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The Modelling of The Dynamics of Hairpin Vortex Packets in Wall Turbulence

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The talk addresses the experimental, analytical and numerical modelling of the dynamics of concentrated vortex packets over a rigid smooth plane. To answer the principal question why and how does fluid in outer region of the turbulent boundary layer organize itself into hairpin streamwise vortex packets with low-speed convective velocity we developed the vortex filament model of hierarchy of hairpin packets. The idea is to explore the flow of effectively inviscid fluid with embedded vorticity, with topology change allowed upon close encounters of vortical fluid regions. We addressed the global vorticity dynamics by representing each hairpin vortex as a filament with a ‘core parameter’, interacting via the Biot-Savart law. The contour kinematic spline method for tracing the vortex filaments in a shear flow over a rigid wall was developed. Special attention is paid to the soliton-like behaviour of the vortex filaments over the rigid plane. Comparisons with experimental results and DNS data show a good correspondence. Although an extreme idealization, the analytical model of vortex filaments appears to shed considerable light on what to expect in the laboratory experiments. This work was supported by the CRDF CGP grant UP-2429-KV-02

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