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Cristian García Bauza, Pablo Lotito, Lisandro Parente, Marcelo Vénere (Eds.)
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DNS STUDY OF AXIAL VELOCITY AND TEMPERATURE DISSIMILARITY IN PERTURBED TURBULENT CHANNEL FLOW

Hugo D. Pasinato

Dpto. Ing. Química, Facultad Regional Neuquén-UTN, Plaza Huincul, hpasinato@uacf.utn.edu.ar

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Abstract. The dissimilarity, or breakdown of Reynolds analogy, between axial velocity and temperature in perturbed turbulent channel flow is studied using direct numerical simulation (DNS). The main goal is to look at the dissimilarity between the mean turbulent fluxes of axial velocity and temperature. Different numerical experiments were performed for which two parallel DNSs are accomplished: one with periodic boundary conditions and the other with inflow-outflow boundary conditions, which is locally perturbed using blowing/suction, and adverse/favorable pressure gradient step. Most results are for a Reynolds number based on the wall parameters equal to 150, but also some results for a relatively high Reynolds of 300 are presented. The temperature is considered to be a passive scalar; thus, the results are also valid for mass transfer. All results are for a molecular Prandtl number equal to 1. A uniform energy source in the domain is used in order to generate the thermal field.

The main results show that turbulence is responsible for a minor part of the mean field dissimilarity when compared to convection, and the pressure gradient, at least for the low Reynolds numbers and the type of perturbations used in the present work. In magnitude, the contribution of turbulence to the mean axial velocity and temperature dissimilarity is mostly because of the differences between the momentum and thermal turbulent wall normal fluxes. The contribution of momentum and thermal turbulent axial fluxes to mean field dissimilarity is lower. From the conservation law for the difference of the momentum and thermal turbulent wall normal fluxes, the results show that the leading contributors to this difference are the production terms, revealing that the major contribution to wall normal stresses dissimilarity is primarily from the dissimilarity in the mean flow. From previous results, a simple model for turbulent heat transfer is presented. Some *a priori* tests of this model show a reasonable performance for the type of perturbation and Reynolds numbers used in this work.