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Symmetry breaking and chaos in droplet electrohydrodynamics
PAUL SALIPANTE, PETIA VLAHOVSKA, Brown University — A classic result due to G.I.Taylor is that a drop placed in a uniform electric field adopts a prolate or oblate spheroidal shape, the flow and shape being axisymmetrically aligned with the applied field. However, recent studies have revealed an instability and transition to a nonaxisymmetric rotational flow in strong fields, similar to the rotation of solid dielectric particles observed by Quincke in the 19th century. We present an experimental and theoretical study of this phenomenon in DC uniform fields, focusing on nonlinear behavior arising from electromechanial coupling at the fluid-fluid interface. Charge convection by the both rotational and straining flows is included in the our model to explain the dependence of critical electric field on viscosity ratio. Hysteresis in the transition is observed for large low-viscosity drops. At stronger fields, chaotic drop tumbling and sustained shape oscillations are observed.

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