Shock-boundary layer interactions in supersonic turbine cascades

William Roberto Wolf*

*University of Campinas, Brazil

ABSTRACT

The physics of shock-boundary layer interactions (SBLIs) in a supersonic turbine cascade is investigated through wall-resolved large eddy simulations. Special attention is given to the characterization of the low-frequency dynamics of the separation bubbles. The suction side bubble leads to compression waves that do not coalesce into a separation shock, and a thin bubble forms on the pressure side despite the strong normal shock of a Mach reflection. Instantaneous flow visualizations illustrate elongated streamwise structures in the incoming boundary layers and their interactions with the shocks and separation bubbles. Space-time cross-correlations reveal that the near-wall streaks drive the motion of the suction side separation bubble, promoting oscillations of the reattachment shock and shear layer flapping. The effects of inlet Mach number variations on the unsteadiness of SBLIs are also investigated. The curved walls of the airfoils impact the SBLIs due to the state of the incoming boundary layers and local pressure gradients. A characterization of the suction side boundary layers indicates that a higher Mach number leads to larger shape factors, favoring separation and larger bubbles, while the reverse holds for the pressure side. Increasing the inlet Mach number also leads to an increase in the time scales of intermittent events. Finite-time Lyapunov exponent fields show the presence of streamwise vortices developing in the turbulent boundary layers on both airfoil sides. These vortices influence the formation of large-scale longitudinal structures which affect the mass imbalance inside the separation bubbles.