A DISCONTINUOUS GALERKIN METHOD FOR EQUILIBRIUM AIR FLOWS

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Abstract: In this paper, a discontinuous Galerkin (DG) finite element method for equilibrium air flows is described in detail. The variational form for each element is obtained by integrating conservative fluxes by parts. This formulation results in boundary fluxes normal to the element interfaces. The advective flux is upwinded using the HLLC Riemann solver, and the diffusive flux is averaged over the two adjacent elements. A special jump term is added to enforce the continuity of the diffusion flux across the elements. This term is found to be essential for the spatial accuracy of the method. A second-order time integration scheme is employed to ensure the time accuracy. A limiting process that contains three steps is designed and applied to improve the solution monotonicity and thus remove possible overshoots and undershoots. An effective gamma approach is used to simulate compressible chemically reacting flows. The effective specific-heat-ratio can be obtained via either polynomial correlations or nonlinear iterations. Numerical results show that either way generates almost identical results. The test cases include a high temperature air flow through an inlet and a hypersonic air flow around a circular cylinder. The numerical results demonstrate the excellent performance of the DG method in capturing discontinuities sharply. The good agreement with the exact solutions and experimental data also shows the accuracy of current DG method in solving equilibrium air flows.

Keywords: discontinuous Galerkin method, compressible flow, limiter, and equilibrium air.