Symmetry breaking and chaos in droplet electrohydrodynamics
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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 exper-
imental and theoretical study of this phenomenon in DC uniform fields, focusing
on nonlinear behavior arising from electromechanical coupling at the fluid-fluid in-
terface. 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.