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Simultaneous achievement of drag reduction and heat transfer augmentation in wall turbulence by optimal control theory AKIRA YAMAMOTO, YOSUKE HASEGAWA, NOBUHIDE KASAGI — The analogy concept between momentum and heat transfer, which is based upon the similarity between the Navier-Stokes and energy transport equations, has been widely used for analyzing turbulent transport phenomena. This fact implies inherent difficulty in enhancing heat transfer with pumping power reduced or not increased as much as heat transfer. We consider a fully developed turbulent channel flow with uniform heat generation in the fluid, so that the averaged transport equations have an identical form. The problem thus posed offers the most difficult challenge to achieve dissimilar momentum and heat transfer. Even under such a difficult condition, we demonstrate that the dissimilar control is possible if we exploit the continuity constraint on the velocity field. In order to optimize the control input, i.e., wall blowing/suction, the optimal control theory developed by Bewley et al. (2001) is applied. By defining the cost functional as a weighted sum of the intensity of the wall blowing/suction and the analogy factor, i.e., the ratio of wall heat flux and skin friction, the analogy factor increases more than double beyond that in the uncontrolled flow. It is also found that the resultant optimized control input exhibits a downstream traveling wave-like property.

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