Center for Environmental & Applied Fluid Mechanics

"Boundary-Layer Noise Due to Surface Irregularities"

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Flow noise from turbulent boundary layers is of concern in many applications. Although sound radiation from a smooth-wall boundary layer is generally weak, it can be enhanced by surface irregularities, such as roughness, steps and gaps. At low Mach numbers, direct computation of boundary-layer noise is prohibitively expensive, and the use of an aeroacoustic theory coupled with high-fidelity simulations of the source field is necessary. In this talk I will discuss first some computational and modeling issues for boundary-layer noise, followed by recent studies involving boundary-layer flows over hemispherical roughness elements and steps using large-eddy simulation and Lighthill's theory. Noise generation mechanisms are investigated in terms of source distributions relative to flow structures and the Green's function structure. In the case of roughness-induced noise, sound production is dominated by unsteady drag dipoles, with the spanwise component at least as strong as the streamwise one. These dipole sources are produced primarily by the impingement of incoming turbulent eddies on a hemisphere and their interaction with vortical structures produced by the hemisphere. The viscous contribution to sound production is negligible, and vortex shedding behind the hemisphere is important only to the extent that it produces stronger turbulence impinging on the downstream roughness elements. For flow over steps, the numerical study provides a clear and quantitative explanation to the previous experimental observation that a forward-facing step is significantly noisier than a backward-facing step.

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