Abstract Submitted
for the DFD20 Meeting of
The American Physical Society

Bypass transition in flow over a vibrating flat plate WENLIN HUANG, ZHIHENG WANG, Xi'an Jiaotong University, XUERUI MAO, University of Nottingham, GUANG XI, Xi'an Jiaotong University — The development of free-stream disturbances in flow over a vertically vibrating flat plate with a slender leading edge is investigated. The evolution of the optimal inflow perturbation that results in the maximum amplification is computed to remark the impact of the plate vibration on the development of free-stream disturbance, secondary instability of streaks and subsequently the bypass transition to turbulence. It is observed that the plate vibration leads to periodic change of the angle of attack, shifting the free-stream disturbance to the upper or lower side of the plate. Therefore, the development of steady inflow perturbations, which receive the largest amplification, is interrupted by the vibration, and the perturbation amplification via the lift-up mechanism is weakened. The vibration brings a second peak of perturbation growth at the vibration frequency, leading to high-frequency free-stream perturbations penetrating into the base boundary layer, which is not observed in flow over a stationary plate owing to the sheltering mechanism. This resonance of the flow perturbation and the vibrating plate is explained by the staggering effect of the leading edge. Further, the vertical vibration of the plate leads to streamwise periodic vorticity near the edge of the boundary layer. This inhomogeneity of the streamwise vorticity brings about streamwisely localised distortion of the low-speed streaks and thus an intermittent secondary instability. Therefore, before the streaks break down to turbulence, they undergo several rounds of secondary instabilities, resulting in an elongated bypass transition process.

Wenlin Huang
Xi'an Jiaotong University

Date submitted: 03 Aug 2020 Electronic form version 1.4