Liquid triboelectrification by sliding droplets

M1/3A internship proposal

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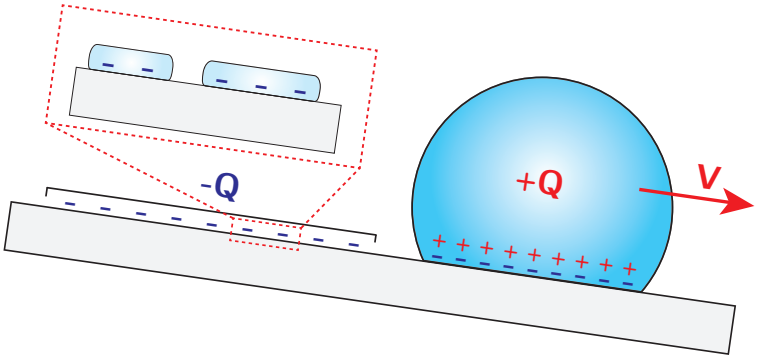

Tribocharging of a hydrophobic solid surface upon sliding of a liquid drop.

The universally-known ***triboelectric effect*** results in the **charging of solid surfaces following mechanical contact**. This ubiquitous phenomenon has macroscopic consequences, both mundane and fundamental (tribo-charging leads to dust aggregation, which might be responsible for initial planetary formation [1]). Very recently, triboelectricity has also seen a surge of interest in the context of the development of novel energy harvesting devices with exceptional performances [2]. However**, the origin of this surface charging remains fundamentally misunderstood, being indistinctively attributed to the transfer of minute quantities of electrons, ions or matter between surfaces [3]**.

In this internship, we will focus on the particularly peculiar case of ***liquid triboelectrification*** in which **the sliding motion of water drops on hydrophobic surfaces leads to a macroscopic separation of charges,** with the **deposition of permanent negative charges onto the solid surface** and to the **positive charging of the drop** [2], [4], [5] (See Figure). These observations suggest that **negative surface charges developing at the solid/liquid interface in the drop get trapped at the solid/air interface during forced droplet dewetting** [6], [7]. This raises a number of questions, related to *(i)* the **interplay between dynamic effects occurring at the moving contact line with charge dynamics at the solid/liquid interface** and *(ii)* the **physicochemical nature of the deposited charges**.

The intern will first perform **macroscopic charge measurements on sliding droplets** of controlled pH and ionic strength. He will then couple these measurements with techniques based on ellipsometry, to probe and reveal **the presence of a molecular liquid film of solvated charges** at the rear of the sliding drop. These measurements will help us **gain novel fundamental physical insights** on the underlying mechanisms at play during the **peculiar liquid triboelectrification**.

Keywords : Triboelectricity, Drops, Soft Matter, Surface Charges
Techniques/methods in use : Electrical measurements, Fast Camera, Ellipsometry
Applicant skills : Soft Matter, Hydrodynamics, Taste for Experimental Work

[1] T. Steinpilz et al., "Electrical charging overcomes the bouncing barrier in planet formation," Nature Physics, vol. 16, no. 2, pp. 225–229, 2020. **[2]** W. Xu et al., "A droplet-based electricity generator with high instantaneous power density," Nature, vol. 578, no. 7795, pp. 392–396, 2020. **[3]** D. J. Lacks and T. Shinbrot, "Long-standing and unresolved issues in triboelectric charging," Nature Review Chemistry, 2019. **[4]** Q. Sun et al., "Surface charge printing for programmed droplet transport," Nat. Mater., 2019. **[5]** N. Miljkovic, D. J. Preston, R. Enright, and E. N. Wang, "Electrostatic charging of jumping droplets," Nature Communication, vol. 4, pp. 1–9, 2013. **[6]** A. Z. Stetten, D. S. Golovko, S. A. L. Weber, and H. J. Butt, "Slide electrification: Charging of surfaces by moving water drops," Soft Matter, vol. 15, no. 43, pp. 8667–8679, 2019. **[7]** M. D. Sosa et al., "Liquid-polymer triboelectricity: Chemical mechanisms in the contact electrification process," Soft Matter, vol. 16, no. 30, pp. 7040–7051, 2020.