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VERIFICATION OF DISCONTINUOUS GALERKIN SCHEME FOR LINEARIZED EULER EQUATIONS

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This work considers the problems of computationally effective implementation of Discontinuous Galerkin (DG) approach for numerical solution of aeroacoustic tasks.

Acoustic tasks are characterized by the necessity to simulate propagation of very small perturbations over non-uniform aerodynamic flowfields. This implies that numerical method should handle multiscale tasks with low dispersion and low dissipation errors for small scales. This requirement leads necessarily to high-order numerical schemes. In addition, very detailed numerical grids and rather large computational domains should be considered to calculate accurately the near acoustic field and to have possibility to impose correctly boundary conditions for calculations of the far acoustic field.

Isentropic Linearized Euler Equations (ILEE) are considered in this paper.

To verify the proposed DG scheme (carefully described in the paper [1]) and its implementation, several test tasks have been done. The first one is the propagation of the Gaussian acoustic pulse over a uniform flow. This test is described in the paper [2]. The second task is the propagation of the acoustic sine wave over a uniform flow. And the final test task is propagation of signals with continuous Π*-like spectrum over a uniform flow. Signals spectra are limited in low and high frequency regions, according to grid and scheme specific structural features. Signals are generated as a processed deterministic pulse and as an uncorrelated stochastic noise. Processing includes bandpass filtering and signal coloring. Such tests yield the opportunity to test the propagation of signal with continuous spectra and check the phase aberrations by comparison of input and output signal logarithmic spectra.*

Grid convergence for each test has been investigated. The calculated solution has been compared with the exact solution where it is possible.

Figure 1 shows Gaussian pulse propagation obtained using implemented DG scheme of the 4th order (K=3). Cubical computational domain ($\underbrace{[-50;50]}_{x}\times\underbrace{[-50;50]}_{y}\times\underbrace{[-50;50]}_{z}$*), covered by uniform square grid (25 cells in each spatial direction), is used for* *calculation. Figure shows cross section of the density fluctuations field and distribution along x-axis in the cell centers imposed on the exact solution.*

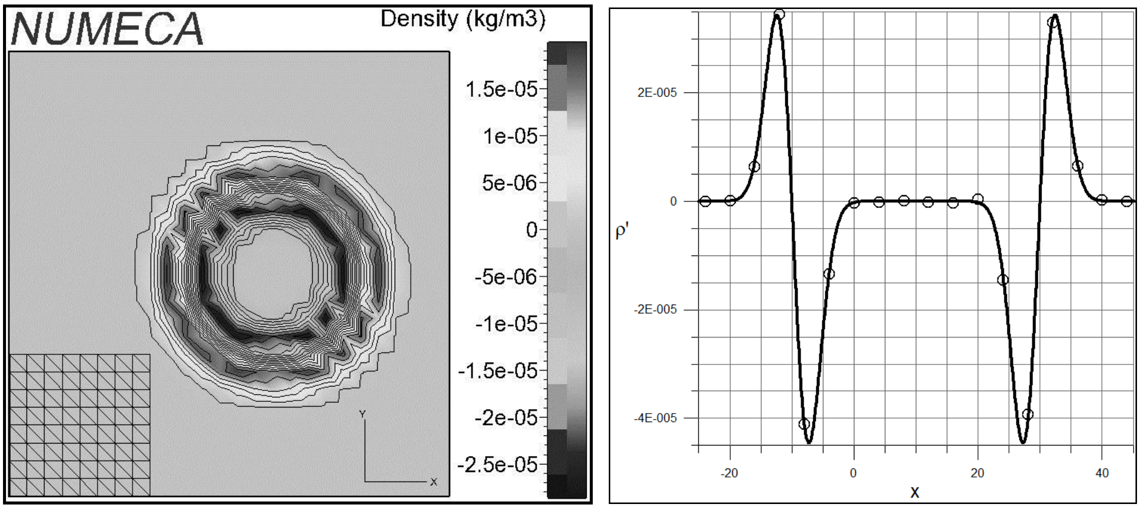

Figure 1. Computed distribution of density fluctuations with K=3 for the moment t=20: a) density fluctuations field; b) density fluctuations along x-axis in the cell centers (marked with circles) and exact solution (solid curve).

The tests performed in the paper demonstrate applicability and effectiveness of the implemented DG scheme for acoustic tasks.

Work has been done in the frame of the IDIHOM project. DG code is based on the code of the NUMECA solver Fine/Open.

REFERENCES

[1] Vlasenko V., Wolkov A., Hirsch Ch. Computationally effective Discontinuous Galerkin scheme for linearized Euler equations. Proceedings of West-East High Speed Flow Field Conference, Moscow, 2007.

[2] C. Bogey, C. Bailly. "Three-dimensional non-reflective boundary conditions for acoustic simulations: far field formulation and validation test cases". ACTA ACUSTICA united with ACUSTICA, Vol. 88, pp.463 – 471 (2002).