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OPTIMIZED FINITE COMPACT SCHEMES APPLIED TO AEROACOUSTIC PROBLEMS

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Researches has revealed that, aeroacoustic problems require special designs on numerical schemes, such as developing low dissipation, low dispersion schemes, to get high short wave resolution. For this purpose, optimized schemes were developed, represented by dispersion-relation-preserving (DRP) [1]. And compact schemes [2, 3] has the nature of low dispersion and low dissipation in wave-number space and high order with small stencil. On the other hand, to obtain oscillation-free numerical solutions in the practical non-linear shock-acoustic wave interaction problems, high-order shock-capturing schemes, such as ENO, WENO schemes should be implemented. In order to unite the advantages of both the optimized DRP schemes and WENO scheme, optimized WENO schemes were developed [4]. Fig. 1 shows the wave-number dispersive errors of relevant schemes. However, the accuracy of the above mentioned optimized schemes are degraded several orders, with respect to the corresponding original high-oder schemes. Furthermore, the optimized schemes have another disadvantage, that is, the optimized wave-number range is specified and narrow, which can not capture the unknown broadband acoustic wave, which exists generally in practical problems, especially for direct noise computation or noise source computation in hybrid method [5]. Fig. 2 shows the analysis property of optimized WENO scheme and the original WENO scheme. The practical computation gets the similar figure. Optimization works only in PPW is between around 4 to 10.

Generalized finite compact schemes [6] were designed as a type of compact-WENO hybrid schemes, which obtain high accuracy in smooth region and impresses unphysical oscillations around the discontinuities, with the help of shock detectors. Within the framework of finite compact schemes, optimized WENO schemes and (optimized) compact schemes can be combined together to overcome the disadvantages of the single original scheme and obtain the advantages in the regions adaptively.

The evaluation of the optimized finite compact scheme and related schemes for CAA benchmark problems was accomplished with several benchmark problems, as 1-D linear acoustic wave (smooth or non-smooth), 1-D shock/acoustic wave interaction, 1-D broad-band acoustic wave, 2-D gust cascade interaction. A tentative 3-D rotor noise source computation was performed. The results show that the optimized finite compact scheme has more adaptability to shock/acoustic wave interaction problems and direct noise computation.

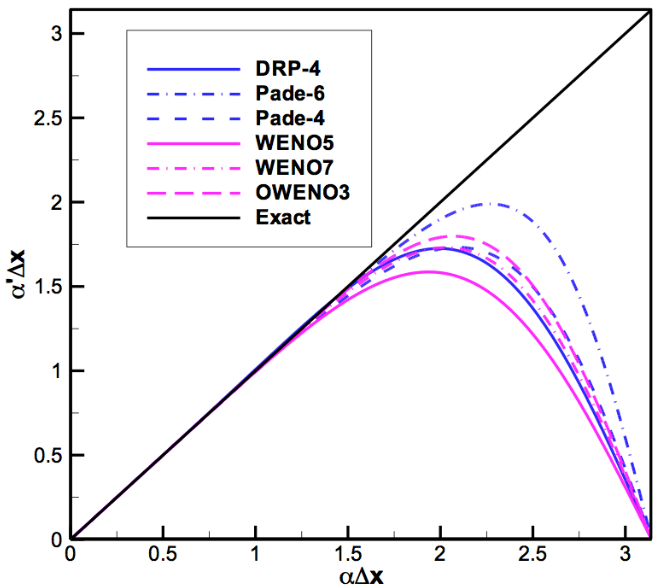

Figure 1: Comparison of relative wave-number errors among several original schemes.

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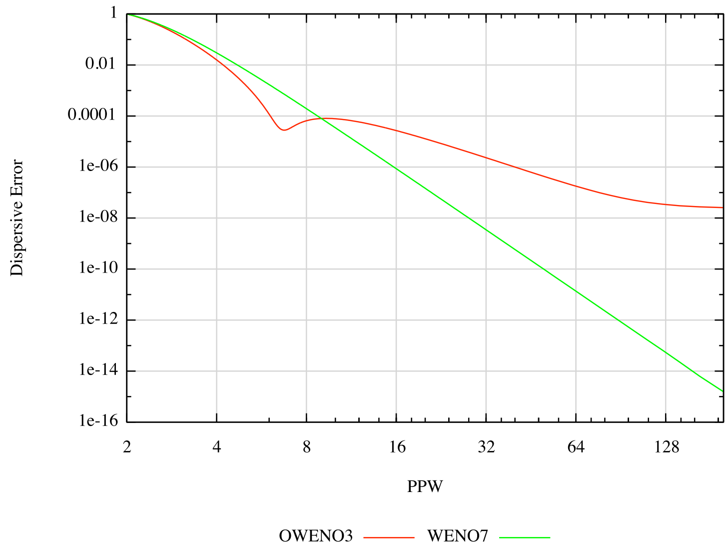

Figure 2: The dispersive and dissipative error vs. PPW - the analysis results.

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