Euler - Navier-Stokes Iterative Coupling

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Abstract: Computations of aerodynamic sound generation can be classified into different strategies according to the extent of the CFD computational domain, where the Navier-Stokes equations are discretized, and the method used for computing the acoustics . Most CAA computations rely on an acoustic analogy and the so-called Kirchhoff surface surrounding the main acoustic sources to predict the far field. The linear theory inevitably breaks down when flow structures leave the computational domain. At one end of the strategies, the CFD computational domain includes only the near-field region where the main acoustic sources are located. At the other end, the CFD computational domain includes both the near-field and a large part of the acoustic field. For subsonic flows , some difficulties can arise with this last strategy due to the large extend of the CFD domain, the small energy level of the acoustic field and the precision of the numerical scheme or of the artificial computational boundary treatment.

In the proposed talk , we will compare closely a strategy based on Euler/Navier-Stokes couplings using Schwarz waveform relaxation methods , with the overset Chimera grid approach in which the CAA computational domain extends over the whole computational domain and so can be meshed with an uniform Cartesian grid. In this case, the embedded CFD computational domain can be meshed independently according to the scales which have to be taken into account; in the overlaid CAA-region, the nonlinear Euler equations in perturbation are discretized, the viscous effects being wrapped up in the source term through a defect-like formulation. In that region, the acoustics are computed twice, first in the CFD domain and secondly in the CAA domain: the reason being that some numerical schemes are good with CFD such as LES but can provide comparatively poor acoustics. Even if we use the same high order scheme like Discontinuous Galerkin in both domains, the limiters needed for the CFD computations deteriorate the pressure waves. Special attention will be paid to the multi-scale aspect requiring highly non conforming space-time discretization for which the discontinuous Galerkin approach is particularly well adapted.

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