Abstract Submitted
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A Phenomenological Theory of Rotating Turbulence YASIR BIN BAQUI, PETER DAVIDSON, University of Cambridge — We present direct numerical simulations of statistically-homogeneous, freely-decaying, rotating turbulence in which the Rossby number, Ro $= u_\perp / 2\Omega \ell_\perp$, is of order unity. The initial condition consists of fully-developed turbulence in which Ro is sufficiently high for rotational effects to be weak. However, as the kinetic energy falls, so also does Ro, and quite quickly we enter a regime in which the Coriolis force is relatively strong and anisotropy grows rapidly, with $\ell_\perp << \ell_{//}$. This regime occurs when Ro ~ 0.4 and is characterised by an almost constant perpendicular integral scale, $\ell_\perp \sim$ constant, a rapid linear growth in the integral scale parallel to the rotation axis, $\ell_{//} \sim \ell_\perp \Omega t$, and a slow decline in the value of Ro. We observe that the rate of dissipation of energy scales as $\varepsilon \sim u^3 \big/ \ell_{//}$ and that both the perpendicular and parallel energy spectra exhibit an $k^{-5/3}$ inertial range; $E(k_\perp) \sim \varepsilon^{2/3} k_\perp^{-5/3}$ and $E(k_{//}) \sim \varepsilon^{2/3} k_{//}^{-5/3}$. We show that these power-law spectra have nothing to do with Kolmogorov's theory and are not a manifestation of traditional critical balance theory, as this requires $\varepsilon \sim u^3/\ell_\perp$ and $E(k_{//}) \sim (\varepsilon^{4/5}/\Omega^{2/5}) k_{//}^{-7/5}$. Finally, we develop a spectral theory of the inertial range that assumes that the observed linear growth in anisotropy, $\ell_{//}/\ell_\perp \sim \Omega t$, also occurs on a scale-by-scale basis all the way down to the Zeman scale.

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