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Nonlinear Analysis of Sound Generation and Propagation in non-Uniform Flow

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Abstract

The linear acoustics is widely used for modeling of propagation of sound generated by airframe such as multi-element airfoil or helicopter blade. The limits of applicability of linear acoustics model will be discussed in the presentation by comparison with non-linear numerical model. Propagation of acoustic waves caused by vortex-body interaction in a non-uniform subsonic flow is numerically investigated by using high-order compact scheme. Flow around rigid cylinder is taken as a prototype of real-world flows around airframe configurations with strong gradients of mean pressure and velocity. Since the ratio of vortex core size to the downstream rigid body may vary from zero to infinity, two various vortex core size were considered: (a) core size is much smaller than the rigid cylinder diameter, and (b) core size is comparable with the cylinder diameter. As the vortex core size increases, the contribution to the sound generation by the second-order nonlinear terms becomes more important. The influence of non-linearity on the directivity and amplitude of wave propagation has been studied for both zero-circulation Taylor vortex model and non-zero circulation Vatistas vortex model. In the last part of presentation, we apply our analysis to sound generation and propagation by cavity in yaw with the flow. Experimental data suggest strong amplification of sound for some yaw angles.

Keyword: Sound generation, Non-linearity, Aeroacoustics, Vortex-body interaction