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GPU-Accelerated Direct Numerical Simulation of the Sandia Flame A

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In this work, the extension of STREAmS-2 (Supersonic TuRbulEnt Accelerated Navier-Stokes Solver[1]), a GPU-accelerated high-fidelty solver for Direct Numerical Simulations (DNS) of compressible flows, is presented. Developed at Sapienza, University of Rome, and originally tailored for canonical wall-bounded turbulent flows in cartesian geometries involving a single species, STREAmS-2 has been recently enhanced to support multicomponent and reactive flow simulations. The updated framework incorporates models for evaluating gas mixture viscosity [2], thermal conductivity [3], and molecular diffusion [4]. Chemical source terms are computed using Arrhenius-type kinetics, and time integration is performed through explicit and implicit schemes, employing an operator splitting technique [5]. The extended solver has been validated through a two-step process: first against lower-dimensional benchmark cases [6] (e.g. 1D reactive shock tube), and subsequently by simulating the well-characterized Sandia-A flame [7], a standard reference case in combustion research [8]. Furthermore, scalability tests were performed to evaluate strong and weak scaling performance both considering only multispecies transport and diffusion, and with full chemical kinetics, assessing the capability of the code to efficiently exploit modern HPC architectures despite the increased computational complexity.

References

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