Abstract Submitted
for the DFD14 Meeting of
The American Physical Society

An exact and dual-consistent formulation for high-order discretization of the compressible viscous flow equations RAMANATHAN VISHNAMPET, DANIEL BODONY, JONATHAN FREUND, University of Illinois at Urbana-Champaign — Finite-difference operators satisfying a summation-by-parts property enable discretization of PDEs such that the adjoint of the discretization is consistent with the continuous-adjoint equation. The advantages of this include smooth discrete-adjoint fields that converge with mesh refinement and superconvergence of linear functionals. We present a high-order dual-consistent discretization of the compressible flow equations with temperature-dependent viscosity and Fourier heat conduction in generalized curvilinear coordinates. We demonstrate dual-consistency for aeroacoustic control of a mixing layer by verifying superconvergence and show that the accuracy of the gradient is only limited by computing precision. We anticipate dual-consistency to play a key role in compressible turbulence control, for which the continuous-adjoint method, despite being robust, introduces adjoint-field errors that grow exponentially. Our dual-consistent formulation can leverage this robustness, while simultaneously providing an exact sensitivity gradient. We also present a strategy for extending dual-consistency to temporal discretization and show that it leads to implicit multi-stage schemes. Our formulation readily extends to multi-block grids through penalty-like enforcement of interface conditions.

Jonathan Freund
University of Illinois at Urbana-Champaign

Date submitted: 29 Jul 2014 Electronic form version 1.4