A mechanism for the growth of anisotropy in rotating turbulence

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In this study we present an investigation into mechanism that drives the formation of columnar structures in a rotating turbulent flow field. The mechanism we explore here is similar to one found in magnetohydrodynamic turbulence at low magnetic Reynolds number[1]. Contrary to other studies[2,3] on the subject the mechanism presented assumes viscous or inertial forces opposing the growth of anisotropy, rather than a mechanism driven by inertial waves. For the case of a flow forced through fluid injection or subtraction aligned with the axis of rotation it is shown that the bulk velocity $\langle\overline{U}\rangle$ perpendicular to the axis of rotation is expected to scale as Q or $Q^{2/3}$ depending on whether viscous or inertial forces oppose anisotropy, where Q is the applied flow rate. These scaling laws are tested experimentally. The experiment consists of a rectangular tank filled with fluid mounted on a rotating turntable. The flow is forced by simultaneously injecting and subtracting fluid through four small orifices arranged in a square pattern at the bottom of the tank. Using a single camera PIV system we are able to characterise $\langle\overline{U}\rangle$ as a function of the rotation rate Ω and Q. Our results (fig.1) show good agreement with the proposed scaling laws. They suggest a transition from a viscous regime to an inertial regime as Q is increased, which is consistent with a relative increase in inertial forces. Turbulent motions close to the point of injection are too small to be affected by the Coriolis force. As such, strong three-dimensional structures form. Close to these structures inertial wave-packets are emitted and propagate through the flow field. The exact relation between these 3D structures, the inertial wave-packets and how they relate to the proposed scaling laws is still not fully understood.

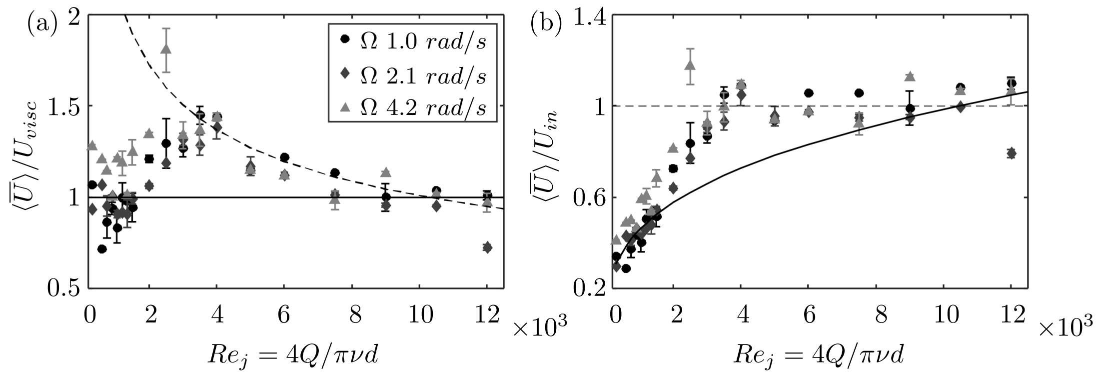

Figure 1: Bulk flow velocity $\langle\overline{U}\rangle$ scaled by a) predicted velocity U_{visc} (—) and b) U_{in} (−−) where viscous or inertial forces oppose the growth of anisotropy

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[2]Davidson et al., *J. Fluid Mech.*, **557**,(2006).
[3]Cambon & Scott, *An. Rev. Fluid Mech.*, **31**, (1999).