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What is the energy dissipation rate in rotating turbulence?

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The scaling of the energy dissipation rate ϵ is one of the most fundamental open issues for rapidly rotating turbulence. For non-rotating 3D turbulence at large Reynolds number, it takes the classical form $\epsilon_{3D} \simeq U^3/L$, with U and L the characteristic velocity and length scales. Here, we propose a simple experiment aiming to probe directly the influence of the background rotation on ϵ: we measure the torque Γ acting on a propeller rotating at constant rate ω in a large volume of fluid rotating at Ω (the torque measurement being performed in the rotating frame). The normalized torque $K_p = \Gamma/(\rho R^4 H \omega^2)$ (where R and H are the propeller radius and height) provides a direct measure of the normalized dissipation ϵ/ϵ_{3D} as a function of the Rossby number $Ro = \omega/\Omega$. For cyclonic propeller rotation ($Ro > 0$) we find a transition between K_p =constant at large Ro (no rotation) and $K_p \simeq Ro$ at small Ro (large rotation), in agreement with weakly nonlinear rotating turbulence prediction. The situation is more intricate for anticyclonic rotation ($Ro < 0$), showing a peak dissipation at intermediate Ro, and a decrease at small Ro but with a different scaling.

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