Abstract #XXX *(to be filled by the organizers)*
Preferred Topics: AEROFLIPHY
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Type: Oral
Status of corresponding author: Regular

Modeling periodic evolution of aero-optical caused by supersonic mixing layer

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Abstract

For all kinds of precision-guided weapons, infrared imaging guidance is one of the main guidance systems to achieve accurate attack. However, the complex flow structures around the optical window such as mixed layer will produce such as target image offset, blur and jitter, and this phenomenon is called aero-optical effects, which is one of the important factors affecting the guidance accuracy of the high-speed weapons and it has become a research hotspot. The supersonic mixing layer is taken as the research object in this dissertation, especially focus on the flow characteristics of vortices in the supersonic mixing layer, spatial and temporal evolution of aero-optical effects as well as the control methods of the aero-optical effects. The relationship between the aero-optical effects of the supersonic mixing layer and the vortices in flow field is revealed, and the mechanism of aero-optical effects of the supersonic mixing layer is studied.

Firstly, the large eddy simulation method is used for numerical simulation. Secondly the ray tracing method is used to simulate the aero-optical effects. Finally, an aero-optical periodic evaluation of the mixing layer is carried out. The results show that there is a remarkable correspondence between the vortex structure of the mixing layer flow field and the minimum optical path difference. The aero-optical effects of mixing layer with low velocity ratio are more serious than the others flow fields. The vortices inside mixing layers impose remarkable aero-optical distortions on a beam even at moderate subsonic speeds. Knowledge about aero-optical effects caused by vortices in the flow field, especially their periodic evolution, is limited for supersonic mixing layers because the flows have very high speeds. the periodic evolution of aero-optical effects caused by vortices in the supersonic mixing layer was investigated.

This paper summarizes the periodicity of the aero-optical induced by the supersonic mixing layer. A trigonometric function model is used to predict the periodicity of the evaluation parameters of aero-optics effects. The results show that the periods and amplitudes of image offset and BSE (bore-sight error) are different with different convective velocity. When the convective velocity is less than 0.8Ma, the prediction model is in good agreement with the numerical results. When the convective velocity increases, the predicted periodicity relationship becomes less consistent with the actual numerical simulation results. When the convective velocity approaches the speed of sound, the simulation value is no longer periodic, and the result becomes chaotic. The model is no longer suitable for predicting aero-optical effect parameters.

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