

Recent results from computational channels up to $Re_\tau = 2000$.

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The study of turbulence near walls has experienced a renaissance in the last decades, largely because of the availability of high-quality direct numerical simulations. The numerical Reynolds numbers, now in the range of $Re_\tau = 2000$, allow for the first time the study in some detail of the dynamics of the buffer and lower logarithmic layers. The present and probable future status of direct simulations of turbulent channels, and some of the results obtained from them, will be reviewed in these two seminars.

Besides questions of mainly computational interest, four issues will be particularly addressed. We will consider first the buffer and viscous layers. It has been known for some time that this part of the channel is relatively independent of the flow above it, and actually survives even when all the rotational fluctuations are artificially removed above $y^+ \approx 60$. This is in agreement with the fact that most of the mean velocity difference, of the turbulence production, and of the energy dissipation, reside in this region, which therefore sees the outer flow as a relatively weak perturbation of the local processes. Its autonomous dynamics has been intensively studied in the last two decades, and we will outline the consistent picture that has begun to emerge.

On the other hand, recent experimental results suggest that there are effects of the Reynolds number on the scaling of buffer-layer quantities. They can only come from interactions with the outer flow, and they are seen in simulations. The seminar will discuss what recent and older simulations and experiments have to say concerning their mechanisms and their locations in scale space.

The next question is the scaling of the size of the structures both in the buffer and in the logarithmic layer. It follows from the study of the numerical energy spectra that the relation between the width and the length of the energy-containing structures is not straightforward, in the sense that both length scales are not proportional to each other, nor to the distance to the wall. Experimental evidence for the latter failure of proportionality had already been found in experiments, but it has only been through numerical simulations that the former has been documented. We will discuss what the problem is, and what its solution appears to be.

Finally we address the question of the scaling of the velocity fluctuations in the logarithmic layer and in the outer layer. The classical view is that all the velocity fluctuations in a wall-bounded turbulent flow should scale with the friction velocity u_τ , but again the experimental evidence suggests otherwise, recalling the observation by Townsend that ‘inactive’ eddies, those not carrying Reynolds stresses, could scale in some other way. We will show that at least some eddies, those large enough to span the whole thickness of the flow, scale with the flow velocity at the centreline, and we will discuss why, and which are the consequences that follow for the behaviour of the overall turbulence intensities at very high Reynolds numbers.

For all the previous questions we will discuss the issue of which properties appear to be universal, and which ones are restricted to some particular class of wall-bounded flows.