Two Decades Old Entropy Stable Methods for the Euler Equations Revisited

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The two decades old high order central differencing via entropy splitting and SBP (summation-by-parts) difference boundary closure of Olsson & Oliger (1994), Gerritsen & Olsson (1996), and Yee et al. (2000) is revisited. The entropy splitting is a form of skew-symmetric splitting of the nonlinear Euler flux derivatives. Central differencing applied to the entropy splitting form of the Euler flux derivatives together with SBP (summation-by-parts) difference boundary closure will, hereafter, be referred to as entropy split schemes. This study is prompted by the recent growing interest in numerical methods for which a discrete entropy conservation law holds, a discrete global entropy conservation can be proved and/or the numerical method possesses a stable entropy in the framework of SBP difference operators and L_2-energy norm estimate. The objective of this paper is to recast the entropy split scheme as the recent definition of an entropy stable method for central differencing with SBP operators for both periodic and non-periodic boundary conditions for nonlinear Euler equations. Standard high order spatial central differencing as well as high order central spatial DRP (dispersion relation preserving) spatial differencing is part of the entropy stable methodology framework. Long time integration of 2D and 3D test cases is included to show the comparison of this efficient entropy stable method with the Tadmor-type of entropy conservative methods. Studies also include the comparison among the three skew-symmetric splittings. These are namely, entropy splitting, Ducros et al. splitting and the Kennedy & Grubber splitting.