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An *hp*-adaptive discontinuous Petrov-Galerkin finite element method for compressible viscous flows

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A Discontinuous Petrov-Galerkin (DPG) technique is useful for approximation of boundary-value problems with small perturbation parameters as it allows one for a robust procedure of solving such problems with the Finite Element Method (FEM). We recently extended the 2D version of DPG method for compressible viscous flows due to Chan *et al.* [1] to three dimensions [2]. Both procedures exploit h-adaptivity, including its anisotropic version, to resolve the typical irregularities of solution to supersonic viscous flow problems: shocks and boundary layers. The present work is focused on application of higher-order elements to approximate highly irregular but analytic solutions in boundary layers. Such an approximation is known to be essentially more effective in this situation than interpolation with larger number of finer elements of low order. Yet, higher order elements are not often used in the context of many schemes as they frequently lead to loss of stability. In contrary, stable behavior of the DPG method is insensitive to the kind of approximation being used. The price that is paid for the discrete stability of DPG is the essential increase of the computational cost, if compared to other popular techniques. We make an attempt to equilibrate this cost by limiting the higher order approximation to the direction perpendicular to the boundary layer, as the solution varies smoothly along the solid wall except the area of stagnation point or shock-boundary layer interaction, where approximation is isotropic. We also use fast integration of stiffness matrices of higher order elements and a two-grid iterative solver. Adequate control of its accuracy of convergence and the number of iterations brings additional savings in the CPU time. Both, the element computations and the iterative solver are implemented to use parallel processing.

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