Mathematics > Numerical Analysis

On the Mechanism of Roe-type Schemes for All-Speed Flows

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In recent years, Roe-type schemes based on different ideas have been developed for all-speed flows, such as the preconditioned Roe, the All-Speed Roe, Thornber's modified Roe and the LM-Roe schemes. This work explores why these schemes succeed or fail with the accuracy and checkerboard problems. Comparison and analysis show that the accuracy and checkerboard problems are caused by the order of the sound speed being too large and too small in the coefficients of the velocity-derivative and pressure-derivative dissipation terms, respectively. These problems can be resolved by choosing coefficients with zero-order sound speed. In addition, to avoid the negative effects of the global cut-off strategy on accuracy while maintaining computational stability, the sound speed terms in the numerator of the coefficients can be determined by local variables, while those in the denominator remain the global cut-off. Two novel schemes are proposed as examples to demonstrate how these ideas can be applied to construct more satisfactory schemes for all-speed flows. Asymptotic analysis and numerical experiments support the theoretical analysis and the rules obtained in the work.

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