Visualization of sinusoidal and varicose instabilities of streaks in a boundary layer

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Nonlinear instabilities of boundary layer streaks is investigated experimentally. Extensive measurements visualizing the sinusoidal and varicose instabilities of streaky structures at the nonlinear stage of the breakdown process in boundary layer are presented. The flow behaviour in the course of spatial evolution of the streaky structures with a secondary high-frequency disturbance generated on them is discussed. Various scenarios of origination and development of coherent vortex structures examined in physical experiments are considered. Specific features of the development of sinusoidal and varicose cases of destruction of the steady streamwise streaks are demonstrated, such as transverse and streamwise modulation of the structure by the secondary-disturbance frequency, appearance of new streaky structures in the downstream direction, and emergence and evolution of unsteady Λ-shaped structures localized in space in both cases. It is shown that streak secondary high-frequency instability of sinusoidal and varicose types at nonlinear stage leads to the dispersion of the disturbed regions via the process of multiplication of streaky structures. The mechanism of the nonlinear streak destruction by means of the development of secondary disturbance is related to the formation of coherent structures resembling Λ-vortices for both sinusoidal and varicose modes of instability. It is shown that the Λ-vortices multiply in the transverse direction in the course of downstream evolution of the disturbance.

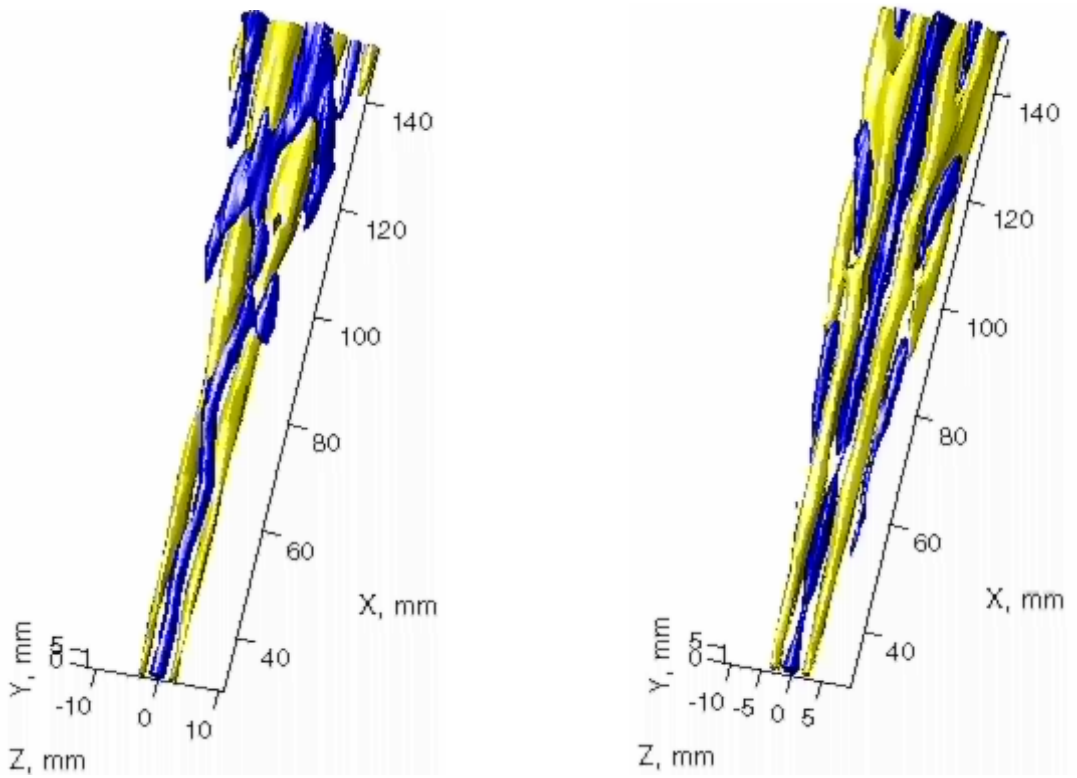

Fig. 1. Hot-wire visualizations of streak breakdown via development of the sinusoidal (*left*) and varicose (*right*) secondary modes in flat plate boundary layer. Iso-surfaces of total streamwise velocity disturbance are shown. Light iso-surfaces are used for the positive perturbations and dark for negative.

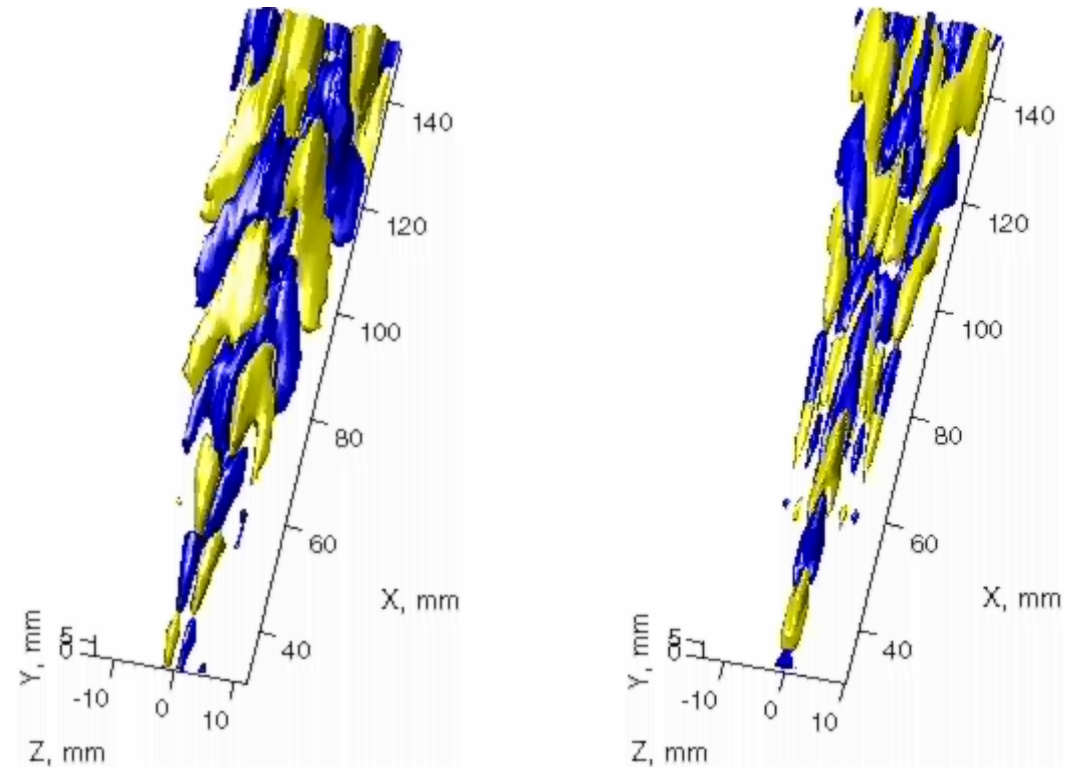

Fig. 2. The sinusoidal (*left*) and varicose (*right*) secondary modes in flat plate boundary layer. Iso-surfaces of the non-stationary part of streamwise velocity disturbance are shown. Light grey iso-surfaces are used for the positive perturbation and dark for negative.