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The Incompressible Preference of Turbulence

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Abstract : An elementary observation of a laminar cylindrical Poiseulle-Couette flow profile reveals no distinction in the parabolic streamwise profile from one without a cross-stream flow in whatever reference frame the observation is made. This is because the laminar flow is in solid-body rotation, and there is no intrinsic fluid rotation. Hence the main streamwise Poiseuille flow is unaffected. However, in turbulent (unsteady) cylindrical Poiseuille-Couette flow, the rotational reference frame must be considered, and any observation from an external inertial reference frame can give outright incorrect results. A common misconception in the study of fluid mechanics is the position of the observer does not matter. In this DNS (direct numerical simulation) study, firstly, turbulent flow in a pipe with axial rotation is established. Then in turbulent flow in the concentric pipe, with inner wall rotation, it is shown how the wall streak direction is oriented by the rotational reference frame. The Coriolis force here is not so fictitious after all!

Keywords : concentric pipe, rotational and inertial frames, frame invariance, wall streaks, flow orientation
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