Reduced-order modelling of wind turbine noise: towards quiet turbines

Student Project Proposal

APPLY

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Short description of the project:

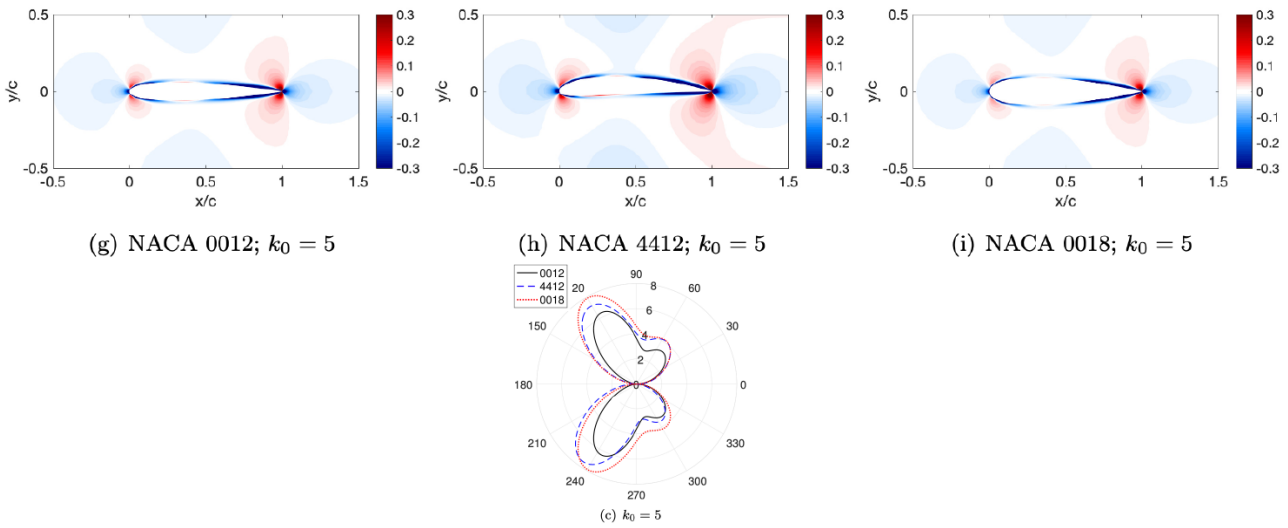
Wind-turbine noise sometimes limits the available location for installation, the number of turbines that can be deployed, and in some cases the amount of energy that can be harvested. Minimizing emitted noise is thus critical in the development of the next generation of turbines. To this end, accurate prediction of noise emission is required, but the cost of current high-fidelity prediction methods hinders their use for optimization. Reduced-order models that can predict noise directivity and the associated sources and guide noise-abatement strategies are required. To be effective, such models need to capture the dominant physical mechanisms behind noise generation. Linearized equations have been used with success in the past decade to predict and model turbulent structures in many different flows [1], successfully capturing the key physical mechanisms at play. The approach consists in identifying flow disturbances that are optimally amplified by the system, and which thus tend to dominate its dynamics. This modelling approach has thus the potential to efficiently model the noise from wind-turbine blades. Preliminary investigations on the acoustic scattering of airfoils, using this linearized technique, have been conducted [2, illustrated in figure 1], but qualitative and quantitative validation of the method against experimental data on canonical and realistic profiles is lacking. The goal of this project is to identify the dominant noise sources and their corresponding sound directivities and validate results against experimental measurements. Canonical profiles, such as NACA0012, and profiles currently in use in the wind energy sector, will be investigated. The project will be developed in close collaboration with Institut Pprime, France.

[1] B. J. McKeon, 'A basis for flow modelling', Journal of Fluid Mechanics, vol. 904, p. F1, 2020, doi:10.1017/jfm.2020.728.

[2] L. I. Abreu, P. A. S. Nogueira, M. M. Nilton, and A. V. Cavalieri, 'Resolvent analysis applied to acoustic analogies', in 25th AIAA/CEAS aeroacoustics conference, 2019, p. 2402.

Keywords

Wind turbine noise, Noise modelling, Aerofoil noise emission, Acoustic array.



(g) NACA 0012; $k_0 = 5$ (h) NACA 4412; $k_0 = 5$ (i) NACA 0018; $k_0 = 5$

(c) $k_0 = 5$

Figure 1: Dominant noise sources (top) and their directivities for three different airfoils (bottom) [2].