Large-eddy simulations of a Richtmyer-Meshkov instability with re-shock

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We present a tuned center-difference (TCD) scheme optimized for large-eddy simulations (LES) using a method proposed by Ghosal [1]. For LES of weakly compressible decaying turbulence, these optimized stencils are shown to provide superior performance when compared to higher-order centered schemes with the same stencil width.

For use in the LES of strongly compressible, shock-driven flows, a hybrid is constructed by combining the TCD stencil with a weighted essentially non-oscillatory (WENO) method [2]. A momentum based detection is employed such that away from shocks and other apparent discontinuities, the TCD stencil is used explicitly, while the WENO method is confined to such areas.

The hybrid method is demonstrated in a three-dimensional LES modeled after the experiment of Vetter and Sturtevant [3]: A Mach 1.5 shock initiates the Richtmyer-Meshkov instability on a multimode perturbed air/SF6 interface, reflects off the end of the shock tube and then re-shocks the interface. A two-dimensional simulation of this flow, without subgrid-scale modeling, is depicted in Figure 1 showing the density field both before and after re-shock of the gas interface. Our three-dimensional simulation uses a computational domain of $600 \times 256 \times 256$ grid points. The subgrid-scale model employed is the structure-base stretched-vortex model extended to compressible flow [4]. The growth of the mixing layer width with time both before and after reshock will be compared with the experimental measurements [4]. Method-based diagnostics indicate the level of WENO coverage required at this resolution.

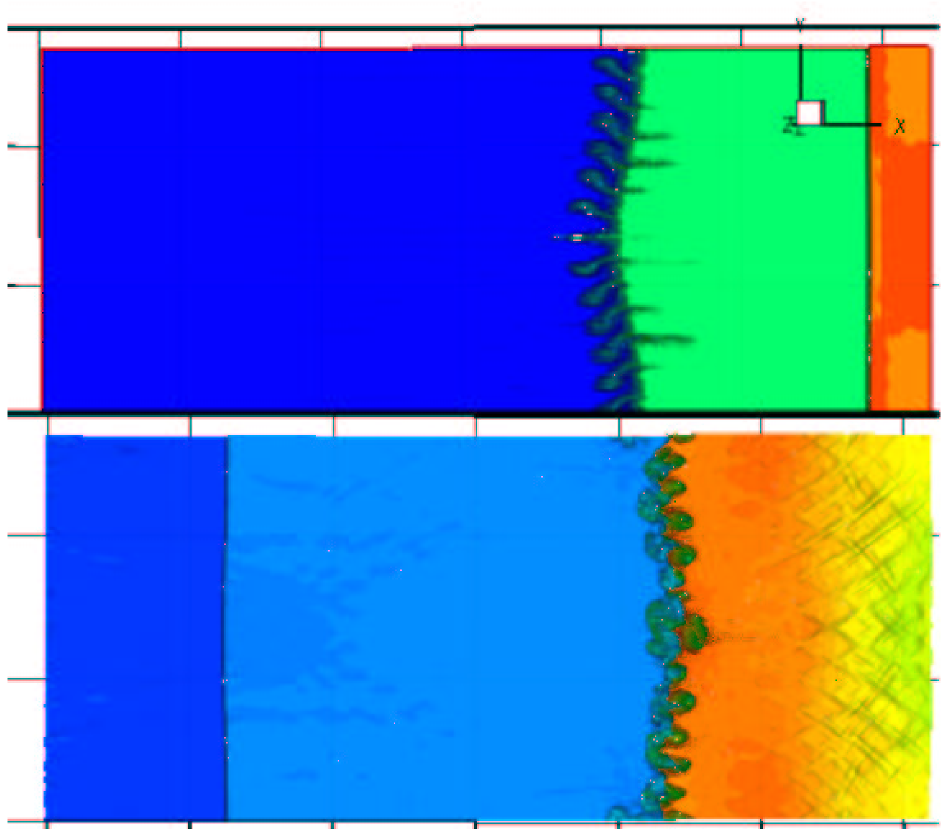

Figure 1: Density interface before and after reshock in a two dimensional Richtmyer-Meshkov calculation. Resolution is 600×256.

References

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