Hessisches Kompetenzzentrum
für Hochleistungsrechnen

# *Simulation of Aeroacoustic Effects Induced by Fluid-Structure Interaction*

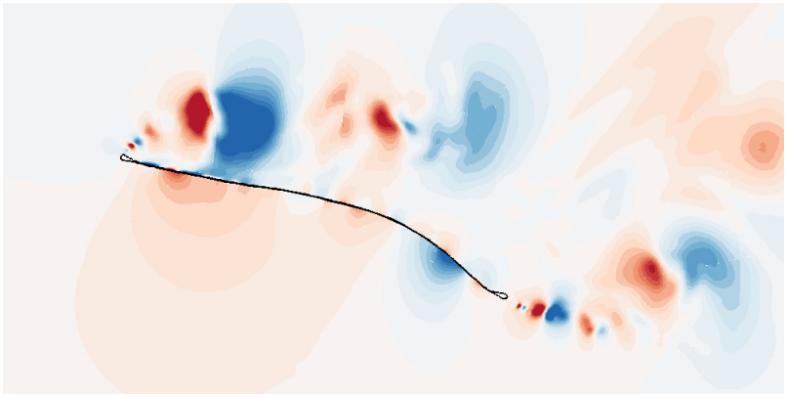


Figure 1: Distribution of acoustic source term around membrane airfoil.

## Introduction

Aerodynamic sound contributes significantly to the noise emission of high-speed applications such as trains, aircraft and wind turbines. The rapid growth of the computational power available enables the simulation of increasingly complex systems. In the research field of computational aeroacoustics, the simulation of flexible parts undergoing large deformations has become a key topic. The simulation of such multi-field problems requires a coupling between the scientific branches of fluid dynamics, structural mechanics and aeroacoustics.

## Methods

To simulate aerodynamic sound radiation from the low Mach number flow over flexible structures, we apply a partitioned computation approach. The structural mechanic problem is solved in the finite element solver CalculiX. The fluid problem is treated with a hydrodynamic/acoustic splitting technique in the finite volume solver FASTEST. Large eddy simulation enables an accurate resolution of large scale turbulent flow structures. Acoustic sources are derived from the incompressible flow field solution. The coupling library preCICE is used to exchange interface data.

## Results

In this project phase, we applied the developed computation approach to study the fluid-structure interaction and aerodynamic sound radiation of a membrane airfoil at high incidences. The results suggest a coupling between the membrane oscillation and large scale flow structures. The acoustic results indicate a mix of sound source mechanisms. The


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Project Term
2020 - 2021

Clusters
Lichtenberg Cluster Darmstadt

Software
FASTEST

Additional Software
CalculiX


Institute
Fachgebiet Numerische Berechnungsverfahren im Maschinenbau

University
Technische Universität Darmstadt

membrane oscillation was found to contribute significantly to the radiated sound.

## Discussion

Within this project, the coupling of the scientific branches of fluid dynamics, structural mechanics and aeroacoustics is investigated. The application of the developed approach to a complex problem such as a membrane wing has been demonstrated. We are currently investigating the numerical aspects that influence the quality of the large eddy simulation and their influence on the coupled solution.

## Publications

Kolb, E.; Schäfer, M.: Aeroacoustic simulation of flexible structures in low Mach number turbulent flows. Computers & Fluids, 227:105020, 2021 https://doi.org/10.1016/j.compfluid.2021.105020

## Reference

[1] Bungartz, H.J.; Lindner, F.; Gatzhammer, B.; Mehl, M.; Scheufele, K.; Shukaev, A.; Uekermann, B.: preCICE - A Fully Parallel Library for Multi-Physics Surface Coupling. Computers and Fluids, 141:250–258, 2016 https://doi.org/10.1016/j.compfluid.2016.04.003

[2] Dhondt, G: The Finite Element Method for Three-Dimensional Thermomechanical Applications, Wiley, 2004 https://onlinelibrary.wiley.com/doi/book/10.1002/0470021217

[3] Dong, S.; Karniadakis, G.E.: DNS of flow past a stationary and oscillating cylinder at Re=10000. Journal of Fluids and Structures, 20:519–531, 2005 https://doi.org/10.1016/j.jfluidstructs.2005.02.004

[4] Technische Universität Darmstadt, Institute of Numerical Methods in Mechanical Engineering, Darmstadt. FASTEST Manual, 2005

[5] Hardin J.C.; Pope, D.S.: An acoustic/viscous splitting technique for computational aeroacoustics. Theoretical and Computational Fluid Dynamics, 6:323–340, 1994 https://doi.org/10.1007/BF00311844

[6] Kornhaas, M.: Effiziente numerische Methoden für die Simulation aeroakustischer Probleme mit kleinen Machzahlen. Diss. Technische Universität Darmstadt, 2012

[7] Kornhaas, M.; Schäfer, M.; Sternel, D.C.: Efficient numerical simulation of aeroacoustics for low Mach number flows interacting with structures. Computational Mechanics, 55:1143-1154, 2015 http://dx.doi.org/10.1007/s00466-014-1114-1

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