

Sneezing droplets

Description

During the COVID-19 pandemic, many of us wondered how viruses are transmitted from one person to another. It turns out that when we cough, sneeze, or speak, we produce numerous droplets that play a crucial role in spreading these viruses (Bourouiba, 2021). Understanding the final droplet distribution during such respiratory actions has been the aim of the scientific community ever since.

From a physics perspective, coughing or sneezing can be understood as the airflow over a thin liquid layer attached to a surface (Kant et al., 2023). This phenomenon is well understood for Newtonian fluids. However, this understanding does not apply well to human coughs, as the mucosal fluid exhibits non-Newtonian behavior. Consequently, we lack a comprehensive understanding of the influence of non-Newtonian effects on the overall dynamics. We have recently made efforts to understand the non-Newtonian effects of the breakup of jets (see Dixit et al. (2025)).

During the coughing, the breakup mucosal fluids into droplets take place in two steps. The first step is breaking liquid sheets into filaments, while the second step involves breaking those filaments into droplets. For Newtonian liquids, the overall dynamics are governed by a competition among three physical effects: capillarity, viscosity, and inertia (Anthony et al., 2019). However, for mucosal fluids (which display viscoelastic properties), elasticity also plays a crucial role (Liu et al., 2022; Sen et al., 2021). Understanding these dynamics, along with the resulting droplet size, is essential for analyzing sneeze droplets and developing effective strategies to mitigate airborne disease transmission. You will numerically study the dynamics of the breakup of viscoelastic filament into the droplets (see figure 2). We will examine the overall dynamics and droplet size and compare our results with existing data on Newtonian fluids (Anthony et al., 2019). Finally, the implication of our analysis will be made on the understanding of droplet distribution during coughing or sneezing.

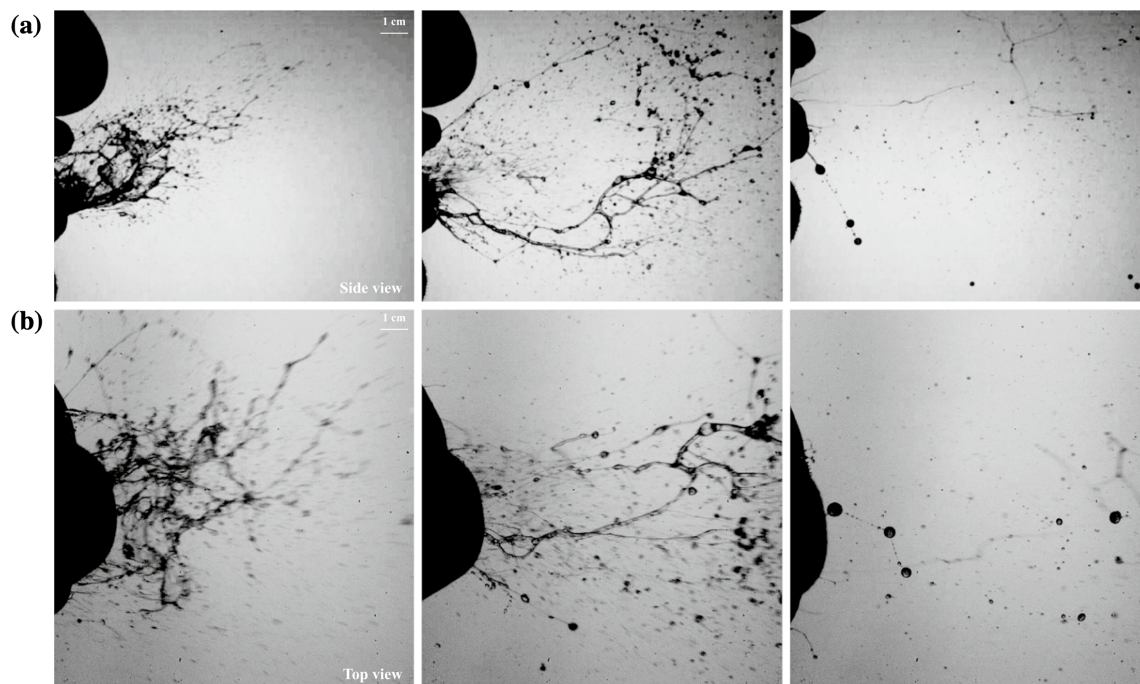


Figure 1: Stages of sneeze ejecta as experimentally reported by Scharfman et al. (2016). One can notice several long filaments breaking up into droplets.

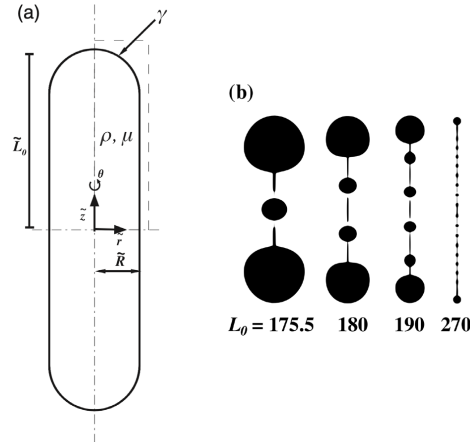


Figure 2: (a) Sketch of the initial filament, and (b) the final shapes obtained for different values of filament length L_0 , studied for Newtonian fluids by Anthony et al. (2019).

What you will do and what you will learn?

1. You will learn about the physics of fluids, and science underlying non-Newtonian fluid flows.
2. You will learn how to utilize computational tools to study real life physics.
3. You will learn how to collaborate with a diverse group of researchers, specifically with other experimentalists and theoreticians.
4. You will have access to a read-to-use codebase (available on [GitHub](#)).
5. As a part of the [CoMPhy lab](#) at the Physics of Fluids Dept., you will learn and adapt open-source coding principles.

If you have any questions, feel free to contact [Ayush](#) (details below).

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References

- Anthony, C. R., Kamat, P. M., Harris, M. T., and Basaran, O. A. (2019). “Dynamics of contracting filaments”. *Phys. Rev. Fluids* 4.9, p. 093601.
- Bourouiba, L. (2021). “The fluid dynamics of disease transmission”. *Annu. Rev. Fluid Mech.* 53, pp. 473–508.
- Dixit, A. K., Oratis, A., Zinelis, K., Lohse, D., and Sanjay, V. (May 2025). “Viscoelastic Worthington Jets and Droplets Produced by Bursting Bubbles”. *J. Fluid Mech.* 1010, A2. ISSN: 0022-1120, 1469-7645. DOI: [10.1017/jfm.2025.237](https://doi.org/10.1017/jfm.2025.237).
- Kant, P., Pairetti, C., Saade, Y., Popinet, S., Zaleski, S., and Lohse, D. (2023). “Bag-mediated film atomization in a cough machine”. *Phys. Rev. Fluids* 8.7, p. 074802.
- Liu, X., Wagoner, B. W., and Basaran, O. A. (2022). “Contraction velocity of viscoelastic filaments”. *Phys. Rev. Fluids* 7.12, p. L121601.
- Scharfman, B. E., Techet, A. H., Bush, J. W. M., and Bourouiba, L. (2016). “Visualization of sneeze ejecta: steps of fluid fragmentation leading to respiratory droplets”. *Exp. Fluids* 57.2, pp. 1–9.
- Sen, U., Datt, C., Segers, T., Wijshoff, H., Snoeijer, J. H., Versluis, M., and Lohse, D. (2021). “The retraction of jetted slender viscoelastic liquid filaments”. *J. Fluid Mech.* 929, A25.