LEEDS INSTITUTE FOR FLUID DYNAMICS

JOHN FOX ANNUAL LECTURE | 26th April 2023

Keynote speaker: Dr Paul Linden

"'The fluid mechanics of STAMP collecting: what SID tells us"

The stratified inclined duct (SID) is a relatively new experimental paradigm that produces a sustained shear flow between two counterflowing layers of fluid supplied by reservoirs at each end of the duct containing fluids of different density. The duct can be tilted at a small angle θ to the horizontal and, for a given fluid, the flow is determined by two nondimensional parameters θ and the

Reynolds number. We have observed four different flow regimes in SID: Laminar when the interface between the layers remains undisturbed, Holmboe characterised by sharp cusped waves on the interface, Intermittent when the flow has bursts of turbulence followed by relatively calm periods and Turbulent when the turbulence occurs throughout the duct and is sustained in time. The laminar regime occurs at low Re and θ, and transitions to the other regimes occur successively as Re and θ increase, so SID allows a systematic study of the different regimes. One of the most important questions in stratified turbulence is the efficiency with which the fluid

is mixed. When the stratification is stable, with density decreasing with height, work needs to be done against gravity to move light fluid downwards and dense fluid upwards so that irreversible mixing can occur. The 'tax' that this irreversible mixing imposes on the kinetic energy of the flow, the so-called 'mixing efficiency' is important to parameterise mixing in ocean and climate models. In this talk I will discuss the philosophy behind SID and explain why the experiment is relevant to this issue, particularly in the context of the energetics of the flow. We summarise our results on turbulent energetics and mixing statistics. We derive the kinetic and scalar energy budgets and explain the specificity and scalings of SID turbulence. We focus on the self-organisation properties of the flows, wherein more strongly turbulent flows tend to an asymptotic state characterised by a uniform gradient Richardson number of order 0.1-0.2 across the shear layer. We assess the relevance of standard mixing parameterisations models, and we compare representative values with the literature. Complementing the experiments we introduce the first accurate 3D DNS for SID. Implementing a suitable forcing method and boundary conditions allow us to maintain steady exchange flow for an arbitrarily long time at a minimal computational cost. With the newly developed numerical model, we explore the diverse transitions in SID from a numerical perspective.

4pm – Steve Tobias Welcome

4.10pm – 5pm – 3 x 15min PhD/PDRA talks

5pm – Keynote Speaker Professor Paul Linden – "The fluid mechanics of STAMP collecting: what SID tells us"

6pm – Drinks reception

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