Fachbereich 4
Produktionstechnik
Maschinenbau &
Verfahrenstechnik

CENTER OF
APPLIED SPACE TECHNOLOGY
AND MICROGRAVITY

Fluids and Space Engineering Seminar

Date: Wednesday, December 7, 2022 at 11:00
Location: ZARM, Room 1730

Characterisation of extreme events in turbulent wall-bounded flows

Dr. Miguel P. Encinar

Universidad Politécnica de Madrid

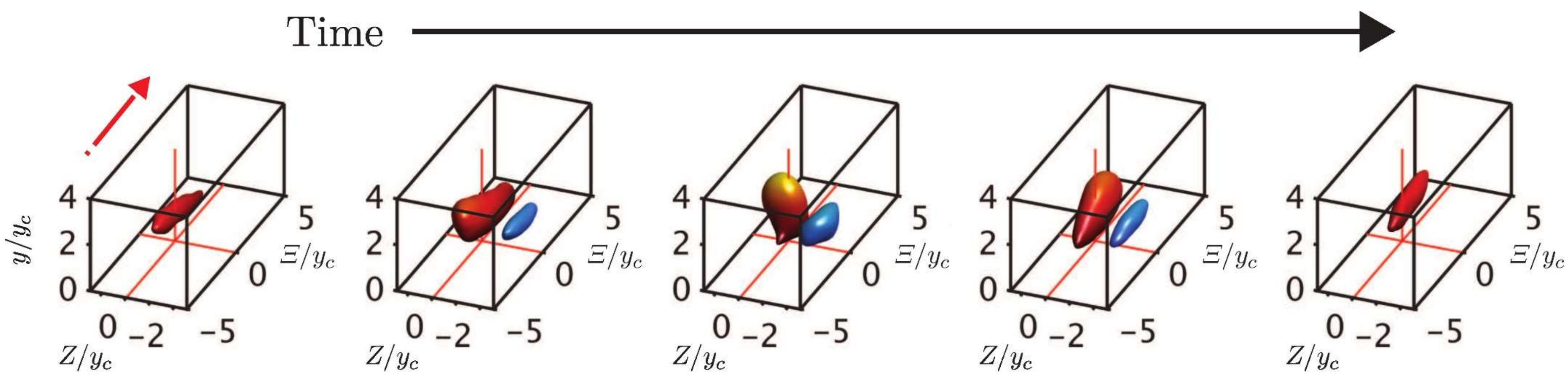

Figure 1: Time evolution of a conditional burst event. Red(Blue) contours are the positive(negative) wall-normal velocity. The time extends for a total of two shear time units.

Wall-bounded flows are essential to many industrial applications, and developing accurate models for their prediction and control is a crucial challenge for the next decades. One fourth of the global energy is used in transportation, and about 20% of that amount is dissipated in wall-bounded turbulent flows. Therefore, turbulence can be considered responsible for about 4% of the CO2 emissions at the present time. Turbulence is a very particular problem. Although an almost perfect model for the turbulent phenomenon exists in the form of the Navier–Stokes equations, the answers that we obtain from it are not satisfactory. From an engineering point of view, the answers for the model are too costly to obtain for any realistic flow without relying in a lot of modelling and tuning. From a physical standpoint, the answers are too complex to be satisfactory. Both points of view are related, as it is hard to conceive better models without a better understanding of the dynamics.

The present work seeks to relate a well-known model of wall-bounded turbulence, the linear Orr–Sommerfeld equations, to the fully non-linear channel flow. Orr-like ‘bursts’ are defined by the relation between the amplitude and local tilting angle of the wall-normal velocity perturbations, and extracted by means of wavelet-based filters. Their sizes and lifespans are proportional to the distance from the wall, forming a self-similar eddy hierarchy consistent with Townsend’s attached-eddy model. It is shown that bursts of opposite sign pair side-by-side to form tilted quasi-streamwise rollers, which align along the streaks of the streamwise velocity with the right sign to reinforce them. On the other hand, temporal analysis shows that consecutive rollers do not form simultaneously, suggesting that they incrementally trigger each other. This picture is similar to that of the streak–vortex cycle of the buffer layer, and the properties of the bursts suggest that they are different manifestations of the well-known attached Q2–Q4 events of the Reynolds stress.