Mitteilung

Fachgruppe: Hyperschallaerothermodynamik

Application of HyperCODA to hypersonic flows around two-dimensional geometries

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Simulating hypersonic flow presents the challenge of describing simultaneous phenomena at different length and time scales. Understanding the relevant physicochemical phenomena within these flows is essential to designing vehicles capable of enduring prolonged survival in environments with high mechanical and thermal loads. The scientific community has developed robust codes that can simulate hypersonic flows using different numerical modeling techniques.

Since 2018, ONERA, DLR, and Airbus have focused their effort on collectively developing a CFD code called CODA (CFD for ONERA, DLR, and Airbus) that is based on the structure and design already employed for the solver Flucs (FLexible Unstructured CFD Software) [1]. This next-generation CFD solver is capable of solving large sparse linear systems derived from the implicit time integration of the RANS (Reynolds-averaged Navier-Stokes) equations with the assumption of a single perfect gas on three-dimensional structured and unstructured grids using either second-order finite-volume or higher-order Discontinuous-Galerkin (DG) discretization.

CODA has been extensively used to solve subsonic and transonic flow regimes because the code has been designed mainly for avionics applications. However, for hypersonic applications, DLR has been internally developing an extension, HyperCODA [2, 3, 4], that expands CODA's physical and numerical modeling capabilities to deal with high enthalpy flows and gas mixtures. This paper aims to explore HyperCODA capabilities and validate its accuracy in solving hypersonic flows around canonical two-dimensional geometries. Making use of the advanced technologies available at DLR, we want to use HyperCODA to solve test cases relevant to the industry and hypersonic research and compare the solutions to DLR CFD solver TAU results and the experiment data from the High Enthalpy Shock Tunnel Göttingen (HEG).

A comparative analysis will be conducted on the solution for a two-dimensional cone-flare and the STORT [5] fin configuration [6]. In particular, the comparison will focus on studying eventual discrepancies in the solutions, comparing computational efficiency and grid requirements in terms of refinement and convergence time, and identifying potential areas of improvement and expansion of HyperCODA capabilities. Figure 1 shows a preliminary comparison of HyperCODA and TAU solutions for a hypersonic flow around a 7/40 degree large cone flare, flying at Mach 5.9 in a single perfect gas. Table 1 summarizes the initial and boundary conditions used for this test case. The free-stream conditions are equivalent to a flight at around 17.75 km of altitude. This preliminary comparison shows good agreement between the solutions. Minor differences are present in the shock interactions and the expansion regions near the outflow. Further investigations are needed to understand the reasons and address them.

References

[1] Leicht, T., Jägersküpper, J., Vollmer, D., Schwöppe, A., Hartmann, R., Fiedler, J., and Schlauch, T., "DLR-Project Digital-X-Next Generation CFD Solver'Flucs'," 2016.

Table 1: Initial and boundary conditions for the 7/40 cone-flare test case

Free-stream Pressure	7808 Pa
Free-stream Temperature	244.38 K
Wall Boundary Condition	Viscous Isothermal Wall
Wall Temperature	300 K

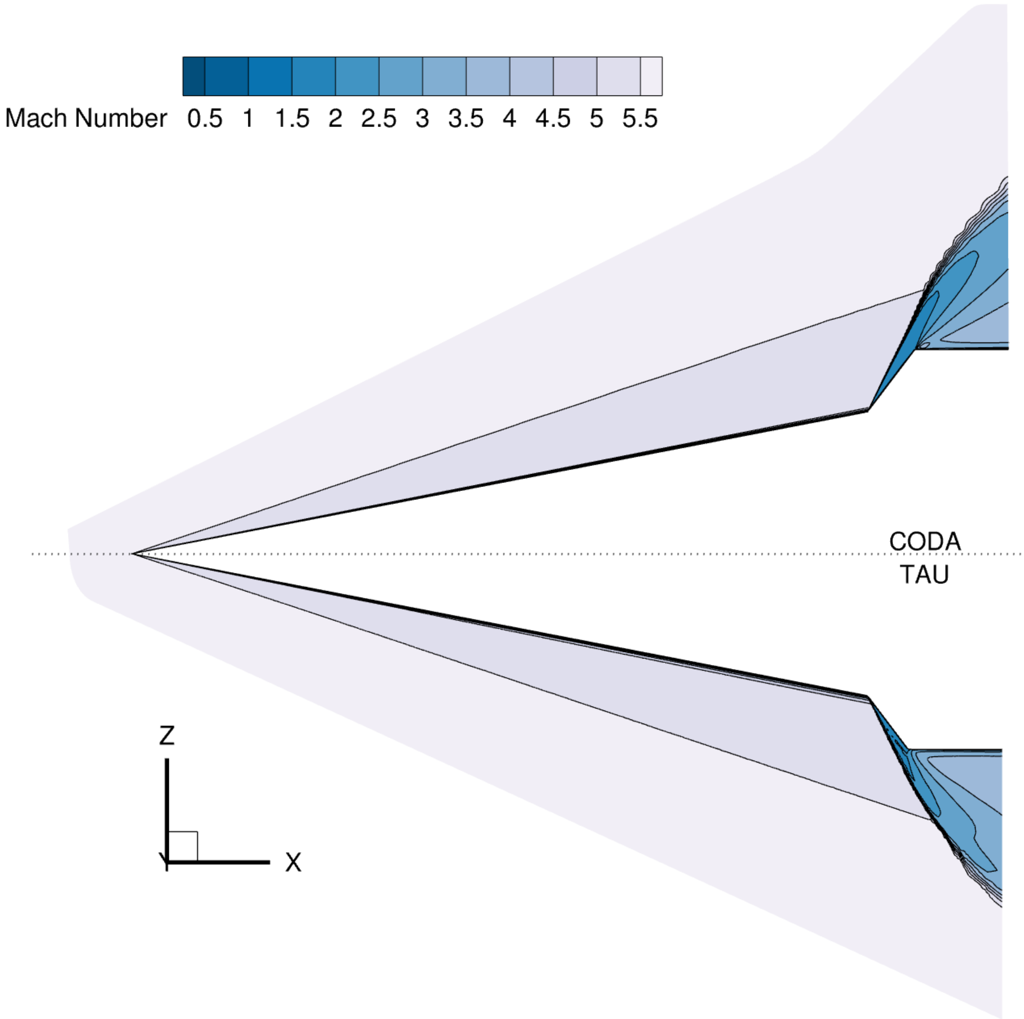

Figure 1: Comparison of HyperCODA and TAU solutions for a perfect gas flow around a cone-flare at Mach 5.9

[2] Huismann, I., Fechter, S., and Leicht, T., "HyperCODA–Extension of Flow Solver CODA to Hypersonic Flows," *HyperCODA–Extension of Flow Solver CODA Towards Hypersonic Flows*, Vol. 13, 2020.

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