EUROPEAN MECHANICS SOCIETY

Colloquium n. 598 – Coherent structures in wall-bounded turbulence: new directions in a classic problem

Dates and location

29 August — 31 August 2018, Imperial College, UK

Chairperson

Yongyun Hwang

Co-chairperson

Bruno Eckhardt, Javier Jimenez, Rich Kerswell

What other funding was obtained?

None

What were the participants offered?

1. Summer student (cheap) accommodations were offered to all the participants (around 60GBP per night).
2. All the six invited speakers had appropriate reimbursement for their travel, accommodation and registration fee (speakers from non-US country had 1500GBP of reimbursement, speakers from EU had 700GBP of reimbursement).
3. The colloquium is organised in a dedicated place which includes a lecture theatre, a discussion room and a garden.
4. Working lunch is served for all three days, and coffee/tea/other refreshments were served four times per each day.
5. A colloquium dinner is served in the second-day evening

Scientific report

Three days of the colloquium were organised in the following manner: Transition (first day), Turbulence in canonical flows (second day), flow control, model reduction and complex flows (third day). The colloquium was finalised with a concluding discussion chaired by Prof. Mike Graham

1. Transition (first day)
Computation of exact coherent states (equilibria and periodic orbits) becomes now routine, and there are now a series of efforts to unveil the dynamics of transition. These efforts include studying dynamically relevant manifolds linked to the known exact coherent states (e.g. homoclinic tangency), bifurcation of spatio-temporally localised exact coherent states, and stabilising/controlling the edge of turbulence. They were also accompanied with development of low-dimensional models which capture the transition dynamics phenomenologically.

2. Turbulence (second day)
Attached eddy hypothesis, which states the self-similar organisation of coherent structures, now appears to be accepted as the common theoretical ground for description of coherent structures. There were dedicated effort to combine the notions of linear/nonlinear dynamical systems theories with attached eddy hypothesis (resolvent mode, impulse response, quasi-linear analysis/statistical dynamics approach, exact coherent states, and novel statistical technique based on casuality) with coherent structures observed in high Reynolds number turbulence. The use of a machine learning theory with massive computational effort was also proposed not to miss any important dynamics.

3. Flow control, model reduction and complex flows (third days)
The third day covered a broad range of topics more generally applicable to complex flows, including flow control, model reduction. Flow control and model reduction techniques appear to be now fairly complete in the linear regime, and there are some dedicated effort for extending these notions to highly chaotic flows. These include sensitivity calculation of chaotic state, computation of new periodic orbits with DMD, optimisation problem and exact coherent states at high Re, and novel modal decomposition techniques for nonlinear flows. There are also some presentations on turbulence control with spanwise wall-oscillation, studying duct flows and asymptotic analysis of transition.

4. Discussion
The discussion session was chaired by Prof. Mike Graham, and there are a number of issues raised.
a) Fluid dynamical relevance of periodic orbits for high Re turbulence;
b) Relevance of hairpin vortices;
c) Attached eddy hypothesis: where to go further;
d) Outlook of low-dimensional modelling (quasi-linear approximation, in particular);
e) Flow control and state space information;
f) The role of the wall in wall-bounded flows.