Paper 24.4

Structure of Wall-Eddies at Re_q ³ 10^6

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ABSTRACT

A smoke visualization experiment has been performed in the first 3 m of the neutrally stable atmospheric boundary layer at *very* large Reynolds number ($Re_\theta > 10^6$). Under neutral atmospheric conditions mean wind profiles are shown to agree well with those in the canonical flat plate zero-pressure-gradient boundary layer. The experiment was designed to minimize the temperature difference between the passive marker (smoke) and the air to insure that any observed structures were due to vortical, rather than buoyant motions. Data was acquired in the streamwise/wall-normal plane using a planar laser light-sheet and CCD cameras. Images obtained are strikingly similar to those observed in classical laboratory experiments at low to moderate Reynolds numbers and reveal large-scale ramp-like structures with downstream inclination of 3°–35° (see Figure 1). This inclination is interpreted as the hairpin packet growth angle following the hairpin vortex packet paradigm of Adrian *et al.* (2000). The distribution of this characteristic angle is shown to agree with the results of experiments at far lower Reynolds numbers, suggesting a similarity in structures at low, moderate, and high Reynolds number boundary layers. These results begin to suggest that the hairpin packet model is valid at *high* Reynolds numbers of technological interest.

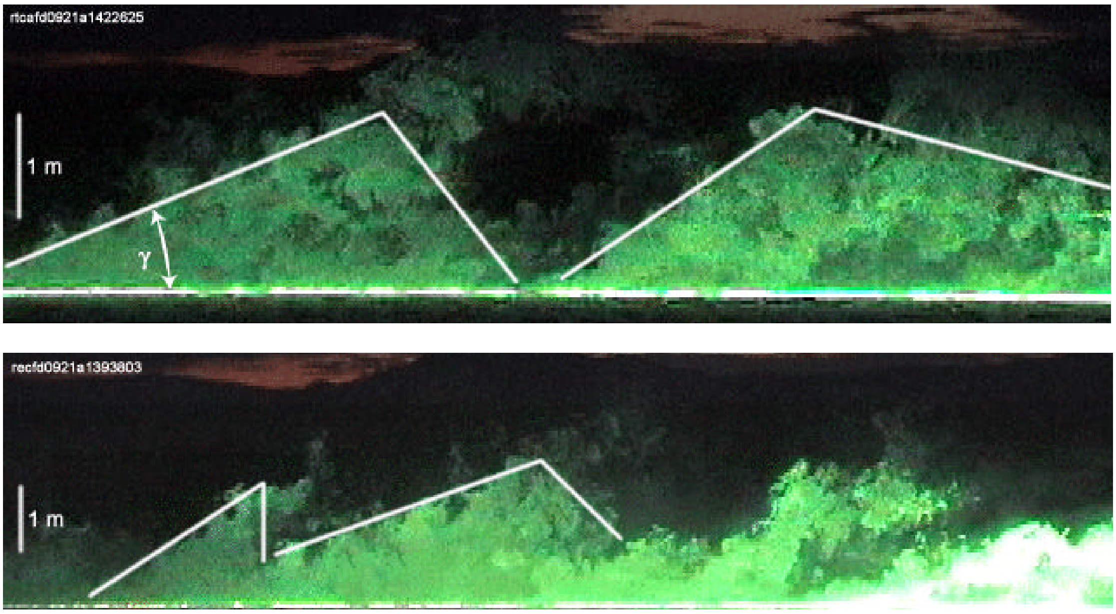

Figure 1. Two representative smoke visualization images in the first 3 m of the atmospheric boundary layer obtained using planar laser light sheet illumination. Flow is from left-to-right at $Re_\theta = 9.2\times10^6$. The approximate extent of the large scale structures has been indicated with white lines inclined at the hairpin packet growth angle γ.