Spatial versus temporal instabilities in a parametrically forced stratified mixing layer

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The present study compares the temporal and spatial instabilities of parametrically excited stratified mixing layer flows. For this purpose a relatively simple iteration procedure yielding solutions of both temporal and spatial problems is proposed. This procedure can be easily extended to other plane-parallel shear flows with the parametric excitation of instability. Using this procedure the parametric analysis of the temporal and spatial Kelvin-Helmholtz and Holmboe instabilities is performed and characteristic features of the instabilities are compared. Both inviscid and viscous models are considered. The parametric dependences on the mixing layer thickness and on the Richardson and Reynolds numbers are studied. It is shown that in the framework of this study the Gaster transformation is valid for the Kelvin-Helmholtz instability, but cannot be applied to the Holmboe one. The neutral stability curves are calculated for the viscous flow case. It is found that the transition between Kelvin-Helmholtz and Holmboe instabilities is continuous in the spatial case and in the temporal case occurs via the codimension two Takens-Bogdanov bifurcation at which a complex pair of the leading eigenvalues merges into a multiple real eigenvalue (Fig.1). It is found also that for the same governing parameters the spatial upstream and downstream Holmboe waves have different amplification rates and different absolute phase velocities, with larger difference observed at larger Richardson numbers. It is also found that at large Richardson and small Reynolds numbers the primary temporal and spatial instabilities set in as a three-dimensional oblique Holmboe wave (Fig. 2).

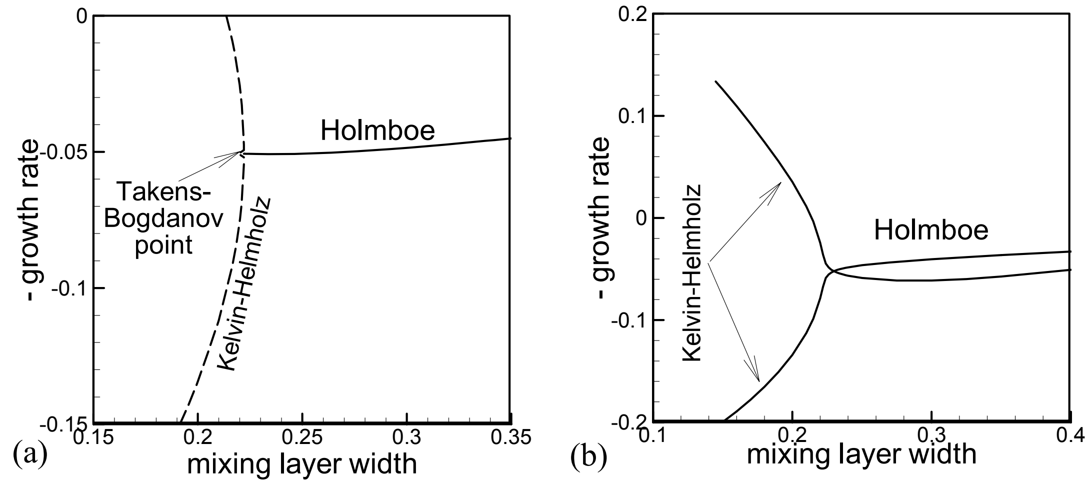

Fig.1. Transition between Kelvin-Helmholz and Holmboe modes for temporal (a) and spatial (b) instabilities.

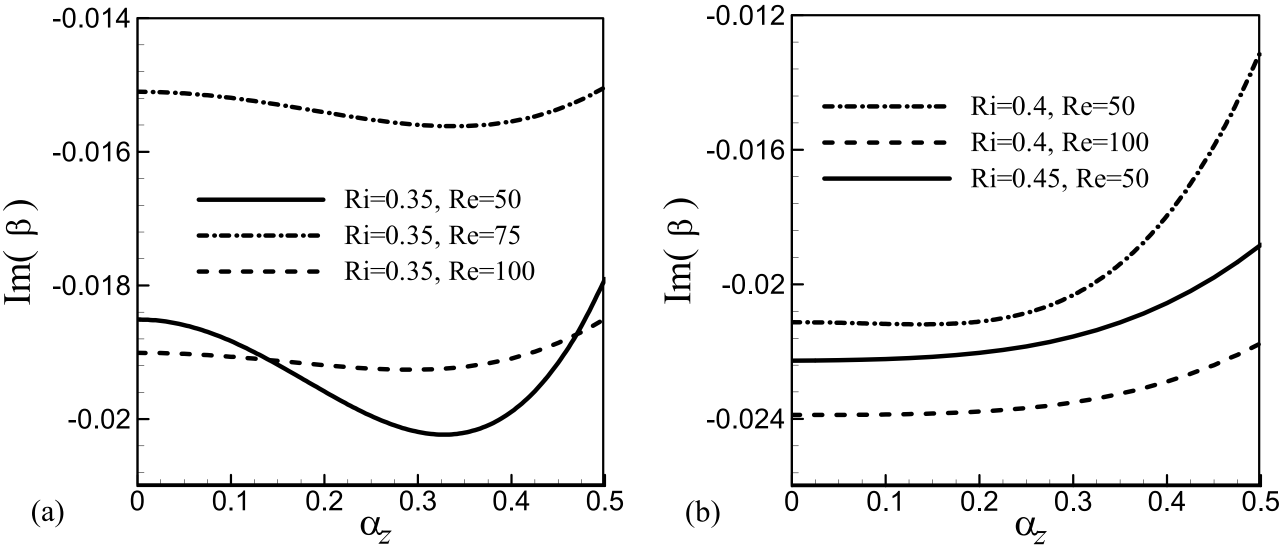

Fig. 2. Dependence of spatial amplification rates on spanwise wavenumber. Second Holmboe mode.