JOHNS HOPKINS
Center for Environmental & Applied Fluid Mechanics

Weekly CEAFM Seminar: Fall 2011

Friday, November 18, 2011
11:00 a.m. – 11:30 a.m.
Gilman 50 (Marjorie M. Fisher Hall)

"Optimal Control of Turbulent Transport Phenomena for Effective Energy Utilization"

Presented by
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Abstract: Enhancement of turbulent heat and mass transfer is extremely important for improving energy efficiencies of various thermo-fluids systems supporting the human life. In meanwhile, wall skin friction, which necessitates pumping power to drive a working fluid, always needs to be reduced, since the applied pumping power is eventually dissipated by the fluid viscosity, and therefore results in the energy consumption. However, a wide applicability of the Reynolds analogy between turbulent momentum and heat transport implies inherent difficulty in diminishing or enhancing skin friction and heat transfer independently.

In the present study, we introduce the optimal control theory for achieving a dissimilar control of enhancing heat transfer, while keeping the skin friction not increased considerably in a fully developed channel flow. The Frechet differentials derived under the condition of zero-net-mass-flux wall blowing/suction clearly show that the responses of velocity and temperature fields to a given control input are quite different due to the fact that the velocity is a divergence-free vector while the temperature is a conservative scalar. This essential difference allows us to achieve dissimilar heat transfer enhancement even in flows where the averaged momentum and energy transport equations have the identical form. Based on these results, a simple open-loop strategy for dissimilar control is proposed and assessed.

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