UNIVERSITY OF SOUTHAMPTON

ABSTRACT

FACULTY OF ENGINEERING

SCHOOL OF ENGINEERING SCIENCES

Doctor of Philosophy

REGENERATION MECHANISMS OF ORGANIZED STRUCTURES IN NEAR-WALL TURBULENCE

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We have performed direct numerical simulations (DNS) of quasi-2D (that is with flow parameters independent of longitudinal coordinate) decaying and forced turbulence and 3D turbulent channel flows in order to ascertain the sustenance mechanism of near-wall turbulence by investigating the mechanism of streak formation. We found the existence of streaks in quasi-2D flows thus demonstrating that contrary to many proposed theories, feedback from longitudinal flow is not necessary for streak formation. Passive scalars having different mean scalar profiles were introduced in forced quasi-2D and 3D turbulent flows in order to compare the streak spacing of the scalars deduced from two-point correlations of DNS results with results obtained theoretically.

It has been found that even for the same vortex structure for all the passive scalars there is a marked variation in streak spacing implying that the preferential streak spacing is not necessarily equal to twice the vortex spacing, as has been suggested by several proposed theories. Moreover, the formation of scalar streaks in a velocity field prescribed as s sum of a mean turbulent velocity profile and random potential perturbations, conclusively supports the fact that organised vortices are not needed for generation of near-wall streaks. It has also been demonstrated that the lift-up mechanism responsible for generation of streaks is also responsible for the cross-flow spacing. The obtained qualitative numerical results are in favour of theory of streak formation based on optimal perturbations (Butler and Farrell, 1993) but at the same time the quantitative agreement is poor. So a modification of the same - Generalized optimal perturbation (Chernyshenko and Baig, 2003) theory has been proposed and it offers significantly better agreement with the DNS results.