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A two-speed relaxation system for Euler equations, and application to low Mach flows

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We introduce a relaxation system to approximate the solutions to the barotropic Euler equations. We show that the solutions to this two-speed relaxation model can be understood as viscous approximations of the solutions to the barotropic Euler equations under appropriate sub-characteristic conditions. Our relaxation system is a generalization of the well-known Suliciu relaxation system, and it is entropy satisfying. A Godunov-type finite volume scheme based on the exact resolution of the Riemann problem associated with the relaxation system is deduced, as well as its stability properties. In a second part, we show how the new relaxation approach can be successfully applied to the numerical approximation of low Mach number flows. We prove that the underlying scheme satisfies the well-known asymptotic-preserving property in the sense that it is uniformly (first-order) accurate with respect to the Mach number, and at the same time it satisfies a fully discrete entropy inequality. This discrete entropy inequality allows us to prove strong stability properties in the low Mach regime. At last, numerical experiments are given to illustrate the behaviour of our scheme.

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