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Energy-Preserving Stable Computations of High-Pressure Supercritical Fluids Turbulence

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High-fidelity computations of turbulent flows at high-pressure supercritical fluid conditions present significant challenges [1]. Besides the inherent broadband nature of the flow, the rapid variation of thermophysical properties across the pseudo-boiling region can result in additional complexities in terms of strong localized density gradients, spurious pressure oscillations, non-linear behaviour of fluids, and amplification of aliasing errors. Different research groups have utilized distinct approaches to achieve numerical stability, mostly resorting to upwind-biased schemes, artificial dissipation or high-order filtering (see e.g., [2] and references therein). However, in these strategies, stability is achieved at the expense of artificially suppressing part of the turbulent energy spectrum.

This work aims to explore the suitability, in terms of stability and accuracy, of recently proposed energy-preserving schemes for scale-resolving simulations of supercritical turbulence. Under ideal gas conditions, these methods are able to provide stable computations of turbulence without the need for any numerical artifact [3]. To this objective, an energy-preserving compressible framework will be extended to high-pressure flows based on real-gas thermodynamics, and assessed on canonical problems corresponding to 1D accuracy/stability tests, and a transcritical turbulent channel flow. The results will be compared against state-of-the-art strategies based on dissipative-like approaches, e.g., the HLLC+ scheme and high-order solution-filtering approaches.

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