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Bounds on stratified mixing with a mixing coefficient constraint
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RICH KERSWELL, University of Bristol — We derive non-trivial upper bounds
for the long-time averaged vertical buoyancy flux $B^* := \langle \rho u_3 \rangle g/\rho_0$ for stably strati-
fied Couette flow, with reference density $\rho_0$, kinematic viscosity $\nu$, thermal diffusivity
$\kappa$, plate separation $d$, driven by constant relative velocity $\Delta U$, maintained at a stat-
ically stable density difference $\Delta \rho$. We numerically solve the variational problem
using the “background method”, and require that the mean flow is streamwise inde-
pendent and statistically steady. We impose a coupling constraint such that a fixed
fraction $\Gamma_c$ 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 $\Gamma_c$ and bulk Richardson numbers $J$. For any $Re$, the calculated upper
bound increases with $J$, until a maximum possible value $J_{\text{max}}(Re, \Gamma_c)$ at which the
new constraint cannot be imposed, and the density field and velocity field become
decoupled. The value of the bound at $J_{\text{max}}$ is a non-monotonic function of $\Gamma_c$, 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 $\Gamma_c$. Imposing the coupling constraint with that $\Gamma_c$, as $J \to J_{\text{max}}$,
the new bound approaches from below the previous bound exactly.

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