Abstract Submitted
for the DFD19 Meeting of
The American Physical Society

Electrohydrodynamic instability of viscous falling films: numerical verification of weakly nonlinear models and higher-order effects TAO WEI, MENGQI ZHANG, National University of Singapore — A study on the nonlinear stability of an electrified film flowing under gravity down an inclined plate is presented with an electric field acting normal to the plate. An asymptotic expansion is applied to derive a nonlinear evolution equation for the interfacial position in the long-wave limit, which retains terms up to 2nd-order in the small parameter. Numerical solutions to two weakly nonlinear models, considering distinct effects of hydrostatic pressure, inertia and viscous dispersion, are compared to those of the fully nonlinear equation with an electric Weber number well above the critical value from linear analysis. Single- and multiple-hump solitary waves are searched for a wide range of electric field and dispersion, described by a nonlinear eigenvalue problem. Two coupled Ginzburg-Landau equations are derived from a multiple-scale analysis, which suggests that the electric destabilization occurs in the form of travelling waves of finite amplitude. The leading-order solutions show that one order-of-magnitude increase in electric supercriticality will cause one order increase in the growth rate. Reasonable agreement is found between the present results and available experiments. In particular, for realistic parameter values an electric field can diminish the film pressure.

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Date submitted: 31 Jul 2019 Electronic form version 1.4