ANALYSIS OF TRANSONIC BUFFET BY DIFFERENT NUMERICAL APPROACHES

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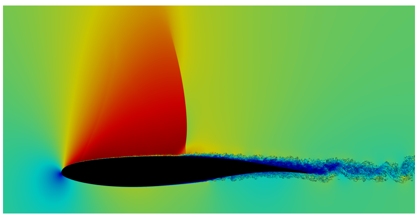
Abstract

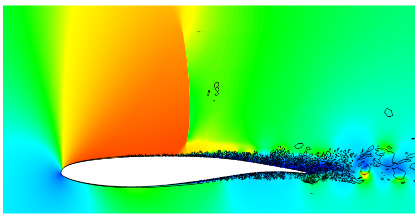
Transonic flow around supercritical airfoils is characterized by a supersonic region on the airfoil suction side terminated by a shock wave. For certain combinations of angle of attack and freestream Mach number the shock wave is subject to self-sustained low-frequency oscillations referred to as buffet. The structural response of the wing to these shock oscillations poses a risk for the integrity of the structure, and consequently, the buffet boundary represents a strict limit to the flight envelope. Despite its relevance to flight safety and the design of future highly efficient commercial aircraft, the buffet phenomenon is not thoroughly understood.

In recent years, numerical analyses of transonic buffet have become increasingly feasible. Today, highly-resolved computational fluid dynamics simulations of the phenomenon are a cornerstone in unraveling the physical mechanisms underlying the self-sustained shock oscillation. However, these simulations exhibit a notable sensitivity to the chosen models and the overall level of modeling.

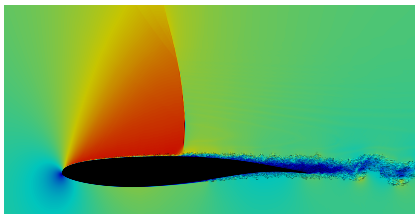
Within the DFG funded research unit FOR2895, various sub-projects are dedicated to investigating the buffet phenomenon using a variety of codes employing different numerical methods. To compare the research group's findings, a coordinated test case based on the OAT15A profile was simulated by the sub-projects utilizing their codes. These include the Cartesian finite volume simulation framework m-AIA, the high-order spectral element-based solver FLEXI, and the finite volume solver from TAU. A detailed analysis of the results from the coordinated test case is given. The global mean flow and farfield conditions are discussed to ensure comparability across all simulations. Due to the importance for the correct prediction of the buffet, a detailed examination of the turbulent boundary layer upstream of the shock and the separated region downstream of the shock is carried out. Furthermore, the dynamics in the flow field is extracted using dynamic mode decomposition and the dominating dynamic modes are discussed.



(a) m-AIA



(b) TAU



(c) FLEXI

FIG 1. Contours of the local Mach number and the Q-criterion from all simulations.