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Invariant domain preserving approximation of the Euler equations via convex limiting

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A second-order finite-element-based method for approximating the compressible Euler equations is introduced. The method preserves all the known invariant domains of the Euler system: positivity of the density, positivity of the internal energy and the local minimum principle on the specific entropy. In addition, it preserves the upper bound on the density if the equation of state allows for it. The technique combines a first-order, invariant domain preserving, Guaranteed Maximum Speed method using a Graph Viscosity (GMS-GV1) with an invariant domain entropy consistent, possibly violating the invariant domain, high-order method. Invariant domain preserving auxiliary states, naturally produced by the GMS-GV1 method, are used to define local bounds for the high-order method which is then made invariant domain preserving via a convex limiting process. Numerical tests confirm the second-order accuracy of the new GMS-GV2 method in the maximum norm, where 2 stands for second-order. The proposed convex limiting is generic and can be applied to other approximation techniques and other hyperbolic systems with convex invariant domains.