Isotropy recovery in rotating-stratified turbulence: the role of Ozmidov and Hopfinger scales.

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Abstract

In rotating-stratified flows, two characteristic time scales, namely the BV frequency N and the Coriolis parameter f, are driving the scale of transition from isotropy to anisotropy in homogeneous turbulence. Introducing the turbulent dissipation rate ϵ, two length scales can be obtained, namely the Ozmidov length scale [1] $L_o = (\epsilon/N^3)^{1/2}$ and the Hopfinger length scale [2] $L_h = (\epsilon/f^3)^{1/2}$. Note that the Hopfinger length scale is often called the Zeman length scale [3], but was first introduced by Mory and Hopfinger in 1985 [2]. L_o and L_h compare the relative effects of inertia and of the buoyancy force or of the Coriolis force respectively, and thus quantify the rise of anisotropy in different scale ranges: at large scales (larger than L_o or L_h) the anisotropy due to strong stratification or strong rotation is dominant, whereas at small scales (smaller than L_o or L_h), universal 3D isotropic characteristics of turbulence appear to be restored.

To confirm directly the role of these two scales, we performed numerical simulations at high resolution (2048^3 points) in freely decaying turbulence at four different stratification rates and six rotating rates. We confirm the role played by L_o and L_h by considering the angular energy spectra. Moreover the two scales are associated to a change of behavior of the poloidal/toroidal components of velocity, linked to Riley's decomposition in wave/vortex mode [4], revisited using its spectral counterpart given by the Craya/Herring frame of reference in Delache et al. [5]. In addition, the latter paper has shown the evidence by DNS of a non-monotonic scale-by-scale distribution of directional anisotropy, from the smallest wave vectors (larger scales) to the Hopfinger threshold wavenumber.

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