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Lie Algebraic Analysis of Thin Film Marangoni Flows: Multiplicity of Self-Similar Solutions ZACHARY NICOLAOU, SANDRA TROIAN, California Institute of Technology, 1200 E. California Blvd., MC 128-95, Pasadena, CA — The rapid advance of an insoluble surfactant monolayer on a thin liquid film of higher surface tension is controlled by distinct flow regimes characterized by the relative strength of viscous, Marangoni and capillary forces. Such flows play a critical role in human pulmonary and ocular systems. During the past quarter century, researchers have focused exclusively on self-similar solutions to the governing pair of nonlinear PDEs for the film thickness, $H(r/t^a)$, and surface concentration, $\Gamma(r/t^a)/t^b$, in the limit where the Marangoni or capillary terms vanish, where r denotes the spatial variable, t is time, and a and b are fractional exponents. Using Lie algebraic techniques, we demonstrate for the first time the existence of several embedded symmetries in this system of equations which yield multiple self-similar solutions describing more complex scaling behavior, even when all three forces are incorporated. A special and previously unrecognized subset of these solutions reveals the dynamical behavior of film thinning and surfactant distribution near the origin, which ultimately meters the downstream flow. Finite element simulations confirm the suite of scaling exponents obtained analytically.

Sandra Troian
California Institute of Technology, 1200 E. California Blvd., MC 128-95, Pasadena, CA

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