ON NONLINEAR WAVE INTERACTION IN SPANWISE MODULATED SUPERSONIC BOUNDARY LAYER

A.D. Kosinov, A.V. Panina, N.V. Semionov, Yu.G. Yermolaev

Khristianovich Institute of Theoretical and Applied Mechanics SB RAS
630090, Novosibirsk, Russia

Usage of the controlled disturbances technique to study the nonlinear interaction mechanisms of unstable waves in a supersonic boundary layer is a preferable method. The paper is devoted to investigation of nonlinear wave train development in the spanwise modulated flow of the supersonic boundary layer. By this method the subharmonic and oblique breakdown mechanisms were detected in real competition. The investigations continue the series of experiments that were conducted before. The experiments were conducted in low noise T-325 supersonic wind tunnel of ITAM SB RAS at Mach 2 and unit Reynolds number $Re_1 = 5\times10^6$ m^{-1}. Source of artificial disturbances was built in the model at x =37 mm from the leading edge. Controlled pulsations are generated in boundary layer through aperture in diameter of 0.4 mm by glow discharge in chamber at high frequency. Two roughness elements were placed on the surface model to get spanwise modulation of mean flow in boundary layer. It was found that source of disturbance generates pulsations of fundamental and subharmonic frequency. Roughness elements generate spanwise flow nonuniformity about 5% (pick-to-pick). Due to flow modulation nonlinearity of wave train development is observed from x = 80 mm. We can say that both nonlinear mechanisms start at this x-position. It is determined that oblique breakdown mechanism origins in center of fundamental wave train. Similar results were obtained before for subharmonic resonance for smooth surface and also here. In physical space it looks (very similar one to other for both) as stable waves in wave train center. It corresponds to small scale amplitude modulation in spanwise distributions at center of wave trains. As the results of nonlinear interactions the strong inclined waves at $|\beta|$ = 2 rad/mm are exited for subharmonic and fundamental wave train. There is also quasi two dimensional disturbance growth that may explain by mean flow distortion. The spanwise flow modulation can lead to competition of subharmonic and oblique breakdown mechanism.

Keywords: supersonic boundary layer, spanwise modulated boundary layer, laminar-turbulent transition, aerodynamic experiment, nonlinear stability.