

# 1. Introduction

Aeroacoustic problems are by nature very different from standard aerodynamics and fluid mechanics problems. Before discussing how to solve aeroacoustics problems numerically or simulate them computationally, an approach generally referred to as Computational Aeroacoustics (CAA), it is important to recognize and to have a good understanding of these differences. These differences pose a number of major challenges to CAA. A few of the important computational challenges are listed below.

- a. Aeroacoustics problems, by definition, are time dependent, whereas aerodynamics and fluid mechanics problems are generally time independent or involve only low frequency unsteadiness.
- b. Aeroacoustics problems typically involve frequency range that spreads over a wide bandwidth. Numerical resolution of the high frequency waves becomes a formidable obstacle to accurate numerical simulation.
- c. Acoustic waves usually have small amplitudes. They are very small compared to the mean flow. Oftentimes, the sound intensity is five to six orders smaller. To compute sound waves accurately, a numerical scheme must have extremely low numerical noise.
- d. In most aeroacoustics problems, interest is in the sound waves radiating to the far field. This requires a solution that is uniformly valid from the source region all the way to the measurement point at many acoustic wavelengths away. Because of the long propagation distance, computational aeroacoustics schemes must have minimal numerical dispersion and dissipation. Also, it should propagate the waves at the correct wave speeds and is isotropic irrespective of the orientation of the computation mesh.
- e. In general, flow disturbances in aerodynamics or fluid mechanics problems tend to decay exponentially fast away from a body or their source of generation. Acoustic waves, on the other hand, decays very slowly and actually reach the boundaries of a finite computation domain. To avoid the reflection of outgoing sound waves back into the computation domain, radiation boundary conditions must be imposed at