A Dynamical Transport Theory of Wall-Bounded Turbulent Flows

T.-W. Lee[a] and J.E. Park[a]

There are few theories that fully describe the turbulence in wall-bounded flows. Most rely on modelling (eddy viscosity, Reynolds stress) or approximations (large-eddy, restricted non-linear) with varying degrees of agreement with data. In a recent series of works[1-3], we demonstrate that by applying the conservation principles to a control volume moving with the mean flow turbulent flows are amenable to dynamical analysis. One outcome is the transport equation for the Reynolds shear stress:

$$\frac{d(u'v')}{dy} = -C_{11}U\frac{d(u'^2)}{dy} + C_{12}U\frac{dv'^2}{dy} + C_{13}\frac{d^2u'}{dy^2} \qquad (1)$$

Other components of the Reynolds stress tensor can be written in a similar manner, which in conjunction with Reynolds-averaged Navier-Stokes equation can be used to complete prescription of wall-bounded turbulent flows. In addition, self-similar behaviour appears in the gradient structures, which will be discussed in the full paper.

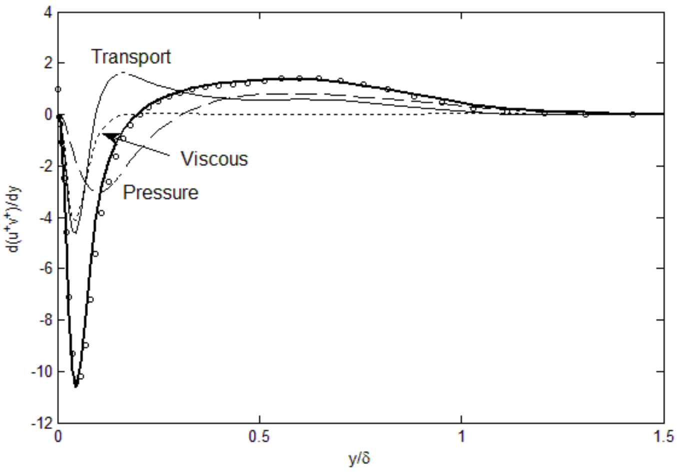

Figure 1. *Validation of the turbulent transport equation (Eq. 1) with DNS data. Transport (C_{11} term), pressure (C_{12}) and viscous (C_{13}). These three processes combine to form du'v'/dy structure.*

[1]Lee, *Physics of Fluids*, **33**, 055105 (2021).
[2]Lee, Progress in Turbulence IX, 237 (2022).
3.Lee and Park, *Entropy,* **21**, 11 (2021).

[a] Mechanical and Aerospace Engineering, SEMTE, Arizona State University, Tempe, AZ, USA