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Editorial

Recent Advances in Aeroacoustics

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Acoustics is one of the oldest examples of applied research, long before the term was even coined: witness the concept of musical scales by the ancient Greeks and the construction of musical and other sound instruments in most civilizations through the ages. Compared with sound in the strict sense of small pressure perturbations in a homogeneous, non-dissipative medium at rest, modern aeroacoustics has a much broader scope, mostly driven by the unrelenting progress of aerospace science and technology as a provider of fast and safe transport of passengers and cargo and as a platform for sensors and exploration.

The problem of sound generation by the flow through an orifice relates to musical instruments like the flute, and gains new dimensions with bias flows through acoustic liners and jets used for flow control. Strictly speaking, acoustic waves as pressure perturbations of a potential homentropic flow are modified, due to vortex shedding by the orifice. That leads to the presence of vortical modes. The combination of analytical and numerical methods provides complementary insight into the problem.

A fluid in the absence of external forces can support three types of waves: (i) sound due to homentropic potential perturbations; (ii) vortical modes due to shear and swirl; (iii) entropy modes associated with heat exchanges and inhomogeneities. The gravity/Coriolis/magnetic forces in a stratified/rotating/ionized fluid would add internal/inertial/magnetic modes respectively. Within the context of acoustic-vortical-entropy modes, the inclusion of viscosity is important as concerns decay of vorticity and sound absorption (that would also be affected by heat conduction). The use of various forms of the Navier-Stokes (NS) equations in CFD (Computational Fluid Dynamics) can be coupled to the identification of the sources of sound in CAA (Computational Aeroacoustics). A good example of CFD/CAA applied to the NS equations is noise generation by a vortex ring.

The environmental objectives of low noise footprint are not always easy to combine with high fuel efficiency; the latter is not just an economic benefit, it also reduces emissions that are another environmental concern. The significant reductions in aircraft noise in the last 50 years since the beginning of the jet age have been associated with turbofan engines of increasing bypass-ratio in a win–win situation: (a) lower fuel consumption due to the higher efficiency of a larger mass flux at lower average speed for the same thrust; (b) a slower and colder by-pass flow shielding the noise from a hot high-speed core jet. As the by-pass ratio increases well beyond 10:1 the size and weight of a nacelle detract from the efficiency; the counter-rotating open rotor balances torque and provides higher fuel efficiency, leading to a complex acoustic signature due to the wake of one rotor impinging on the other.

One of the major developments in electromagnetic theory in the last decades is the development of "stealth" technologies that combine wave absorption with tailoring of the reflection pattern, to minimize energy scattered in certain critical directions. The demonstration of reductions in radar cross-section (RCS) of several orders of magnitude in specific directions is an incentive to try likewise in acoustics, rendering sound sources "almost inaudible" in sensitive directions. A related topic is metamaterials, whose properties can be selected for synthesis instead of being restricted to what nature provides, sometimes in small qualities and at high cost. The use of metamaterials in acoustics is a rather novel prospect.

Aeroacoustics involves an appealing combination of traditional longstanding research and modern technological progress.

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