Report on the meeting of the GDR's "Turbulence" and "Control of Flow Separation", Ile d'Oléron, May 13-16, 2008-06-06

Session on "Linear models of transition and control"

This session was based on only two contributions, one by A. Bottaro, DICAT, University of Genova and one by A. Sempey, LEPTAB, University of La Rochelle.

Bottaro presented a model of the early stage of transition in a duct, based on a triple decomposition of the flow variables. The model considers a set of equations for a nonlinear distorted base flow and a set for the disturbance variables. An optimisation procedure based on adjoint equations is set up, aimed at maximising the amplification of the disturbances, over a fixed time frame. It is found that a disturbance wave can grow on top of a distorted mean flow; through the action of the Reynolds stresses the wave feeds a streamwise vortex. The lift-up effect is then the cause of the amplification of a streak out of the vortex. The model produces realistic initial flow patterns, very similar to the unstable "edge state" which can be found to mediate the transition process. Direct simulations of the transition to turbulence have then been conducted, highlighting the fact that classical optimal disturbances (i.e. streamwise homogeneous perturbations) are inefficient at initiating transition, whereas the optimal wavy perturbations found here can trigger early transition at small values of the inlet disturbance amplitude. Finally, calculations of 2D minima defects have been shown; such defects are similar to the flow states set up shortly after the inlet by the optimal wave, but present much sharper gradients. More details can be found on: D. Biau & A. Bottaro, "An optimal path to transition in a duct", invited paper in *Phil. Trans. Royal Soc. London* (2008).

Sempey presented a computational model of the thermal feedback control of the air ventilation in a room, taking into account the interior temperature distribution and air velocity field. Models, based on CFD, give this information but they are improper for real-time applications. Therefore, a reduced model is needed. So the size of a CFD model is reduced by first considering the velocity field fixed and solving only the energy balance equation, then putting this equation in the form of state-space and finally by reducing its order by Proper Orthogonal Decomposition (POD). This algorithm was applied to a room equipped with a fan coil. The state space form of the reduced order model allows to estimate the temperature in the occupancy zone, without a direct measurement, and to feedback it to a controller. Several controllers were compared, all of which were designed with the internal model theory.