Generalizing classical theories of wetting to real liquids

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Liquid wetting and evaporation play a significant role in thermal energy conversion, liquid cooling, and microfluidic devices. To date, our understanding of liquid-solid interaction has largely constraint to single component liquids, while this is not the case in real systems with the wide existence of salt, surfactants, contaminants, etc. The lack of knowledge leads to the out-control of those complex liquids and greatly limits the technological development for liquid transport in practical scenarios.

In this talk, I will start with the basic mechanisms that govern the dynamic wetting of single component liquids, as can be scaled by the spatial-temporal interplay between capillary, evaporation, and thermal Marangoni effects. We elucidate and quantify these complex interactions using phase diagrams based on theoretical, numerical, and experimental investigations. A spreading law of evaporative liquids is derived by generalizing the classical Tanner's law (spreading law of non-volatile liquids) to a wide range of liquids with saturation vapor pressure from 10^1 to 10^4 Pa and on substrates with thermal conductivity from 10^{-1} to 10^3 W/m/K. (*Journal of Fluid Mechanics*, 987, 2024, A15; *Applied Physics Letters*, 124.10, 2024, Editor's Pick, Rising Stars Collection)

I will further extend the talk to more complex systems, such as, by adding a pinch of hygroscopic salt into a droplet. Due to the hygroscopic effect, the direction of vapor diffusion changes. The interfacial phase change (evaporation or vapor absorption) leads to spatiotemporal variation of the concentration field, introducing solutal Marangoni flow and resulting in more complex liquid behaviors demonstrated by contact line advancing, receding, and oscillating. The approach demonstrates the significance of additional components in dynamic wetting, and provides another freedom for controllable liquid behaviors in practical conditions. (*Journal of Fluid Mechanics*, 912, 2021, A2; *Physics Reports*, 960, 2022, 1-37)