Abstract Submitted
for the DFD20 Meeting of
The American Physical Society

A three-dimensional small deformation theory for drop electrohydrodynamics[1] DEBASISH DAS, University of Strathclyde, DAVID SAINTILLAN, University of California, San Diego — Electrohydrodynamics of drops is a classic fluid mechanical problem where deformations and microscale flows are generated by application of an electric field. In weak fields, electric stresses acting on the drop surface cause the drop to adopt a steady axisymmetric shape. This phenomenon is best explained by the leaky dielectric model under the premise that a net surface charge is present at the interface while the bulk is electroneutral. Increasing the electric field beyond a critical value can cause the drop to start rotating spontaneously and assume a steady tilted shape. This symmetry breaking phenomenon, called Quincke rotation, arises due to the action of the electric torque countering the viscous torque on the drop, giving rise to steady rotation in sufficiently strong fields. Here, we present a small deformation theory for the electrohydrodynamics of dielectric drops for the complete leaky dielectric model in three dimensions that is able to capture the transition to Quincke rotation. Retention of both straining and rotational flow components in the governing equation for charge transport enables us to perform a linear stability analysis and derive a criterion for the electric field strength that must be overcome for the onset of Quincke rotation of a viscous drop.

[1]D.S. gratefully acknowledges funding from the American Chemical Society Petroleum Research Fund Grant 53240-ND9 and from the National Science Foundation Grant CBET-1705377.

Debasish Das
University of Strathclyde

Date submitted: 09 Oct 2020 Electronic form version 1.4