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Restoring universality to the pinch-off of a bubble AMIR PAHLAVAN, HOWARD STONE, Princeton University, GARETH MCKINLEY, RUBEN JUANES, MIT — We observe the formation of bubbles and drops on a daily basis, from dripping faucets to raindrops entraining bubbles on the surface of a lake. The pinch-off of a bubble is an example of the formation of a singularity, exhibiting a characteristic separation of length and time scales. Because of this scale separation, one expects universal dynamics that collapse into self-similar behavior determined by the relative importance of viscous, inertial, and capillary forces. Here, we report on the intriguing observation that confinement makes the pinch-off of a bubble a universal process, as opposed to the unconfined case, where pinch-off is sensitive to the details of the experimental setting. We show that the pinch-off dynamics of a bubble confined in a capillary tube undergo a sequence of two distinct self-similar regimes, even though the entire evolution is controlled by a balance between viscous and capillary forces. We demonstrate that the early-time self-similar regime restores universality to bubble pinch-off by erasing the system's memory of the initial conditions. Our observations have implications for immiscible flow phenomena from microfluidics to geophysical flows, where confinement, together with fluid-solid physicochemical interactions, play a key role.

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