UNSTEADY LOCALIZED WAVE PACKETS IN LAMINAR SHOCK-WAVE/BOUNDARY-LAYER INTERACTIONS

Sébastien Niessen[1], Koen J. Groot[2], Stefan Hickel[3] & Vincent E. Terrapon[1]
[1]*Multiphysics and Turbulent Flow Computation Group, University of Liège, Liège, Belgium*
[2]*Computational Stability and Transitional Laboratory, Texas A&M University, College Station, USA*
[3]*Aerodynamics Group, Technische Universiteit Delft, Delft, The Netherlands*

The dynamics of the interaction between a developing laminar boundary layer at Mach $= 1.7$ and an impinging oblique shock-wave with an incident angle of 37.93° is investigated through BiGlobal stability analysis. This approach is motivated by the two-dimensionality of the shock-induced recirculation region. Past stability analyses conducted on the laminar shock-wave/boundary-layer have highlighted the presence of a stationary mode ([1, 3]) and, more recently, the existence of a convective instability has been demonstrated [2]. However, the latter stability analysis results in eigenmodes that are non-localized in the sense that their support spans the entire domain, from the inlet to the outlet. Therefore, the modes themselves depend noticeably on the artificial truncation boundary conditions. In the present work, we show how the superposition of many non-localized modes can yield a localized wave packet.

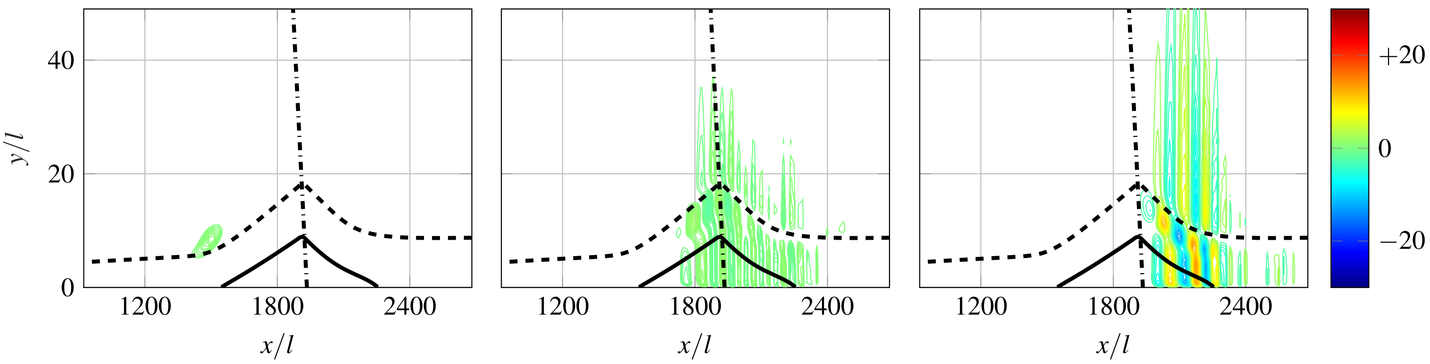

Figure 1. Snapshots at time $t\overline{U}_\infty/l = 500, 1500$ and 2000 (from left to right) of an unsteady wave packet represented by its real part $\Re(\tilde{u})/|\tilde{u}_{t=0}|_{\max}$. The solid, dashed and dash-dotted lines show the recirculation region, the boundary layer height $\delta_{0.9}$ and the incident oblique shock, respectively. The scaling $l = \sqrt{\nu x_{\text{in}}/\overline{U}_\infty}$ is the Blasius length at the inlet of the domain.

This is illustrated in Fig. 1, which depicts the time evolution of a perturbation initially imposed at the inlet of the domain ($x/l = 900$). As opposed to the results presented by Guiho et al. [2], wave packets are confined to the interior of the domain, such that the interaction with the boundary conditions is minimized. We specifically investigate how the localized nature of the wave packets impacts the dependency of the results on the truncation boundary conditions. In addition, the results are compared to those obtained with other (non-)local stability analysis methods such as the Parabolized Stability Equations (PSE) and the Wentzel–Kramers–Brillouin-Jeffreys (WKBJ) method. Finally, the proposed approach allows for a boundary-condition-independent characterisation of the stability properties of the shock-wave/boundary-layer interaction.

References

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