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NUMERICAL AND EXPERIMENTAL STUDY ON TURBULENCE PRODUCTION OF A SELECTED MODE OF STREAMWISE VORTEX INTERACTION IN SUPERSONIC FLOW

By

Davide Viganò

Thesis Advisor: Prof. Luca Maddalena

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Abstract

The development of effective mixing strategies of air/fuel mixtures in supersonic flows has been the subject of a significant body of research for the last 60 years due to the hindering effects of compressibility. Particular attention has been focused on the introduction of streamwise vortices as a way to enhance molecular mixing both in terms of added source for hydrodynamic instabilities on classical shear-layer flows as well as for transverse jet configurations, aero-ramps and hypermixers. However, a large portion of fundamental knowledge for these complex flows is still missing. This work is centered on a numerical and experimental study of turbulence transport and dynamics associated with pre-selected modes of vortex interactions. A numerical study was initially performed to engineer a unique interaction between supersonic streamwise vortices such as the production of turbulent kinetic energy is maintained at a positive level. This analysis was conducted by using the in-house developed *VorTx* code after been upgraded by the author to allow for the correct calculation of derived quantities such as strain rates via a new application of vortex-blob methods in supersonic flows. The successive experimental investigation of the selected vortex interaction has successfully confirmed a positive turbulent kinetic energy production for all sampled stations, thus confirming the initial prediction. No other case investigated to this date in our research group or in the available literature, to the best knowledge of the author, has ever shown these results. A detailed analysis on the interaction of the resulting mean flow strain rates and the Reynolds stresses is presented in this work as well as the contribution of this analysis on the augmented understanding of these complex flows. It was found that turbulence anisotropy plays a critical role for turbulent kinetic energy production.
The results of this work are critical for the design of efficient hypersonic air-breathing propulsion systems.