AEROACOUSTIC SOURCE TERMS IN TURBULENT FLOW: DIRECT NUMERICAL SIMULATION RESULTS

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Lighthill's acoustic analogy is formulated for turbulent channel flow with pressure as the acoustic variable, and integrated over the channel width to produce a two-dimensional inhomogeneous wave equation. The equivalent sources consist of a dipole distribution related to the sum of the viscous shear stresses on the two walls, together with monopole and quadrupole distributions related to the unsteady turbulent dissipation and Reynolds stresses respectively. Using a rigid-boundary Green function, an expression is found for the power spectrum of the radiated far-field pressure in the channel. Direct numerical simulations (DNS) of turbulent plane Poiseuille and Couette flow have been performed in very large computational domains in order to get good resolutions of the low-wavenumber source behaviour. Analysis of the DNS databases for all sound radiation sources shows that their wavenumber—frequency spectra have non-zero limits at low wavenumber. The dipole far-field intensity is proportional to Mach number squared, while the monopole and quadrupole contributions are proportional to the fourth power of Mach number. Below a particular Mach number determined by the frequency and radiation direction, the dipole radiation due to the wall shear stress dominates the far field. The quadrupole takes over at Mach numbers above about 0.1, while the monopole is always the smallest term.

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