Weekly CEAFM Seminar: Fall 2015

JOHNS HOPKINS
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Date: **Friday, September 11, 2015**

Time: 11:00 AM

Location: Gilman Hall # 132

Speaker: **Prof. James Wallace** (University of Maryland - College Park)

Title: ***"Taylor's Hypothesis in Turbulent Channel Flow Considered using a Transport Equation Analysis" and "Boundary Layer Turbulence in Transitional and Developed States"***

Abstract

This presentation will be in two parts.

(1) DNSs of turbulent channel flow at Re_τ = 205 and 932 were used to examine the "frozen turbulence" hypothesis of G. I. Taylor, i.e. the simple time-space transformation that allows $(1/\overline{U})\partial/\partial t$ to approximate streamwise derivatives, $\partial/\partial x$, of velocity fluctuations that he proposed in 1938 and that has been widely used ever since. These terms in Taylor's hypothesis appear in the transport equation for instantaneous momentum for this flow. The additional terms, i. e. the additional convective acceleration and the pressure gradient and viscous force terms, act to diminish the validity of Taylor's hypothesis when they are relatively large compared to the Taylor's hypothesis terms and are not in balance. A similar analysis also has been applied to the transport equation for instantaneous vorticity. There the additional terms, namely the additional convective rates of change, the stretching/compression/rotation and the viscous diffusion of vorticity terms, similarly act to diminish the validity of Taylor's hypothesis when they also are relatively large compared to the terms in the hypothesis and are not in balance. Where in the channel flow this diminishment occurs, and to what degree, and which of the non -Taylor's hypothesis terms in the momentum and vorticity equations contribute most to this diminishment will be presented.

(2) Using the DNS by Wu and Moin (2010) of a flat-plate boundary layer with a passively heated wall, statistical properties of the turbulence in transition at Re_θ = 300, from individual turbulent spots, and at Re_θ = 500, where the spots merge, have been compared to these statistical properties for the developed boundary layer turbulence at Re_θ = 1840. When the distributions in the transitional regions are conditionally averaged so as to exclude locations and times when the flow is not turbulent, they closely resemble the distributions in the developed turbulent state at the higher Reynolds number, especially in the buffer layer. Skin friction coefficients, determined in this conditional manner at the two Reynolds numbers in the transitional flow are consistent with the 1/7th power law approximation. An octant analysis based on the combinations of signs of the velocity and temperature fluctuations, u, v, and θ shows that the momentum and heat fluxes are predominantly of the mean gradient type in both the transitional and developed regions. The fluxes appear to be closely associated with vortices that transport momentum and heat toward and away from the wall in both regions of the flow. The results suggest that there may be little fundamental difference between the nonlinear processes involved in the formation of turbulent spots that appear in transition and those that sustain the turbulence when it is developed. They also support the view that the transport processes and the vortical structures that drive them in developed and transitional boundary layer turbulence are, in many dynamically important respects, similar. This may be of importance in the development of low-dimensional models that incorporated the principal structural characteristics of wall turbulence.