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Microhydrodynamics of deformable particles: surprising responses of drops and vesicles to uniform electric field or shear flow

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Particle motion in a viscous fluid is a classic problem that continues to surprise researchers. In this talk, I will discuss some intriguing, experimentally-observed behaviors of droplets and giant vesicles (cell-size lipid membrane sacs) in electric or flow fields. In a uniform electric field, a droplet deforms into an ellipsoid that can either be steadily tilted relative to the applied field direction or undergo unsteady motions (periodic shape oscillations or irregular flipping); a spherical vesicle can adopt a transient square shape or reversibly porate. In a steady shear flow, a vesicle can tank-tread, tumble or swing. Theoretical models show that the nonlinear drop dynamics originates from the interplay of Quincke rotation and interface deformation, while the vesicle dynamics stems from the membrane inextensibility. The practical motivation for this research lies in an improved understanding of technologies that rely on the manipulation of drops and cells by flow or electric fields.