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Physics-Based Preconditioning of a Compressible Flow Solver for Large-Scale Simulations of Additive Manufacturing Processes BRIAN WESTON, ROBERT NOURGALIEV, Lawrence Livermore National Lab, JEAN-PIERRE DELPLANQUE, University of California, Davis — We present a new block-based Schur complement preconditioner for simulating all-speed compressible flow with phase change. The conservation equations are discretized with a reconstructed Discontinuous Galerkin method and integrated in time with fully implicit time discretization schemes. The resulting set of non-linear equations is converged using a robust Newton-Krylov framework. Due to the stiffness of the underlying physics associated with stiff acoustic waves and viscous material strength effects, we solve for the primitive-variables (pressure, velocity, and temperature). To enable convergence of the highly ill-conditioned linearized systems, we develop a physics-based preconditioner, utilizing approximate block factorization techniques to reduce the fully-coupled 33 system to a pair of reduced 22 systems. We demonstrate that our preconditioned Newton-Krylov framework converges on very stiff multi-physics problems, corresponding to large CFL and Fourier numbers, with excellent algorithmic and parallel scalability. Results are shown for the classic lid-driven cavity flow problem as well as for 3D laser-induced phase change.

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