Some characteristics of the coherent structures in turbulent boundary layers

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Abstract The present work describes the results of an experimental study about the kinematics of the coherent structures in an open channel flow. The coherent events, detected in the near-wall region, are analysed by an original method based on conditional-sampling. Using simple kinematic characteristics occurring during the bursting events the coherent structures are grouped into several clusters obtaining a substantial improvement over the classical conditional average. In this way different kinds of coherent structures are distinguished, and probably ascribed to different phases of the same group of coherent structures. In particular, we show experimental evidence supporting the hypothesis about coherent packets of hairpin vortices formulated by Zhou et al. 1999 even at high Reynolds number. This analysis of the near-wall region is realised by means of a new experimental technique which allows an accurate measurement of the streamwise and wall-normal turbulent velocity components (u and v respectively) in the flow field very close to the wall.

1. Introduction

It is well known that the near-wall region of turbulent boundary layers shows a complex temporal-spatial organisation dominated by streaky structures (e.g. Robinson 1991, Jiménez & Pinelli 1999). Even if the scenario is composed of a large number of different elements (low-speed streaks, vortical structure, ejections, sweeps, streamwise vorticity), it is generally accepted that there exists an overall structure that comprises all of them.

Although different scenarios have been proposed (Smith et al. 1991, Jeong et al. 1997, Zhou et al. 1999), it seems that in the near-wall region a fundamental role is played by the so-called "bursting cycle" which is responsible for most of the turbulence production. The core of the cycle consists of low-speed streaks that intermittently become unstable, break down and erupt into the outer region. Nevertheless, several studies have suggested that the previous scenario of the bursting cycle may have even more complex evolution (Smith and Walker, 1997;