An hybrid LES/CAA method applied to a 3D shear flow simulation

O. Labbé*, C. Peyret,

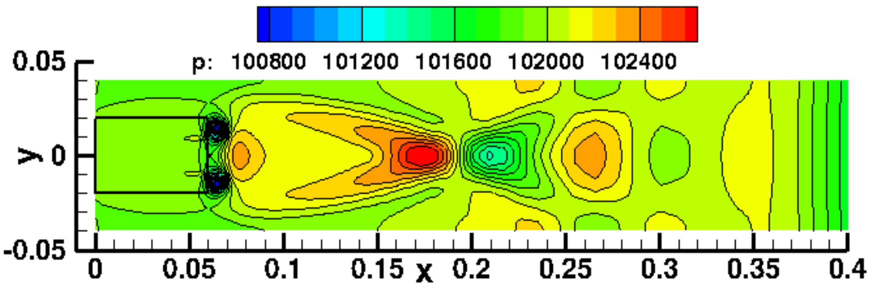
ONERA - The French Aerospace Lab
F-92322 Châtillon, France

Email: odile.labbe@onera.fr, web page: http://www.onera.fr/fr/dsna/mach

ABSTRACT

This aeroacoustic coupling is based on the splitting into noise sources generation and acoustic propagation in separate physical domains. The key idea is to limit, as much as possible, the CFD domain to the noise generation region and to accurately propagate the acoustic waves with a CAA solver. The approach presented here is a domain decomposition method based on the coupling of different equations, grids, which allows a simulation of both flow and acoustics in one single calculation suitable for far field predictions with reflecting bodies through a coupling boundary. The aerodynamic solver FUNk developed at ONERA, based on the compressible Navier-Stokes equations expressed in conservative form (cell-centered Finite Volume methodology on structured grid) is reduced to the region of viscous effects. The CAA computation is carried out with the SPACE solver developed at ONERA [1], which solves the full non-linear Euler equations with a Discontinuous Galerkin Method (DGM). It is well adapted to unstructured meshes and makes easier the access to high order schemes. The fluxes are computed with a local Lax Friedrich scheme. A nodal DGM with a Lagrangian polynomial basis is used to solve the conservative form of Euler equations. At the coupling boundary, the DG solver is fed at each increment of the Runge-Kutta method with the conservative variables from the CFD solver at the Gauss points belonging to the coupling boundary. These variables are computed with an interpolation (P1 or Q1) starting from the nodal values of the LES cells containing the Gauss points under consideration. And vice-versa, the CAA solver fills the ghost cells of Finite Volume method in order to apply the scheme at the coupling boundary.

In a previous study [2], this splitting method was applied to a hot jet simulation, that only dealt with a one way coupling from LES to CAA and thus mainly focused on the acoustic purpose. Here, the computational domain is 3D cylinder, which includes a smaller one, and can be considered as a model of jet/wing interactions. A shear flow (100m/s-50m/s) is imposed at the inflow of the small cylinder and a symmetry wall conditions is imposed at the external boundary of the big cylinder, which induces waves reflections impacting on the shear flow.



2D-view of iso- instantaneous pressure contours with the CFD/CAA coupling boundary (black line)

REFERENCES

[1] Léger, R., Peyret, C., and Piperno, S., Coupled Discontinuous Galerkin/Finite Difference Solver on Hybrid Meshes for Computational Aeroacoustics, AIAA Journal, Vol. 50, No. 2, pp. 338, 349, 2012.

[2] O. Labbé, C. Peyret, G. Rahier, and M. Huet, *A CFD/CAA coupling method applied to jet noise prediction*. Computers & Fluids 86 (2013) 1–13.