THE FLUIDS, THERMAL AND CHEMICAL PROCESSES GROUP
OF
THE DIVISION OF ENGINEERING
AND
THE CENTER FOR FLUID MECHANICS
SEMINAR SERIES

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On Describing Mean Flow Dynamics in Wall Turbulence

The transport phenomena associated with wall-bounded turbulent flows factor prominently in the performance of a large number of engineering applications and observations of natural processes. For this reason, the study of wall-flow dynamics and their scaling behaviors with increasing Reynolds number warrants considerable attention. Attempts to date, however, have primarily focused on questions relating to *what* scaling behaviors occur, rather than the dynamical reasons *why* they occur. Given these considerations, the present talk is organized in three parts. In the first part it is shown that the predominant methodology for discerning the dominant mechanisms associated with the mean flow dynamics is problematic, and can lead to erroneous conclusions. In the second part we examine the Millikan-Izakson (inner/outer/overlap) arguments that underpin the widely accepted derivation for a logarithmic mean profile. Rigorous existing results from the theory of functions are outlined. They reveal that the Millikan-Izakson arguments constitute something exceedingly close to a tautology and embody very little physics. The first two parts establish the context for the third. The presentation concludes with a physical interpretation of the mathematical conditions necessary for a logarithmic (or nearly logarithmic) mean profile. The basis for this interpretation is the analysis of Fife et al., (2005 JFM **532**}, 165) which reveals that the mean differential statement of Newton's second law rigorously admits a hierarchy of physical layers each having their own characteristic length. These analyses show that the condition for exact logarithmic dependence exists when the normalized equations of motion (normalized using the local characteristic length) attain a self-similar structure, and physically indicate that the von Karman constant will only be truly constant when an exact self-similar structure in the gradient of the turbulent force is attained across a range of layers comprising the hierarchy. These results are discussed relative to the physics of boundary layer Reynolds number dependence and recent data indicating that the von Karman constant varies for varying mean momentum balance.

TUESDAY, APRIL 8, 2008
Barus & Holley, Room 190
4:00pm