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Physics-Based Preconditioning for the Numerical Solution of the All-Speed Compressible Navier-Stokes Equations with Laser-Induced Phase Change BRIAN WESTON, University of California, Davis, ROBERT NOURGALIEV, Lawrence Livermore National Laboratory, JEAN-PIERRE DELPLANQUE, University of California, Davis, ANDY ANDERSON, Lawrence Livermore National Laboratory — The numerical simulation of flows associated with metal additive manufacturing processes such as selective laser melting and other laser-induced phase change applications present new challenges. Specifically, these flows require a fully compressible formulation since rapid density variations occur due to laser-induced melting and solidification of metal powder. We investigate the preconditioning for a recently developed all-speed compressible Navier-Stokes solver that addresses such challenges. The equations are discretized with a reconstructed Discontinuous Galerkin method and integrated in time with fully implicit discretization schemes. The resulting set of non-linear and linear equations are solved with a robust Newton-Krylov (NK) framework. To enable convergence of the highly ill-conditioned linearized systems, we employ a physics-based operator split preconditioner (PBP), utilizing a robust Schur complement technique. We investigate different options of splitting the physics (field) blocks as well as different block solvers on the reduced preconditioning matrix. We demonstrate that our NK-PBP framework is scalable and converges for high CFL/Fourier numbers on classic problems in fluid dynamics as well as for laser-induced phase change problems.

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