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Surface Tension Driven Instability in the Regime of Stokes Flow
ZHENWEI YAO, MARK BOWICK, XIANGJUN XING, Syracuse University — A cylinder of liquid inside another liquid is unstable towards droplet formation. This instability is driven by minimization of surface tension energy and was analyzed first by [1,2] and then by [3]. We revisit this problem in the limit of small Laplace number, where the inertial of liquids can be completely ignored. The stream function is found to obey biharmonic equation, and its analytic solutions are found. We rederive Tomotika's main results, and also obtain many new analytic results about the velocity fields. We also apply our formalism to study the recent experiment on toroidal liquid droplet[4]. Our framework shall have many applications in microfluidics. [1] L.Rayleigh, On The Instability of A Cylinder of Viscous Liquid Under Capillary Force, Scientific Papers, Cambridge, Vol.III, 1902. [2] L.Rayleigh, On The Instability of Cylindrical Fluid Surfaces, Scientific Papers, Cambridge, Vol.III, 1902. [3] S.Tomotika, On the Instability of a Cylindrical Thread of a Viscous Liquid surround by Another Viscous Fluid, Proceedings of the Royal Society of London. Series A, Mathematical and Physical Sciences, Volume 150, Issue 870, pp. 322-337. [4] E.Pairam and A.Fernández-Nieves, Generation and Stability of Toroidal Droplets in a Viscous Liquid, Physical Review Letters 102, 234501 (2009).

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