High order simulation of rigid body motion induced aeroacoustics

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ABSTRACT

The numerical simulation of Fluid-Structure-Acoustics (FSA) problems is a challenge in applied science. Most simulations neglect the produced acoustics when considering the turbulent flow induced by the movement of an obstacle (rigid body) in a fluid. However, noise is an important factor in the design of machinery today as excessive or constant noise can pose severe hazards for health. For example, wind turbines can provide a significant contribution of clean energy, but they also produce some noise. More detailed simulations may help to design machinery with a lower noise emission. In this work, we present an approach that enables the simulation of acoustics emitted by the flow around a moving body with high-order methods. The simulation of the whole problem (near-field up to far-field) with the same equations is not feasible due to the high computational cost. To keep the computational costs in a reasonable frame but still allow the simultaneous consideration of all parts in the complex setup, we employ partitioned coupling. For this approach, we split the whole simulation domain according to the relevant physics into smaller parts. Each part is then solved with respect to its physical requirements. Hence different equations, scheme order, and spatial resolution are used in each. With this approach we assure, to solve the more complex and expensive equations, where they are needed and allow simplifications where it is allowed. This allows the direct simulation of the involved effects with minimised computational costs. To realise the communication between the individual parts, we use the coupling tool preCICE [1]. This library takes care of the data exchange and the interpolation of the state variables at the interfaces between the various parts.

For our simulations, we consider a simple test case and model the rigid moving body with an immersed boundary. This enables us to use the same high-order scheme for the modelling of the geometry as for the discretisation of the solution. We decompose the whole problem into parts with increasing distance from the obstacle. In the subdomain immediately around the moving body, we solve the full compressible Navier-Stokes equations. Further away, where viscous effects can be neglected, we use a subdomain where we solve the inviscous Euler equations. Finally, in the subdomain surrounding the others and representing the far-field, we only expect acoustic waves and solve the linearised Euler equations. With this approach we can make sure, to reduce the computational cost considerably while not compromising on the level of detail of the simulation.

REFERENCES

[1] Bungartz, Hans-Joachim and Lindner, Florian and Gatzhammer, Bernhard and Mehl, Miriam and Scheufele, Klaudius and Shukaev, Alexander and Uekermann, Benjamin *preCICE – A fully parallel library for multi-physics surface coupling.* Computers and Fluids, Elsevier, 2016