論文の内容の要旨

Abstract of Dissertation

論文題目：Noise Radiation and Self-sustained Oscillations in Supersonic Cavity Flows

和訳（超音速キャビティ流れにおける自励振動と音響波発生に関する研究）

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Noise radiation and self-sustained oscillations in supersonic cavity flows are numerically investigated with high-fidelity implicit large-eddy simulations.

The mechanism driving the self-sustained oscillations in supersonic cavity flows is verified to be a feedback-loop mechanism between the shear-layer instability and acoustics disturbances. Large-scale shedding vortices at the cavity leading edge are generated by the excitation of feedback compression waves. The generation mechanism of the feedback compression waves is comprehensively discussed. The successive passage of large-scale vortices over the trailing edge, associated with periodical vorticity productions and pressure oscillations, results in a noise source radiated from the trailing edge. While the higher-speed fluid impinging on the aft wall is less related to the generation of the feedback compression waves. In the supersonic laminar cavity flows, it is the first time to address that the reflection of Mach waves at the cavity aft wall has significant contributions to the generation of feedback compression waves.

The noise radiation in supersonic cavity flows is a strong function of the upstream boundary-layer. The supersonic cavity flow with laminar upstream provides much stronger oscillations and noise than that with turbulent upstream, and this effect is global in all cavity walls. The upstream boundary-layer thickness has critical impacts on the dominant mode of the cavity tones. The dominant mode is varied to a lower-frequency mode if the upstream boundary-layer increases. While the amplitude of the cavity tones is not always decreased with the increase of upstream boundary-layer thickness. The existence of turbulent disturbances has significantly impacts both on the dominant mode and the amplitude of the cavity tones, and it can not be ignored in the simulation of turbulent cavity flows.

Upstream mass blowing is an effective and adaptive approach for supersonic cavity noise control. Two primary mechanisms are addressed for the noise suppression with upstream mass blowing: lifting up of cavity shear-layer and increase of the shear-layer thickness. Steady upstream mass blowing is more effective than that with low-frequency pulsed mass blowing. Significant noise suppression is observed with steady mass blowing. However, with the pulsed mass blowing, no significant noise attenuation is observed in resonant noise; almost no effect is found on the suppression of broadband noise.