

Spanwise rotating shear flows – instabilities and turbulence

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Shear flows subjected to system rotation, where the rotation axis is parallel with the mean flow vorticity direction have many interesting features. The rotation induces a Coriolis force which have a strong effect on the flow field even at low rotational speeds. Here we will discuss plane Couette flow (PCF) under spanwise system rotation. PCF exists between two planes moving in opposite directions, each with a speed U_w in the x -direction and separated by a distance of $2h$ in the y -direction. Without rotation the flow described is linearly stable for all Reynolds numbers ($Re = U_w h / \nu$, ν is the kinematic viscosity) however, in experiments transition to turbulence starts around $Re \approx 350$.

On the other hand PCF with spanwise system rotation $\mathbf{\Omega} = \Omega_z \hat{e}_z$ (rotating plane Couette flow, RPCF, figure 1a), show linear instability for anticyclonic rotation with the marginal stability limit

$$Re_c = \Omega + 107\Omega^{-1}$$

where $\Omega = 2\Omega_z h^2 / \nu$ is the non-dimensional rotation number. The smallest Reynolds number for flow instability is as low as 20.7. For flow parameters close to, but above the stability line, straight, counter-rotating roll cells are observed (figure 1b). For other parameters this flow can reach a number of different instabilities as shown by Tsukahara et al. (2010), Suryadi et al. (2014), Kawata & Alfredsson (2016a,b).

In the presentation new results obtained with stereoscopic particle image velocimetry in laminar and turbulent RPCF showing details of the three-dimensional flow structures observed in RPCF will be presented.

Acknowledgement: Takuya Kawata, Alexandre Suryadi, Takahiro Tsukahara, Antonio Segalini and Nils Tillmark are acknowledged for various contributions to this work.

References

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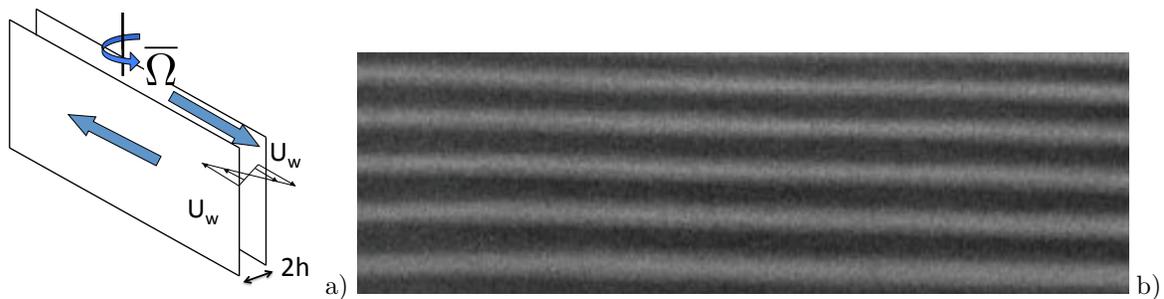


Figure 1: a) Schematic of RPCF, b) flow visualisation of Taylor cells at $Re = 50, \Omega = 2.6$