Effect of uniform blowing/suction in spatially developing turbulent boundary layers

Yukinori KAMETANI, Institute of Industrial Science, The Univ. of Tokyo., Komaba 4-6-1, Meguro-ku, Tokyo, 153-8505 Japan, <yukkam@iis.u-tokyo.ac.jp>
Koji FUKAGATA, Dept. Mechanical Engineering, Keio Univ., Hiyoshi 3-14-1, Yokohama, Kanagawa, 223-8522 Japan, <fukagata@mech.keio.ac.jp>
Ramis ÖRLÜ, Linné FLOW Centre, KTH Mechanics, Osquars Backe 18, SE-100 44 Stockholm, Sweden, <ramis@kth.mech.se>
Philipp SCHLATTER, Linné FLOW Centre, KTH Mechanics, Osquars Backe 18, SE-100 44 Stockholm, Sweden, <pschlatt@kth.mech.se>

A number of well-resolved large-eddy simulations of a spatially evolving turbulent boundary layer with uniform blowing or suction is performed in order to investigate the effect on skin friction drag as well as turbulence statistics and spectral composition at moderate Reynolds numbers up to $Re_\theta = 2500$, based on the free-stream velocity and the momentum thickness. The amplitude of uniform blowing or suction is set to be 0.1% of the free-stream velocity with different streamwise ranges of the controlled region as depicted in Fig. 1.

Through spectral analysis of the cross-spectra of the Reynolds shear stress , the enhancement and reduction of the fluctuation energy in the outer region by blowing and suction are found, respectively, as shown in Fig. 2. It is also found that the emergence of a second peak in the outer region is promoted by blowing, while it is inhibited in the case of suction. In spite of the weak amplitude of the control, more than 10% of drag reduction and enhancement are achieved by means of blowing and suction, respectively, as shown in Fig. 3. In the case of blowing, where drag reduction is achieved, the mean drag reduction rate increases as the blowing region extends because the local reduction rate, i.e. the streamwise gradient of the mean drag reduction rate, grows in the streamwise direction. The net-energy saving rate and the control gain have the same trends.

Reference

[1]Y. Kametani, K. Fukagata, R. Örlü and P. Schlatter, "Effect of uniform blowing/suction in a turbulent boundary layer at moderate Reynolds number," *Int. J. Heat Fluid Flow* **55**, pp. 132-142. (2015)

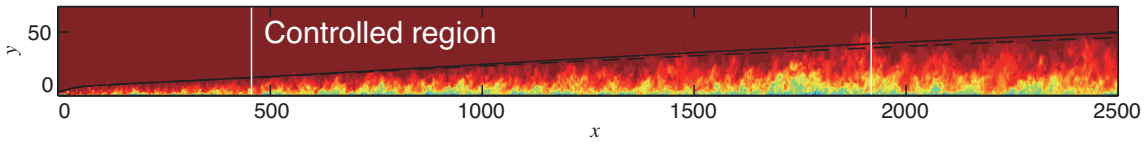

Fig. 1 Instantaneous streamwise velocity in the blowing-controlled case [1]

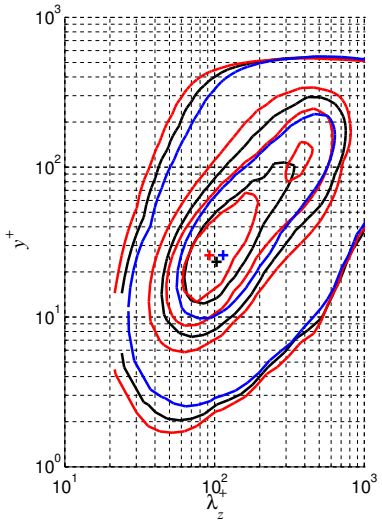

Fig. 2 Cross-spectra of Reynolds shear stress at $Re_{\theta,nc} = 1800$[1]

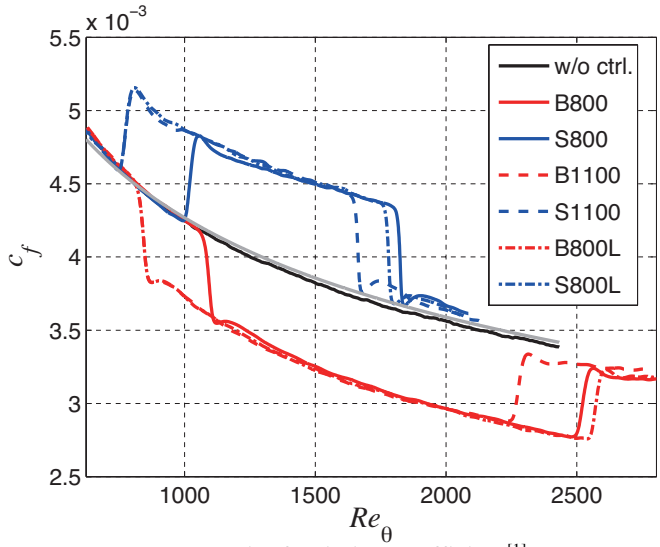

Fig. 3 Friction coefficient[1]