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LES prediction of wall-pressure fluctuations and noise of a low-speed airfoil

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The wall-pressure fluctuations and noise of a low-speed airfoil are computed using large-eddy simulation (LES). The results are compared with experimental measurements made in an open-jet anechoic wind-tunnel at Ecole Centrale de Lyon. To account for the effect of the jet on airfoil loading, a RANS calculation is conducted in the full wind-tunnel configuration, which provides velocity boundary conditions for the LES in a smaller domain within the potential core of the jet. The flow field is characterized by an attached laminar boundary layer on the pressure side and a transitional and turbulent boundary layer on the suction side. The predicted unsteady surface pressure field shows reasonable agreement with the experimental data in terms of frequency spectra and coherence in the trailing-edge region. In the nose region, characterized by unsteady separation and transition to turbulence, the wall-pressure fluctuations are highly sensitive to small perturbations and difficult to predict or measure with certainty. The LES, in combination with the Ffowcs Williams and Hall solution to the Lighthill equation, also predicts well the radiated trailing-edge noise. A finite-chord correction is derived and applied to the noise prediction, which is shown to improve the overall agreement with the experimental sound spectra.