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Forced wetting transition and bubble pinch-off in a capillary tube

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In their seminal works, Taylor and Bretherton showed that when a wetting viscous liquid is displaced by a less viscous non-wetting fluid in a capillary tube, a film of the defending liquid is left on the walls. Here, we revisit this classic problem in the partial wetting regime using both experiments and theory, and show that the flow dynamics drastically changes from the classic picture. We show that at a critical displacement rate a wetting transition occurs; before transition, the interface moves as a traveling wave, but beyond transition a film of the defending liquid becomes entrained on the walls of the tube. This film is unstable and recedes from the wall, forming a growing dewetting rim, which ultimately leads to bubble pinch-off. Therefore, we show that contact line dynamics can lead to macroscopic changes in the flow behavior as well as bubble/drop generation even in the absence of any geometric constraints.

References

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