

## Application of FR/CPR Method on Boundary Layer Transition

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In this paper, both the whole transition process on a flat plate and the flow passing a single forward-facing step in a boundary layer are investigated with a developed FR/CPR method<sup>[1,2]</sup>, which can obtain a relatively high accuracy considering efficiency. For the flat plate transition, a Blasius laminar similarity solution is included at the inlet. The free stream Mach number is  $M = U_\infty/c = 0.2$  and the Reynolds number based on the distance from the leading edge is  $Re_x = 10^5$ . One disturbance strip is adopted to trigger a K-type transition with a shape like TS wave.<sup>[3]</sup> Typical transition processes including the TS wave,  $\lambda$  vortex, and the vortex ring are observed. The process of breaking down and the development of the turbulent spot are also investigated. In contrast, if a forward-facing step exists during the developing process of the disturbances, the streamwise vorticity is amplified rapidly after the step and induces an earlier transition compared with the flow on a flat plate.

### REFERENCES

- [1] H.T. Huynh, A flux reconstruction approach to high-order schemes including discontinuous Galerkin methods. *AIAA paper*, 4079, 2007
- [2] T. Haga, H. Gao and Z. J. Wang, A High-Order Unifying Discontinuous Formulation for the Navier-Stokes Equations on 3D Mixed Grids, *Math. Model. Nat. Phenom.*, V6, 03, pp.28-56, 2011.
- [3] T. Sayadi, C.W. Hamman and P. Moin, Direct numerical simulation of complete H-type and K-type transitions with implications for the dynamics of turbulent boundary layers. *Journal of Fluid Mechanics*, 724, pp.480-509, 2013