## Effects of rotation rates on roll-cells in ribbed channel flows

Karthikeyan Jagadeesan*, Vagesh D. Narasimhamurthy*,
Helge I. Andersson† and Leo R. M. Maas‡

Taylor-Görtler instability has been observed in spanwise rotating channel flows.[1] It occurs in pairs of counter-rotating roll-cells on the pressure side of the channel. We investigate using direct numerical simulations (DNS), the effects of rotation rates on these roll-cells. Symmetrically ribbed channel flow at Reynolds number $Re_\tau = 400$ was simulated using the in-house finite-volume solver MGLET.[2] The channel was rotated about its spanwise $(z)$ axis at dimensionless rotation numbers $Ro = 0$, 2, 6, 12 and 24. Here $Re_\tau = u_\tau h/\nu$ and $Ro = 2\Omega h/u_\tau$, where $u_\tau$, $h$, $\nu$ and $\Omega$ denote the friction velocity, channel half-height, kinematic viscosity and the magnitude of angular velocity, respectively.

In the configuration shown in Fig. 1, the angular velocity is antiparallel to the mean-shear vorticity at the bottom wall. Due to the Coriolis force, the adjoining side is at a higher pressure and is denoted the *pressure side*. The side adjacent to the top wall is called the *suction side*. With increase in $Ro$ from 0 to 6, besides the roll-cells emerging, the near-wall coherent vortices on the pressure side form increasingly dominant streamwise clusters.[3] The clustering happens at the interfaces of the roll-cells, where the flow is from the pressure side to the suction side. In Fig. 1, velocity vectors projected on the $(y, z)$-plane represent the roll-cells. Up to $Ro = 6$, these roll-cells are continuous along $x$ and temporally persistent. With increase in $Ro$ to 12 and 24, the roll-cells become more irregular and the streamwise clustering of the coherent vortices disappears. In this work, we try to explain this weakening effect on the roll-cells. We will also explore the role of ribs along with other high-$Ro$ effects.

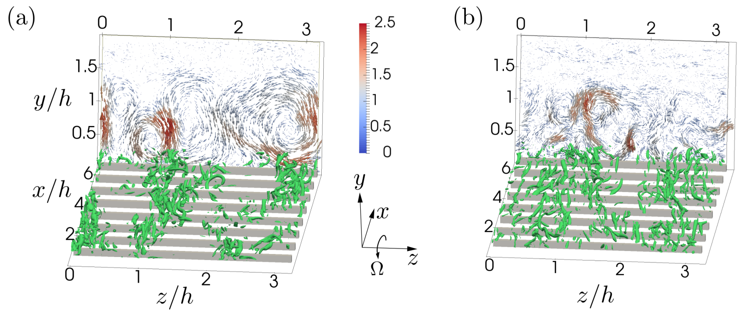


Figure 1: Velocity vectors and near-wall vortices (green) at (a) $Ro = 6$. (b) $Ro = 24$. The flow is along $x$ and the channel rotates about $z$ at the rate $\Omega$. Vortices are identified using $\lambda_2$[4] and the colorbar denotes the magnitude of the velocity vectors.

---

*Dep. Applied Mechanics, Indian Institute of Technology Madras, Chennai, India
†Dep. Marine Technology, Norwegian University of Science and Technology, Trondheim, Norway
‡Institute for Marine and Atmospheric Research, Utrecht University, Utrecht, The Netherlands

[1] Kristoffersen and Andersson, *J. Fluid Mech.* **256**, 163 (1993).
[2] Manhart, *Comput. Fluids* **33**, 435 (2004).
[3] Jagadeesan et al., *Int. J. Heat Fluid Flow* **95**, 108956 (2022).
[4] Jeong and Hussain, *J. Fluid Mech.* **285**, 69 (1995).