nonliner electrohydrodynamic marangonl stability

abdel raouf farid el-hefnawy.

This thesis deals with the nonlinear electruhydrodynamicMaran~oni stability of both Rayleigh-Taylor and Kelvin-Helmholtzmodels in the presence of different electric field distributions.This thesis consists of six chapters:In chapter I, we explain the main aspects, the previous studiesof electrohydrodynamics and their various applications. We discussthe concepts of electrohydrodynamics and stability. The equations.governing the motion, the electric field and the associated boundaryconditions aPe introduced. We explain the surface ten:::ion and adsorptionand the related differential equations. The concept of Marangoniinstability is explained. We present a review of both Rayleigh-Taylorand Kelvin-Helmholtz models in the last section.In chapter II, we study the problem of electrohydrodynamicMarangoni stability in Kelvin-Helmholtz flow in the presence of atangential electric field of an interface between two semi-infinite,dielectric, inviscid -and incompressible fluids. The two fluids areassumed to be streaming in the x direction. Also, the motion in eitherfluids is assumed to be irrotational. We use the method of multiplescales to expand the various perturbation quantities to yield the linearand slcce!'lsive nonlinear partial differential equat.ions of the variousorders. The solutions of these equations are obtained.Chapter III is connected with the second chapter presented inthis thesis, where the linear electrohydrodynamic Marangoni stabilityis discussed in both Rayleigh-Taylor and Kelvin-Helmholtz models. Weobtained a third-order dispersion relation with real and complexcoefficients for the Raylei~h-Taylor and Kelvin-Helmholtz instabilitiesrespectively. The necessary and sufficient conditions of stabilityare discussed theoretically and numerically in both models. For RayleighTaylorinstability, we find that the critical value of the fieldincreases with the idbrease of adsorption which means that theadsorption is destabilizing while the surface tension is stabilizing.For Kelvin-Helmholtz instability, the behavior is similar to that ofRayleigh-Taylor instability. Only the Kelvin-Helmholtz instabilityrequires larger values of the field than those in the Rayleigh-Taylorinstability.In chapter IV, -we study the nonlinear electrohydrodynamicMarangoni stability in both Rayleigh Taylor and Kelvin-Helmholtzmodels. We get the nonlinear SchrBdinger equation with complexcoefficients. The surface elevation and the cutoff wavenumber in themarginal state are obtained. We discuss the stability conditions ofnonlinear Schrodinger equation with complex coefficients in differentcases. The numerical -analysis in the marginal state is discussed forboth models. For nonlinear Rayleigh

Taylor instability, we observethat the nonlinearity plays a dual role in the stability criterionregarding the effect of the electric field, the adsorption and thesurface tension. For nonlinear Kelvin-Helmholtz instability,we ob~~rv~that the surface tension and the adsorption are playing a dual role,but in a manner different from that in the Rayleigh-Taylor instability.In chapter V, we study the stability of the system at thecritical point. We get the nonlinear Klein-Gordon equation with complexcoefficients, while the nonlinear Klein-Gordon equation with realcoefficients is obtained in the absence of interfacial adsorption •The stability conditions of the latter nonlinear Klein-Gordon equationare obtained and the stability analysis of that equation is discussed.We find that the necessary condition of stability is that either ofthe following conditions should be satisfied:(i) 0.283