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Electrohydrodynamic deformation of drops and bubbles at large Reynolds numbers ORY SCHNITZER, Department of Mathematics, Imperial College London — In Taylor's theory of electrohydrodynamic drop deformation by a uniform electric field, inertia is neglected at the outset, resulting in fluid velocities that scale with E^2, E being the applied-field magnitude. When considering strong fields and low viscosity fluids, the Reynolds number predicted by this scaling may actually become large, suggesting the need for a complementary large-Reynolds-number analysis. Balancing viscous and electrical stresses reveals that the velocity scales with $E^{4/3}$. Considering a gas bubble, the external flow is essentially confined to two boundary layers propagating from the poles to the equator, where they collide to form a radial jet. Remarkably, at leading order in the Capillary number the unique scaling allows through application of integral mass and momentum balances to obtain a closed-form expression for the $O(E^2)$ bubble deformation. Owing to a concentrated pressure load at the vicinity of the collision region, the deformed profile features an equatorial dimple which is non-smooth on the bubble scale. The dynamical importance of internal circulation in the case of a liquid drop leads to an essentially different deformation mechanism. This is because the external boundary layer velocity attenuates at a short distance from the interface, while the internal boundary-layer matches with a Prandtl-Batchelor (PB) rotational core. The dynamic pressure associated with the internal circulation dominates the interfacial stress profile, leading to an $O(E^{8/3})$ deformation. The leading-order deformation can be readily determined, up to the PB constant, without solving the circulating boundary-layer problem. To encourage attempts to verify this new scaling, we shall suggest a favourable experimental setup in which inertia is dominant, while finite-deformation, surface-charge advection, and gravity effects are negligible.

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