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Bounds on stratified mixing with a mixing coefficient constraint

WENBO TANG, UC, San Diego, C.P. CAULFIELD, University of Cambridge, RICH KERSWELL, University of Bristol — We derive non-trivial upper bounds for the long-time averaged vertical buoyancy flux $\mathcal{B}^* := \langle \rho u_3 \rangle g/\rho_0$ for stably stratified Couette flow, with reference density ρ_0, kinematic viscosity ν, thermal diffusivity κ, plate separation d, driven by constant relative velocity ΔU, maintained at a statically stable density difference $\Delta\rho$. We numerically solve the variational problem using the "background method", and require that the mean flow is streamwise independent and statistically steady. We impose a coupling constraint such that a fixed fraction Γ_c of the energy input into the system leads to enhanced irreversible mixing. We calculate the bound up to asymptotically large Reynolds numbers for a range of choices of Γ_c and bulk Richardson numbers J. For any Re, the calculated upper bound increases with J, until a maximum possible value $J_{\max}(Re, \Gamma_c)$ at which the new constraint cannot be imposed, and the density field and velocity field become decoupled. The value of the bound at $J_{\max}$ is a non-monotonic function of Γ_c, with $\Gamma_c = 1/2$ leading to the largest possible values as $Re \to \infty$, consistently with the findings in Caulfield, Tang & Plasting (2004) where this coupling constraint was not imposed. In fact, at any particular Re, the previous solution may be associated with a specific value of Γ_c. Imposing the coupling constraint with that Γ_c, as $J \to J_{\max}$, the new bound approaches from below the previous bound exactly.

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