Electrohydrodynamic Interfacial Stability Conditions in the Presence of Heat and Mass Transfer and Oblique Electric Fields

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A novel mathematical formulation to deal with interfacial stability problems of the Kelvin-Helmholtz type with heat and mass transfer in the presence of oblique electric fields is presented. The perturbed system is composed of two homogeneous, inviscid, incompressible, dielectric, and streaming fluids separated by a horizontal interface, and bounded by two rigid planes. The effect of a phase transition on the instability is considered, and the linear dispersion relations are obtained and discussed. It is found that the electric field has a major effect and can be chosen to stabilize or destabilize the flow. For Rayleigh-Taylor instability problems of a liquid-vapor system it is found that the effect of mass and heat transfer enhances the stability of the system when the vapor is hotter than the liquid, although the classical stability criterion is still valid. For Kelvin-Helmholtz instability problems, however, the classical stability criterion is found to be substantially modified due to the effects of the electric field, mass and heat transfer. A new stability condition relating the magnitude and orientation of the electric field and the dielectric constants is obtained. Oblique electric fields are found to have stabilizing effects which are reduced by the normal components of the electric fields. The effects of orientation of the electric fields and fluid depths on the stability configuration are also discussed.

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