DESCRIPTION FOR GENERAL PUBLIC

Turbulence is ubiquitous phenomenon commonly encountered in nature and in engineering applications, ranging from geophysical flows (atmosphere, ocean currents, river streams) to flows around an aeroplane wing or within industrial pipelines. The American Nobel Prize Laureate for Physics Richard Feynman once described turbulence as ”the most important unsolved problem of classical physic”. This is also regarded as one of the six millennium problems in mathematics today. One fundamental aspect of turbulence is its origin, i.e. when and why turbulence starts and what the mechanisms of its self-sustainment are. This problem can be traced back to the seminal paper of Osborne Reynolds [1] and since more than one century still poses challenges.

Turbulent flow is chaotic and substantial drag increase when compared to laminar flow. From practical point of view, the global transport sector is responsible for one third of the total final energy demand, most of which comes from oil-based fuels. This weighs heavily on climate, energy security and environmental considerations. Therefore, the question how to characterise, predict, and control the transition between the laminar and turbulent states is of crucial importance.

Investigation of transition process is an extremely difficult task. From experimental perspective, turbulence is advected by the bulk flow that flushes away turbulence out of the test section and, as a result, only finite time observations are possible. Typically, the available time scales are at least hundred times shorter than the estimated characteristic time scales of transition. This also implies that extremely long test sections would be required to study their dynamics for sufficiently long time. One possibility is to create the base flow with zero mean bulk velocity to keep the turbulent structures stationary in space and study their dynamics for arbitrarily long time. **This will enable to study turbulence on time scales that were inaccessible before**. In this project novel experimental set-up will be constructed to create a generic planar shear flow with zero mean advection velocity. In addition, recent advancement of our understanding of the transition to turbulence relies to great extent on statistical analysis [e.g. 2, 3, 4, 5]. From this perspective experiments are the most suitable and most effective approach to acquire reliable statistical data on the dynamics of turbulence.

During this project two different experimental techniques will be used. Flow visualisations will enable to visually detect turbulent regions and distinguish them from surrounding laminar flow. This will enable to statistically characterise the behaviour of typical turbulent structures that can be observed during transition process. One important aspect is to evaluate whether these structures are stable, which will have deep impact on our theoretical understanding of transition to turbulence [6]. With a second technique in use, Particle Image Velocimetry (PIV), velocity fields will be measured to gain additional information about dynamics of these turbulent structures. In addition, it has been observed that flow of large spatial scales is generated around typical turbulent structures [7]. During this project spatial structuring and temporal evolution of this large-scale-flow will be extracted and its role in transition to turbulence will be characterised. Finally, in the proposed installation the magnitude of global pressure difference can be controlled, which will enable to evaluate the role of global pressure force on transition process.

References

[1] O. Reynolds. An experimental investigation of the circumstances which determine whether the motion of water shall be direct or sinuous, and of the law of resistance in parallel channels. *Philos. Trans. R. Soc.*, 174:935–982, 1883.
[2] S. Bottin, F. Daviaud, P. Manneville, and O. Dauchot. Discontinuous transition to spatiotemporal intermittency in plane Couette flow. *Eur. Phys. Lett.*, 43(2):171, 1998.
[3] G. Lemoult, L. Shi, K. Avila, S. V. Jalikop, M. Avila, and B. Hof. Directed percolation phase transition to sustained turbulence in Couette flow. *Nature Physics*, 12(3):254–258, 2016.
[4] C. S. Paranjape. *Onset of turbulence in plane Poiseuille flow*. PhD thesis, IST Austria, 2019.
[5] S. Gomé, L. S. Tuckerman, and D. Barkley. Statistical transition to turbulence in plane channel flow. *Phys. Rev. Fluids*, 5(8):083905, 2020.
[6] Y. Pomeau. The long and winding road. *Nature Physics*, 12(3):198–199, 2016.
[7] Y. Duguet and P. Schlatter. Oblique laminar-turbulent interfaces in plane shear flows. *Phys. Rev. Lett.*, 110(3): 034502, 2013.