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Fast contact line on soft solids

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When a droplet is resting on a soft surface, the capillary forces deform the surface into a sharp wetting ridge. The amplitude of the wetting ridge is determined by elasto-capillary length, but the angles by which the interfaces meet at the ridge tip only depend on the balance of surface tensions, the so-called Neumann balance. For moving contact lines, dissipation in the wetting ridge leads to viscoelastic braking. In recent literature, various effects that could alter Neumann balance and viscoelastic braking have been suggested: free, extractable oligomers, strain-dependent solid surface tension, or point forces emerging from bulk viscoelasticity.

We visualize moving wetting ridges at high spatio-temporal resolution and determine the tip geometry for various liquids and PDMS substrates. With these different materials, we tune, on the one hand, the elasto-capillary length over a wide range that allows us to resolve the near field of the ridge tip, orders of magnitude below the elasto-capillary length. On the other hand, we tune the ratio of liquid and solid surface tensions, going from the much-studied, highly non-linear regime (e.g. water on PDMS) to a regime where the Neumann balance and linear viscoelasticity theory may be used.

We experimentally resolve the logarithmic curvature singularity of the ridge near its tip, caused by the singular traction of the contact line, to a degree that allows a faithful determination of the solid angles. These differ significantly from the prediction obtained by Neumann's law and the surface tensions against non-crosslinked PDMS, pointing to a strain-dependent solid surface tension. We further show that dissipation remains regular for moving wetting ridges. However, we also show that dissipation is more localized than linear theory predicts, even for mild solid opening angles.

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