On the stability of a forced-free boundary layer flow with viscous heating

Abstract

The inviscid instability of an accelerating forced-free convection boundary layer with viscous dissipation is investigated. The boundary layer equations for the flow with free-stream velocity $U_\infty xn$ admit self-similar solutions for n=1 only. The "overshooting" of the free-stream value, characteristic of accelerating buoyant boundary layers, is found to increase with increasing viscous heating. The scaled temperature profile is also found to exceed its plate value close to the plate where the viscous dissipation effects are strongest. For Eckert number Ec=0 only one single inviscid unstable mode exists. For the flow with viscous dissipation, three unstable modes have been identified. The secondary modes may be associated with the combined effect of thermal buoyancy and viscous heating. There is evidence of these modes crossing at relatively higher wavenumbers. The disturbance growth rate is found to increase with increasing buoyancy and viscous heating.

Keywords

Boundary layer;
Viscous dissipation;
Buoyancy;
Super-velocities;
Inflectional points;
Eigenvalues;
Eigenfunctions
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