JOHNS HOPKINS
Center for Environmental
& Applied Fluid Mechanics

Friday, May 4, 2018
3:00 PM, 132 Gilman Hall

"*Properties of the Mean Momentum Balance in Polymer Drag-Reduced Channel Flow*"

Presented by Prof. Christopher White

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Abstract: In the first part of the talk, Professor White will briefly outline his ongoing research projects. In particular, recent work on the development of a simple dynamical model of the turbulent boundary layer will be presented. The formulation of the model is based on recent findings that reveal that at large Reynolds numbers the inertially-dominated region of the turbulent boundary layer is composed of large scale zones of nearly uniform momentum segregated by narrow fissures of concentrated vorticity. It will be shown that a simple model that exploits these essential elements of the turbulent boundary layer structure can reproduce statistical profiles of the streamwise velocity that agree remarkably well with those acquired from direct numerical simulation at high Reynolds number.

The main part of the talk will discuss research related to the phenomenon of polymer drag reduction in wall-bounded turbulent flows. Here a mean momentum equation based analysis of polymer drag reduced channel flow is performed to evaluate the redistribution of mean momentum and the mechanisms underlying the redistribution processes. Similar to channel flow of Newtonian fluids, polymer drag reduced channel flow is shown to exhibit a four layer structure in the mean balance of forces that also connects, via the mean momentum equation, to an underlying scaling layer hierarchy. The self-similar properties of the flow related to the layer hierarchy appear to persist, but in an altered form (different from the Newtonian fluid flow), and dependent on the level of drag reduction. With increasing drag reduction, polymer stress usurps the role of the inertial mechanism, and because of this the wall-normal position where inertially dominated mean dynamics occurs moves outward, and viscous effects become increasingly important farther from the wall. For the high drag reduction flows of the present study, viscous effects become non-negligible across the entire hierarchy and an inertially dominated logarithmic scaling region ceases to exist. It follows that the state of maximum drag reduction is attained only after the inertial sublayer is eradicated. According to the present mean equation theory, this coincides with the loss of a region of logarithmic dependence in the mean profile.