Possible Topic for a MASTER THESIS OR STUDY PROJECT

at Brandenburg University of Technology (BTU) in Cottbus, Germany

Acoustic characterization of rough wall turbulent channel flows

Synopsis – Turbulence is an important source of sound radiation. Flow instabilities as well. Although Lighthill formulated the equations for sound generation based on the pressure wave equation back in the 1950s [1], it is only recently that the available computational power has achieved levels that allow detailed numerical evaluations. One example is a very recent investigation of sound generation in turbulent channel flows by means of Direct Numerical Simulations (DNSs) [2]. Although the insight given in [2] is remarkable, the high cost of such DNSs makes it almost unfeasible to test correlations between variables in a moderately large parameter space. This is a task that could be achieved in a more efficient way by the use of reduced order models. Some preliminary work has shed some ideas on the potential use of a selected reduced order stochastic turbulence model, the One-Dimensional Turbulence (ODT), on the study of sound generation by turbulence [3,4]. It is desired to bring new and relevant fundamental insights into the potential acoustic characterization of surface roughness. This considers sound generation due to: a) unbounded isotropic and homogeneous turbulence away from the walls (quadrupole sound sources), and b) flow forcing due to the effect of confined or bounded domains, as well as its compensation by shear, or the appearance of shear instabilities due to viscous stresses (dipole sound sources). The surface roughness has a considerable effect on the near wall shear in this regard, i.e., the effect of the roughness function. Specific interest lies here then on the verification of the accuracy of sound generation estimates by means of the reduced order stochastic ODT model. To that extent, anyone of the following modalities is possible:

- **a) Master Thesis (1 semester):** In this case the student will focus on the capabilities of ODT for the evaluation of rough wall channel flows.
- **b) Study Project (2 semesters):** Same as a), but the student will also develop and validate an approach for sound generation using the flow field generated with the standalone ODT model.
- **c) Study Project and Master Thesis (3 semesters):** Same as b). Additionally, the student will evaluate rough wall channel flows with the three-dimensional hybrid Large Eddy Simulation (LES) extension of ODT, ODTLES [5]. In this sense, a comparison of the approach developed for sound generation by the flow field, and the obtained pressure fluctuations in ODTLES is desired.

[1] Lighthill (1952), *Proc. R. Soc. Lond. A* **211**, 564-587 — [2] Hu, Morfey and Sandham (2003), *J. Fluid Mech.* **475**, 269-302 — [3] Sharma *et al.*, *Phys. Fluids* **34**:085134 — [4] Medina Méndez *et al.*, 20. STAB-Workshop, November 16-17 (2021), Göttingen, Germany. Book of Abstracts, `https://www.dlr.de/as/Portaldata/5/Resources/dokumente/veranstaltungen/stab_workshop/STAB-Jahresbericht-2021.pdf` — [5] Glawe *et al.* (2019), *Z. Angew. Math. Mech.* **98**, 1907-1923

Tasks

- Review of relevant literature and theoretical foundations
- Code development, compilation and testing
- Visualization, post-processing, and data analysis of numerical simulation data
- Comparison of simulation results with relevant reference data

Desired skills and requisites

- Solid knowledge of fundamentals of fluid mechanics and acoustics
- Affinity to programming (preferably Python and C/C++)
- Scientific attitude (curiosity, self-motivation, and critical reasoning)
- Experience with data analysis, numerical simulation and modeling, or CFD is an asset
- **For the intended take of the Master Thesis:** The student must have approved the modules of Turbulence Modeling, CFD 1 and Engineering Acoustics.
- **For the intended take of the Study Project:** The student is required to take the modules of Turbulence Modeling, CFD 1 and Engineering Acoustics in parallel to the project time frame.

Contact information:

Dr.-Ing. Juan Medina E: medinjua@b-tu.de T: +49-355-69-6033

Dr.-Ing. Sparsh Sharma E: sparsh.sharma@b-tu.de

Chair of Numerical Fluid and Gas Dynamics, Brandenburg University of Technology (BTU)
Siemens-Halske-Ring 15A, D-03046 Cottbus, Germany

URL: https://www.b-tu.de/en/fg-stroemungsmodellierung