Nonlinear Electrohydrodynamic Stability of Two Superposed Bounded Fluids in the Presence of Interfacial Surface Charges

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The method of multiple scales is used to analyse the nonlinear propagation of waves on the interface between two superposed dielectric fluids with uniform depths in the presence of a normal electric field, taking into account the interfacial surface charges. The evolution of the amplitude for travelling waves is governed by a nonlinear Schrödinger equation which gives the criterion for modulational instability. Numerical results are given in graphical form, and some limiting cases are recovered. Three cases, in the pure hydrodynamical case, depending on whether the depth of the lower fluid is equal to or greater than or smaller than the one of the upper fluid are considered, and the effect of the electric field on the stability regions is determined. It is found that the effect of the electric field is the same in all the cases for small values of the field, and there is a value of the electric field after which the effect differs from case to case. It is also found that the effect of the electric field is stronger in the case where the depth of the lower fluid is larger than the one of the upper fluid. On the other hand, the evolution of the amplitude for standing waves near the cut-off wavenumber is governed by another type of nonlinear Schrödinger equation with the roles of time and space are interchanged. This equation makes it possible to determine the nonlinear dispersion relation, and the nonlinear effect on the cut-off wavenumber.

Key words: Hydrodynamic Stability; Electrohydrodynamics; Nonlinearity; Interfacial Instability; Dielectric Fluids; Surface Charges.

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