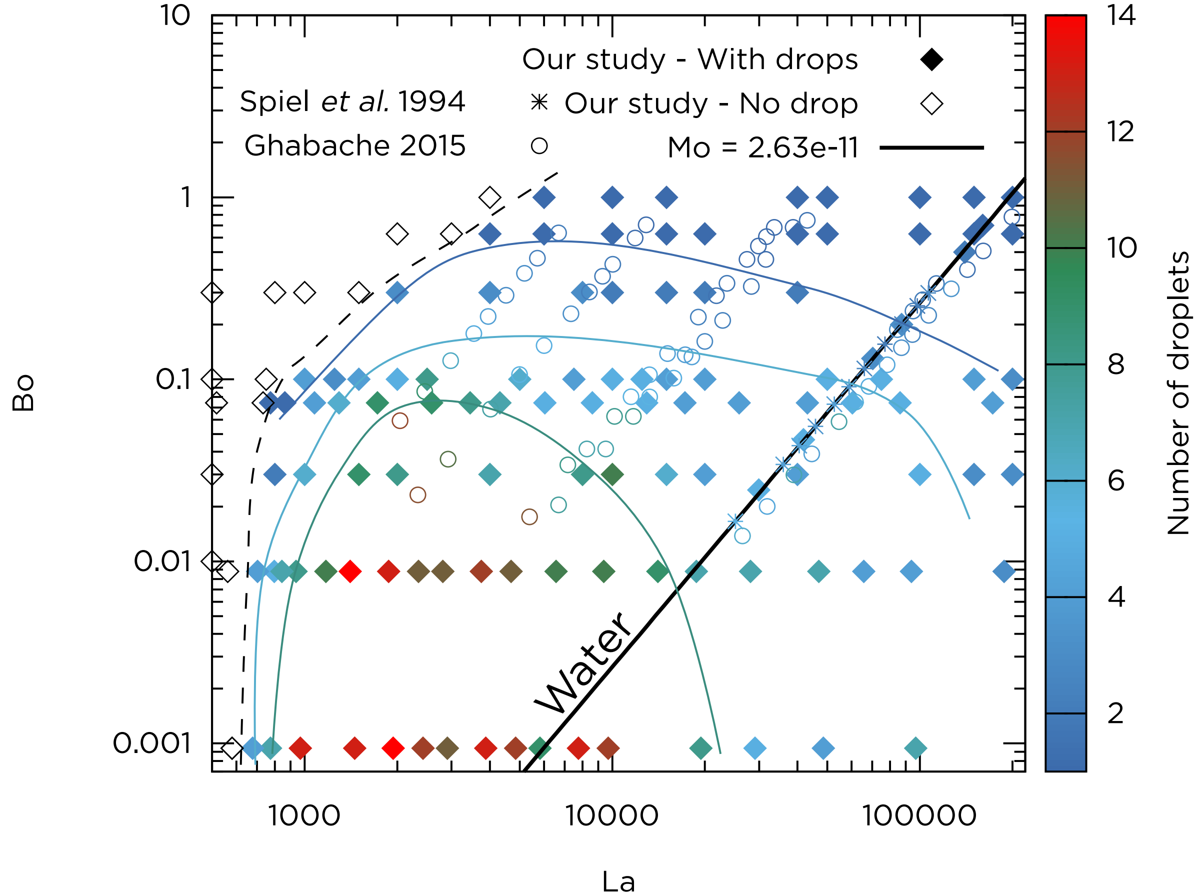
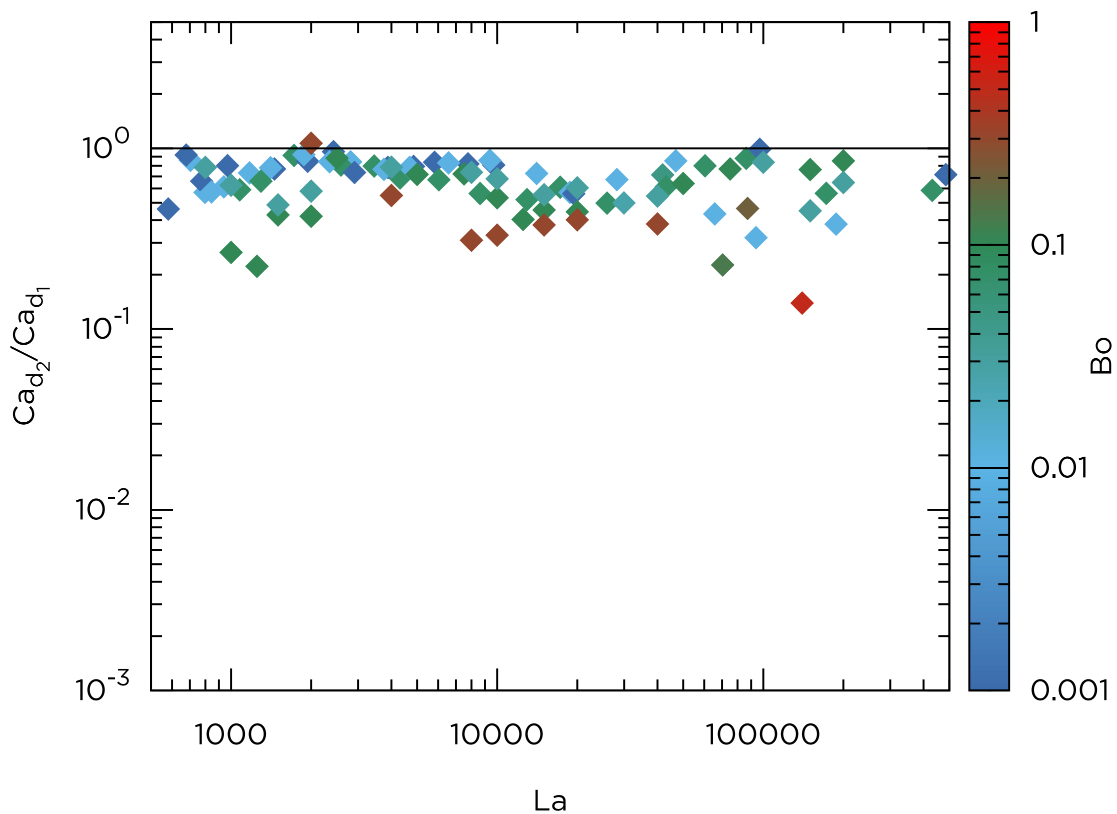
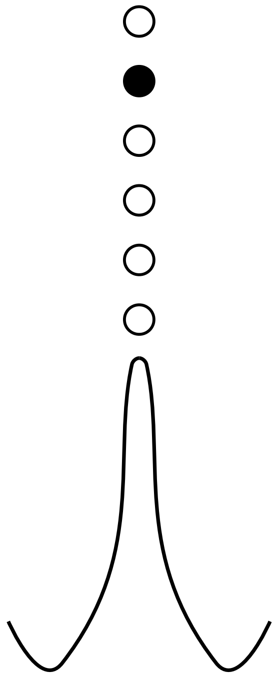
Counting the drops

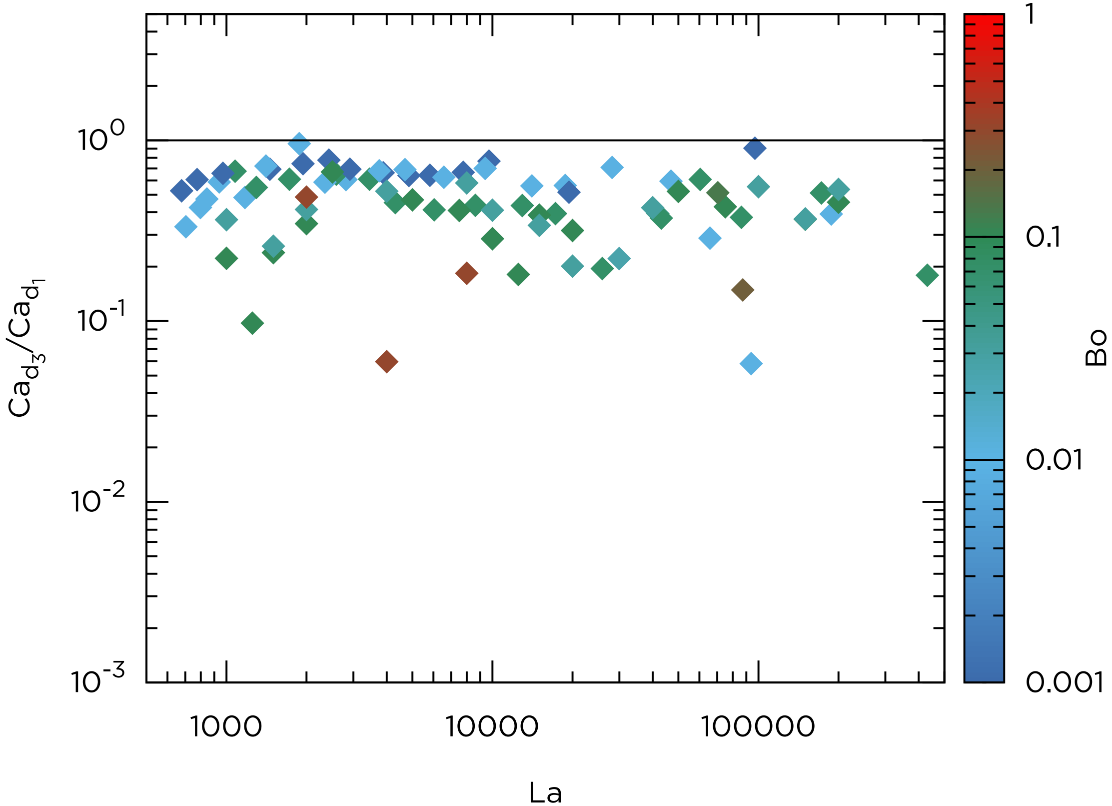


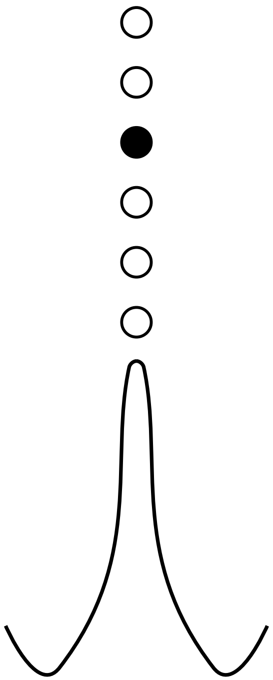
Velocity of the second drop



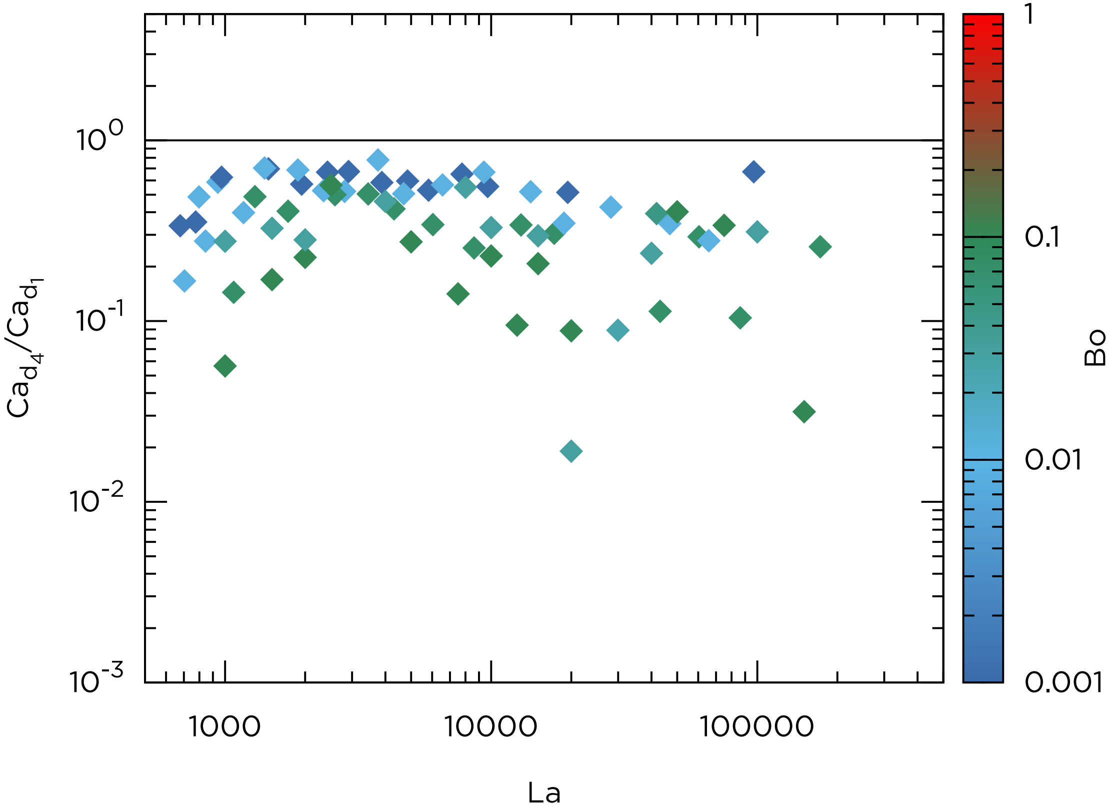


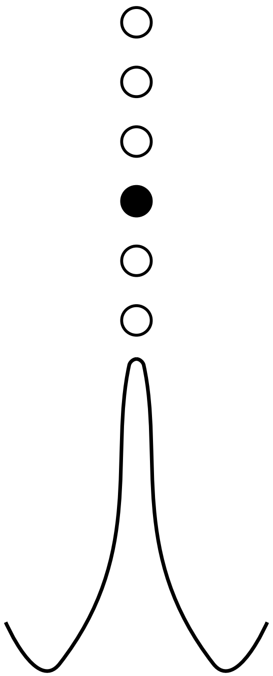
Velocity of the third drop



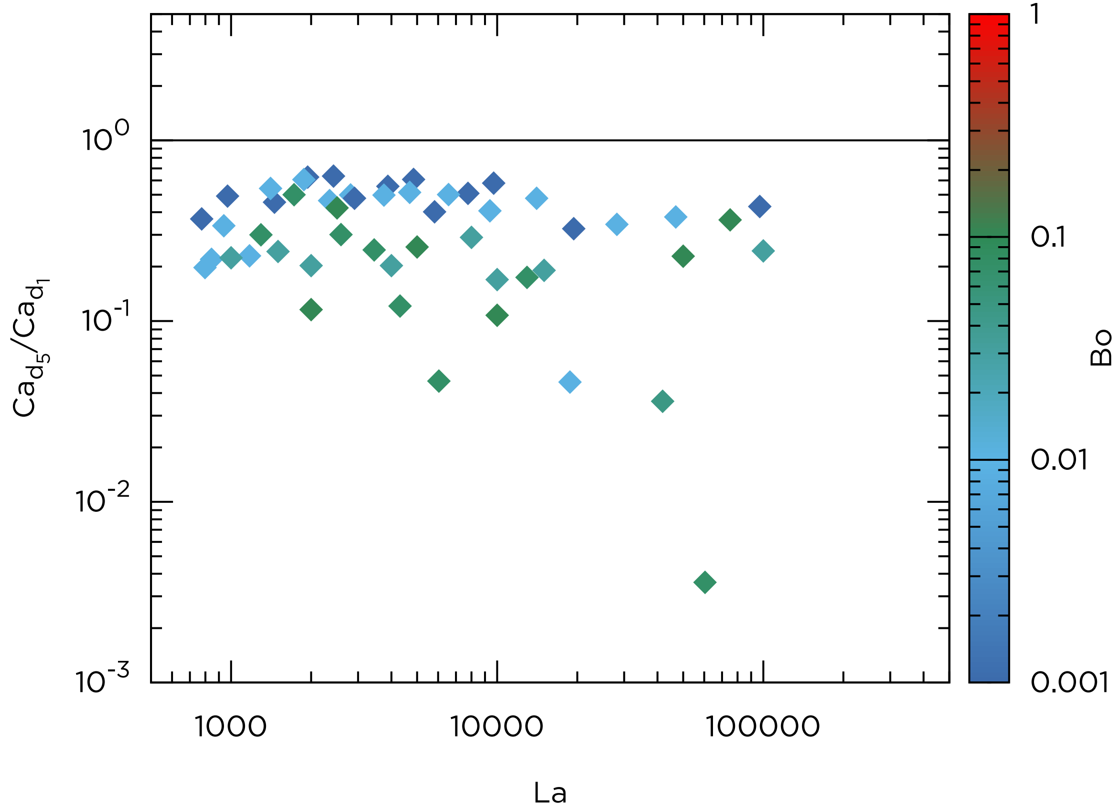


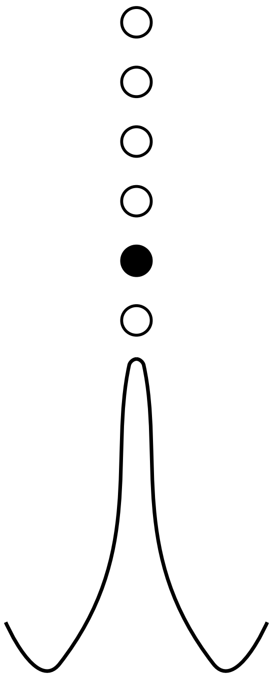
Velocity of the fourth drop





Velocity of the fifth drop





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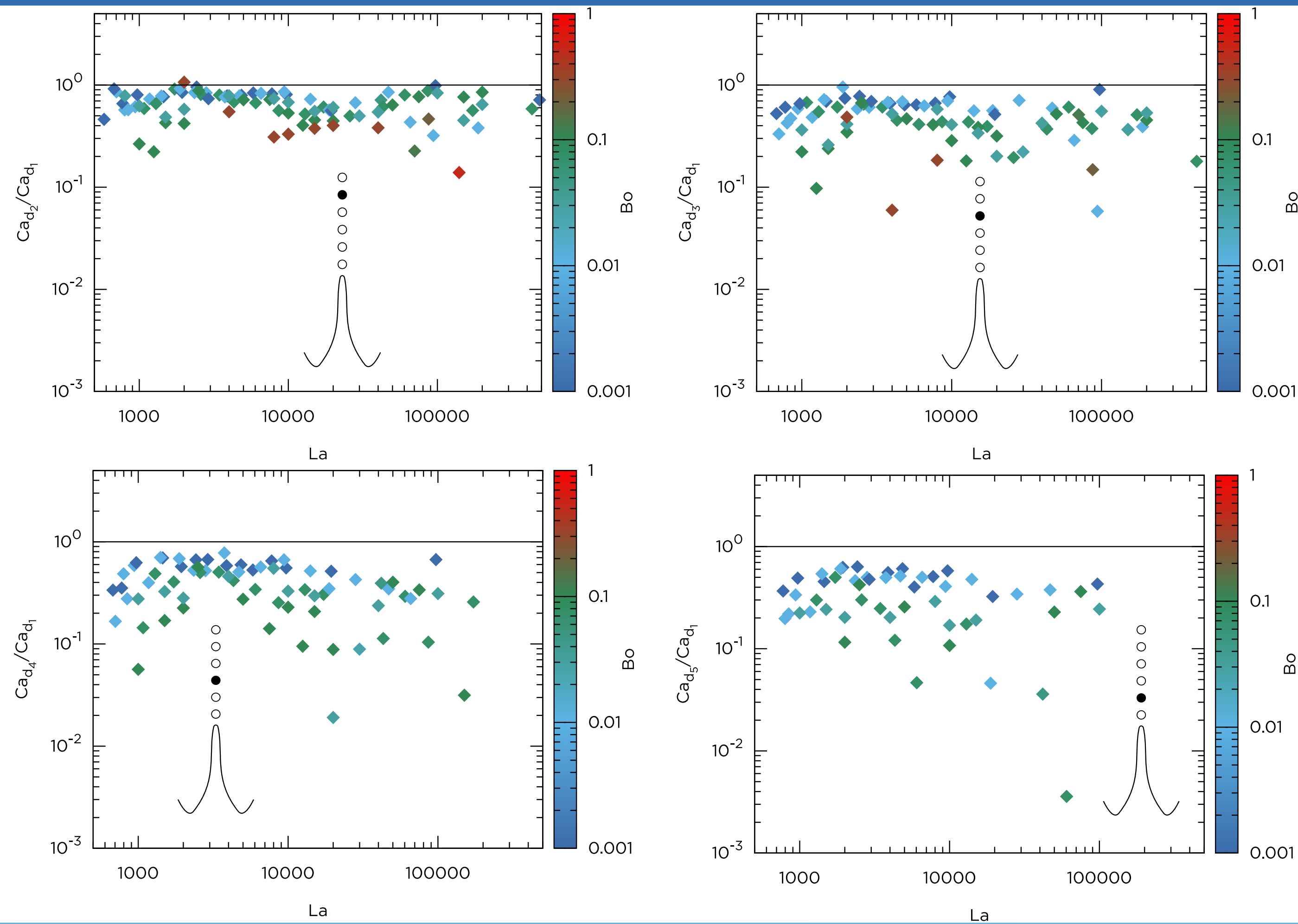
Velocity of drops 2 to 5



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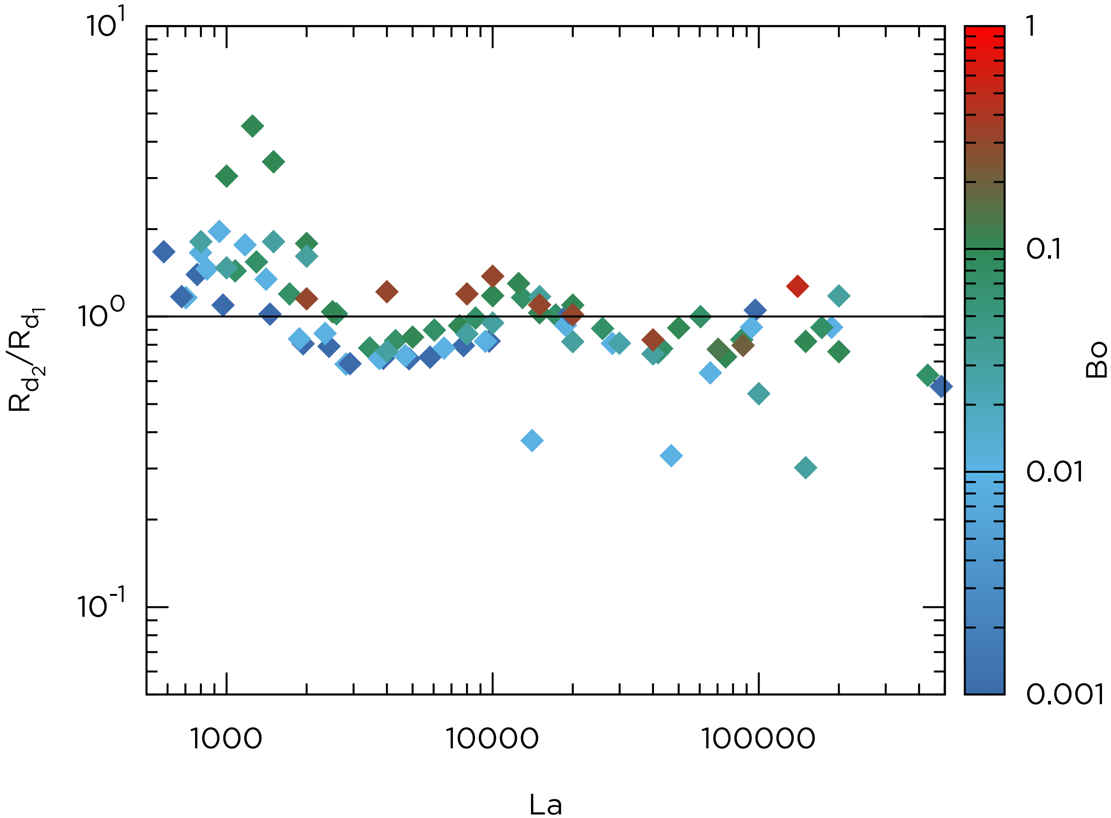
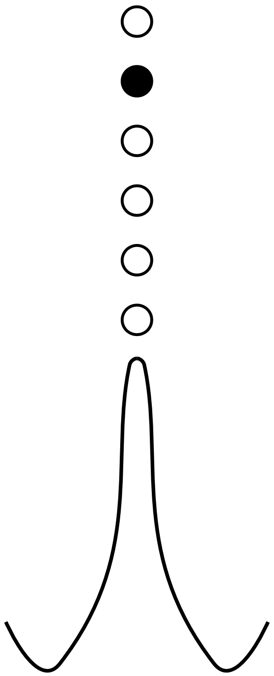
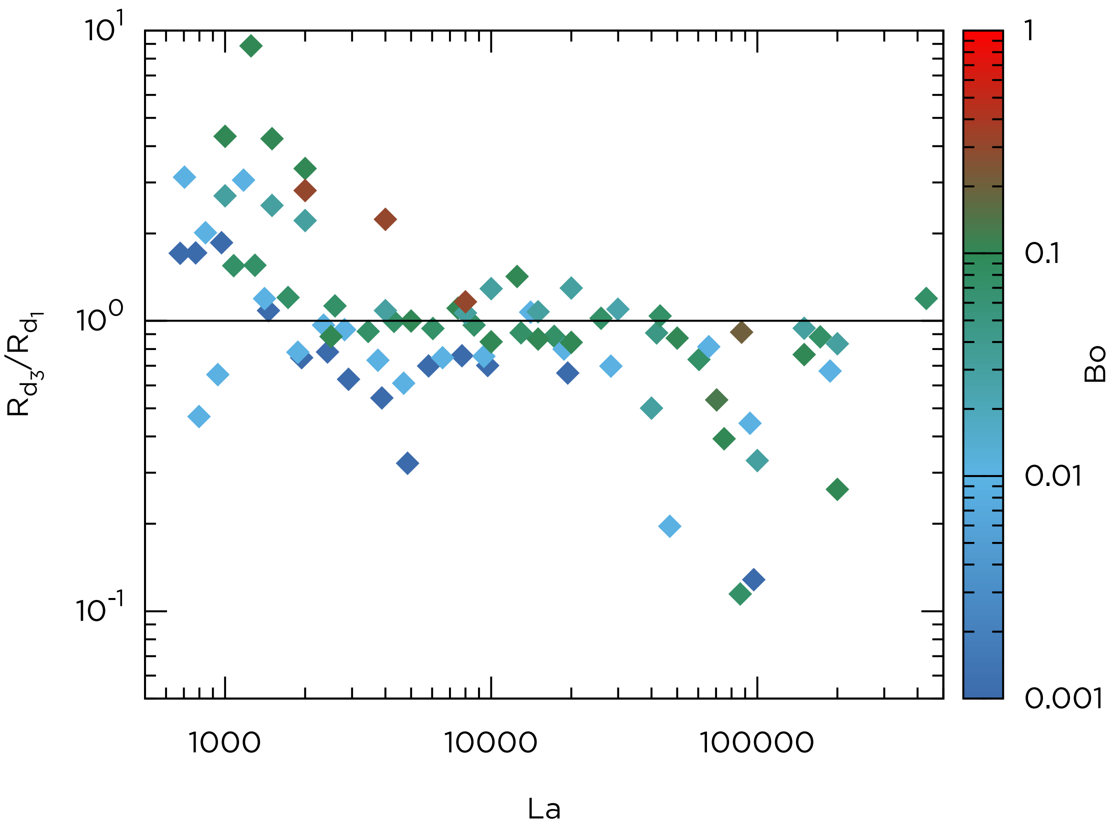
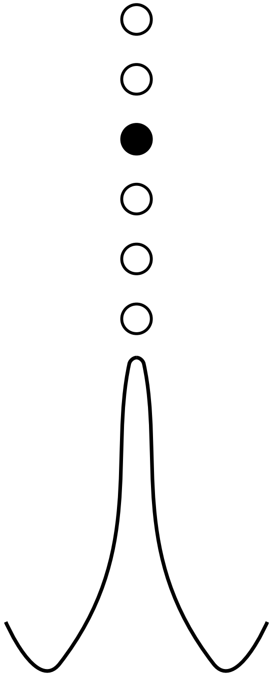
Size of the second drop



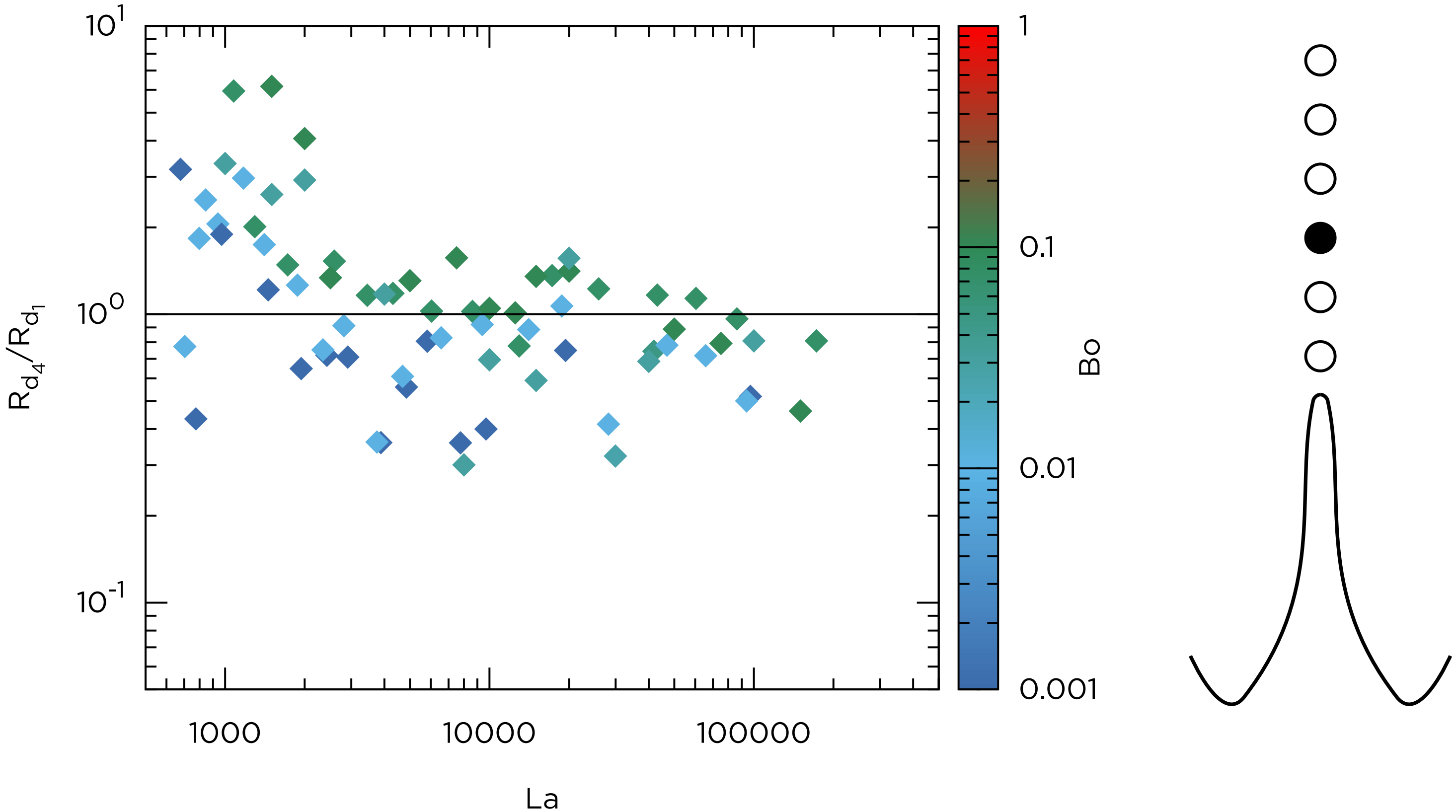


Size of the third drop

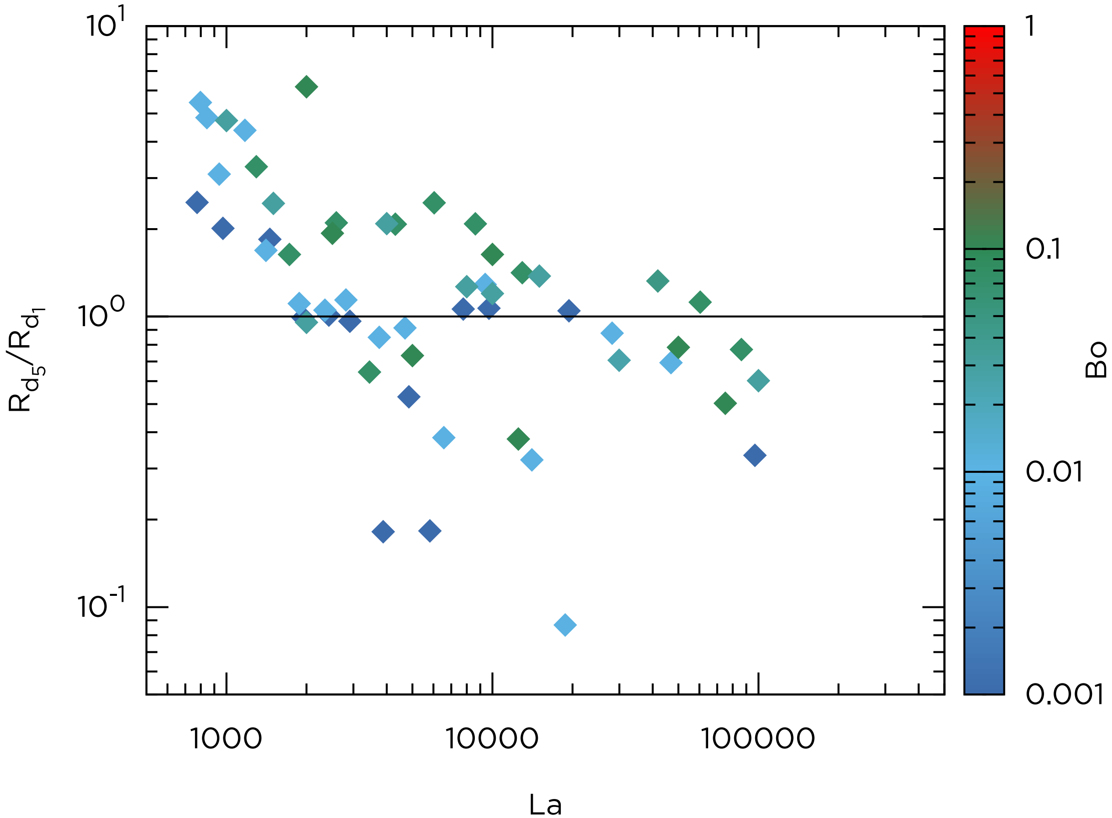


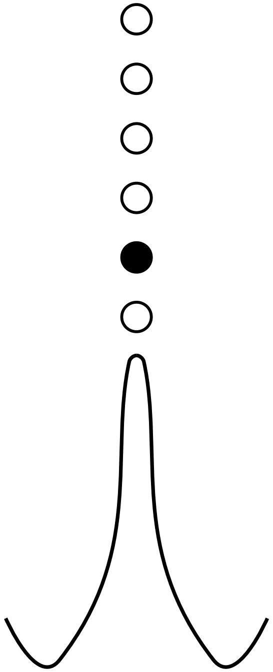


Size of the fourth drop

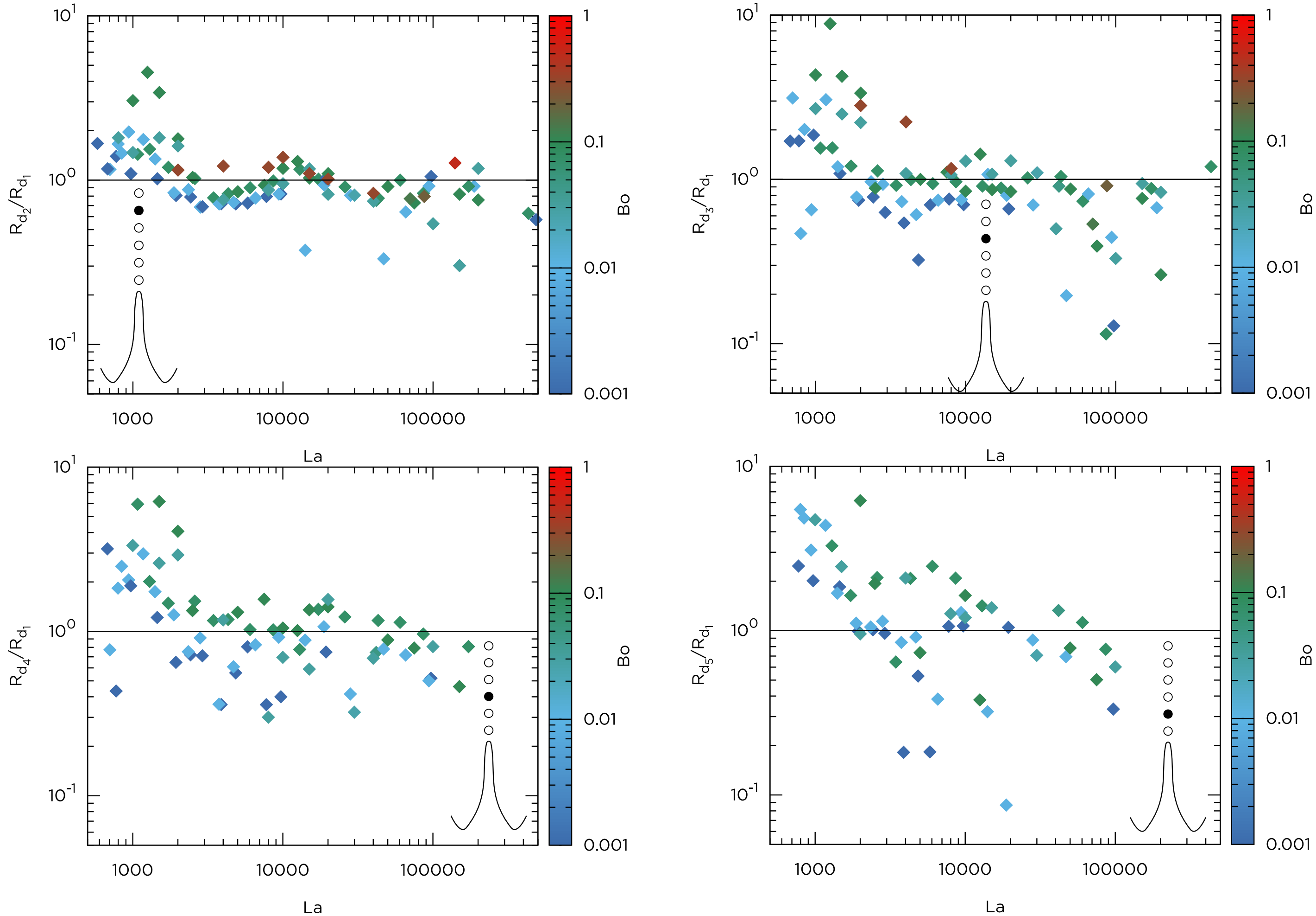


Size of the fifth drop





Size of drops 2 to 5



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Discussion

- Velocity:
  - Similar behavior for all the drops
  - Droplet velocity decreases with the drop number
- Size:
  - Subsequent drops between 0.1 and 10 times the first drop
  - Size of the subsequent drops roughly centered around the size of the first drop
- Data gets noisier as drop number increases

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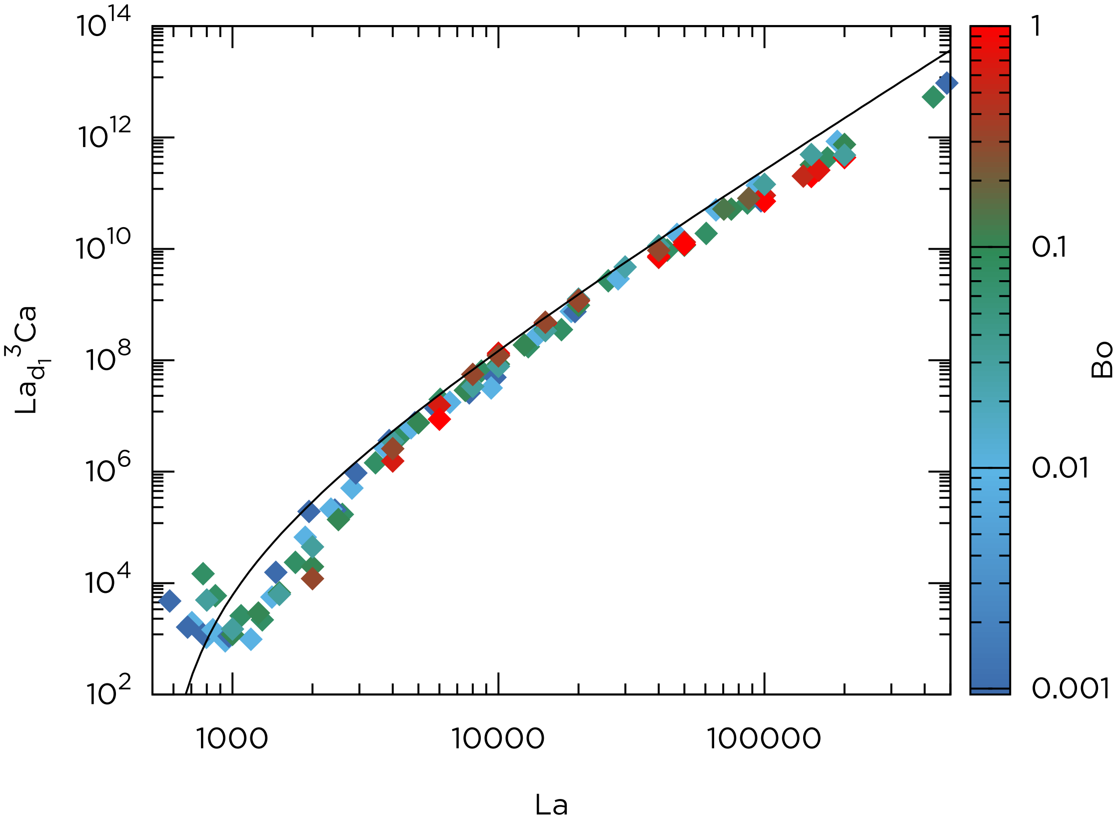
Characterizing the flux

- From the data sets :
  - We compute $F_{di} = \mathrm{Ca}_{di} \times \mathrm{La}_{di}^3$
- From previous scaling, asymptotic behavior for the first drop mass flux is $F_{d_1} \propto \mathrm{La}^3$
- What about the total flux?
  - We compute $\Sigma_i F_{d_i} = \Sigma_i \mathrm{Ca}_{d_i} \mathrm{La}_{d_i}^3$

Mass flux of the first drop



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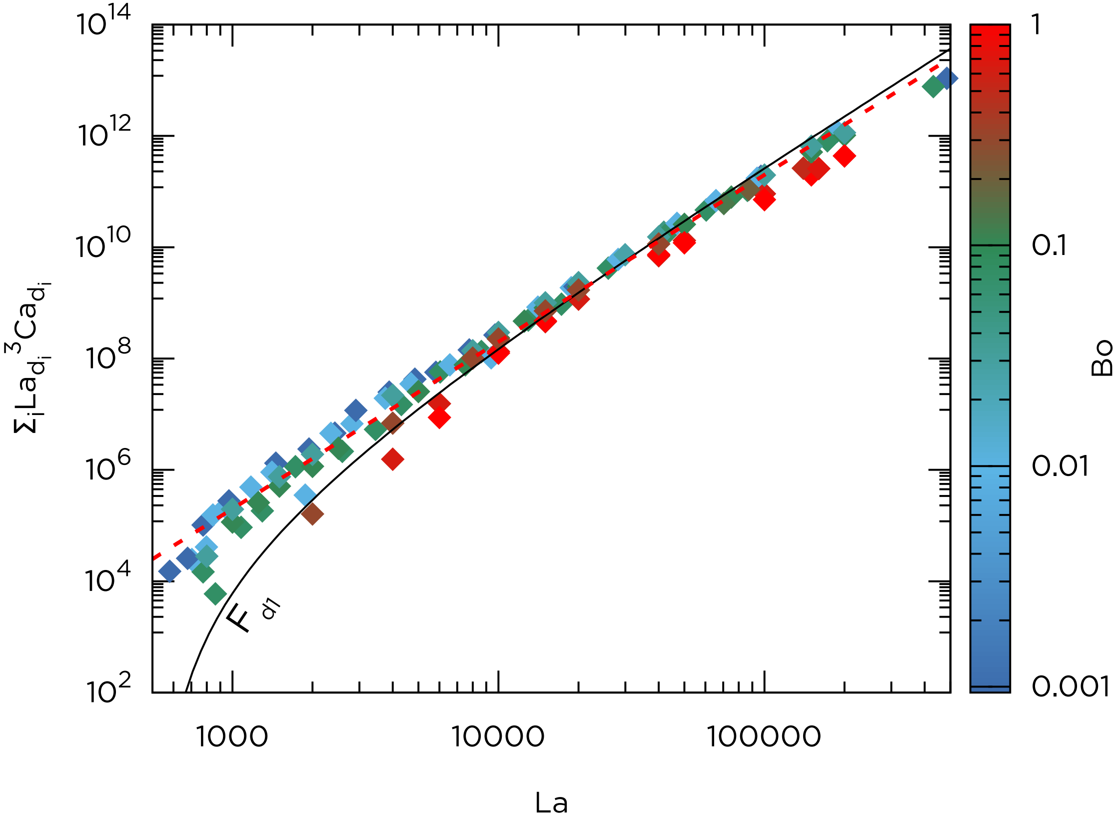
Mass flux of all the drops

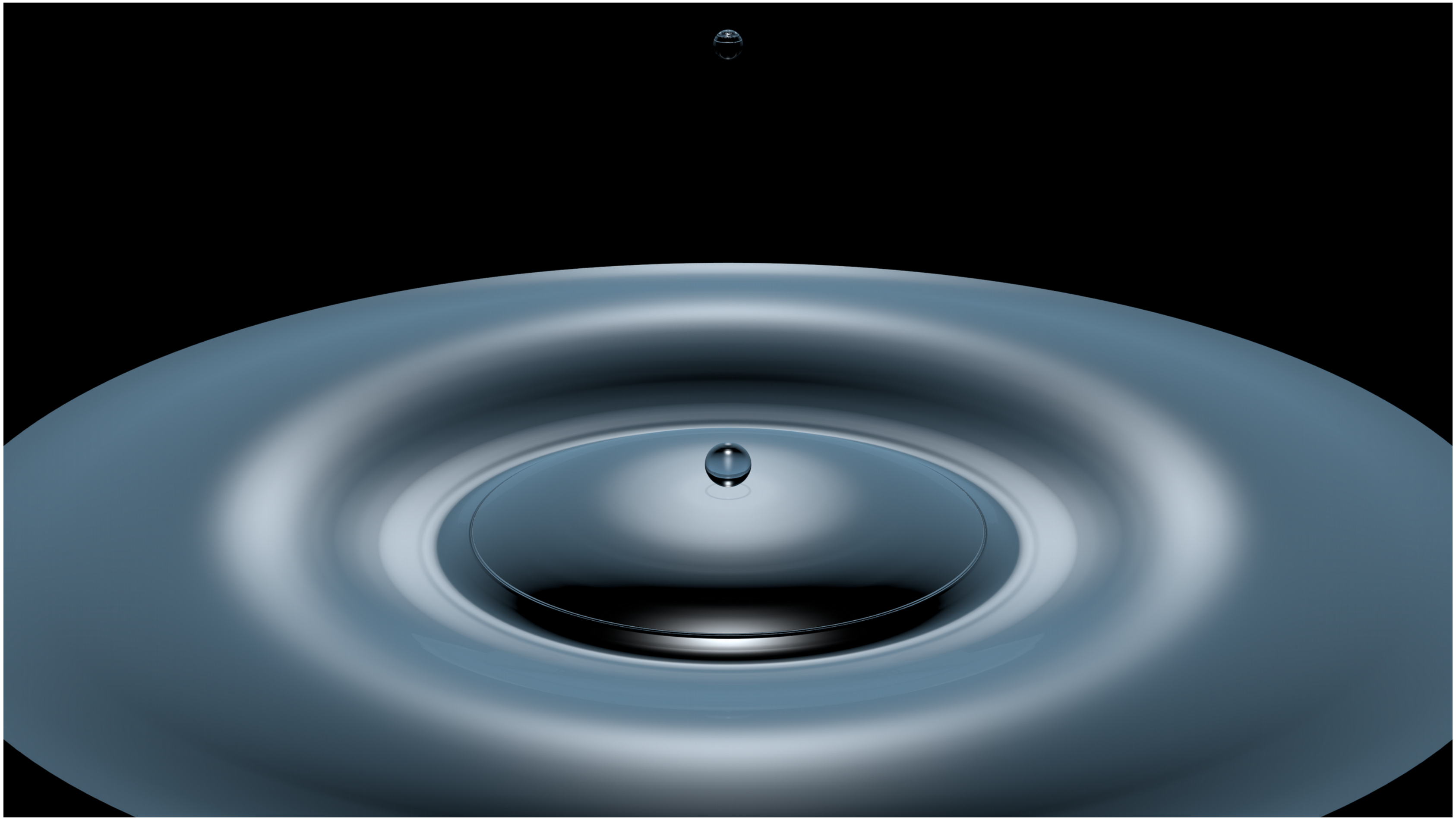


Takeaways

- Simulated a bursting bubble with Basilisk
- Characterized the size and the velocity of all the drops
- The total flux coming from all the jet drops is

$$\Sigma_i F_{d_i} \propto \mathrm{La}^3$$

Questions?



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