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Electrohydrodynamic and flow induced tip-streaming

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A liquid subjected to a strong electric field emits thin fluid jets from conical structures (Taylor cones) that form at its surface. Such behavior has both practical and fundamental implications, e.g. for raindrops in thunderclouds and in electrospray mass spectrometry. Theoretical analysis of the temporal development of such electrohydrodynamic (EHD) tip- streaming phenomena has been elusive given the large disparity in length scales between the macroscopic drops/films and the microscopic (nanoscopic) jets. Here, simulation and experiment are used to investigate the mechanisms of EHD tip-streaming from a film of finite conductivity. In the simulations, the full Taylor-Melcher leaky-dielectric model, which accounts for charge relaxation, is solved. Simulations show that tip- streaming does not occur for perfectly conducting or perfectly insulating liquids. Scaling laws for sizes of drops produced from the breakup of the thin jets is developed. Further, simulations demonstrate the critical role played by electrically induced surface shear stresses in the inception of tip-streaming. This invites a comparison to flow focusing, i.e. tip-streaming induced by co-flowing two fluids. The latter phenomenon is also investigated by simulation. In collaboration with Ronald Suryo, Exxon-Mobil; and Jeremy Jones, Michael Harris, and Osman Basaran, Purdue University.