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Effect of Mach Number for Gust-Airfoil Interatcion Noise

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Abstract : The interaction of turbulence with airfoil is an important noise source in many engineering fields, including helicopters, turbofan, and contra-rotating open rotor engines, where turbulence generated in the wake of upstream blades interacts with the leading edge of downstream blades and produces aerodynamic noise. One approach to study turbulence-airfoil interaction noise is to model the oncoming turbulence as harmonic gusts. A compact noise source produces a dipole-like sound directivity pattern. However, when the acoustic wavelength is much smaller than the airfoil chord length, the airfoil needs to be treated as a non-compact source, and the gust-airfoil interaction becomes more complicated and results in multiple lobes generated in the radiated sound directivity. Capturing the short acoustic wavelength is a challenge for numerical simulations. In this work, simulations are performed for gust-airfoil interaction at different Mach numbers, using a high-fidelity direct Computational AeroAcoustic (CAA) approach based on a spectral/hp element method, verified by a CAA benchmark case. It is found that the squared sound pressure varies approximately as the 5th power of Mach number, which changes slightly with the observer location. This scaling law can give a better sound prediction than the flat-plate theory for thicker airfoils. Besides, another prediction method, based on the flat-plate theory and CAA simulation, has been proposed to give better predictions than the scaling law for thicker airfoils.

Keywords : aeroacoustics, gust-airfoil interaction, CFD, CAA
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