Nonlinear inviscid damping and shear-buoyancy instability in the two-dimensional Boussinesq equations

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We investigate the long-time properties of the two-dimensional inviscid Boussinesq equations near a stably stratified Couette flow. We prove that the system experiences a shear-buoyancy instability: the density variation and velocity undergo inviscid damping while the vorticity and density gradient grow. The result holds at least until a natural, nonlinear timescale. The proof relies on several ingredients: (A) a suitable symmetrization that makes the linear terms amenable to energy methods and takes into account the classical Miles-Howard spectral stability condition; (B) a variation of the Fourier time-dependent energy method introduced for the inviscid, homogeneous Couette flow problem developed on a toy model adapted to the Boussinesq equations.