Wavy modes in forced rotating turbulence cause bursting

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Columnar structures parallel to the rotation axis are known to form in rapidly-rotating flows characterized by a small Rossby number (Ro = $u/\Omega l$). Using the pseudo-spectral code TARANG[1], we have performed direct numerical simulations of forced rapidly-rotating turbulence in a triply periodic box of size $(2\pi)^3$ at large Reynolds number (Re=5000) and small Rossby number (Ro=0.04). We observe several cycles of the cyclonic vortex core bursting followed by the core regeneration. One such instance is shown in Fig. 1a where bursting is visible after 94 eddy turnover times. When the bursting occurs, peaks are seen in the time-series of mean energy dissipation. It is important to note that our simulations are forced at small wavenumber, k_f = [3,4]. In contrast, no such bursting is observed with forcing at the intermediate scales[2].

A cross-section of the z-vorticity through the column at t = 94 shows the presence of 'wavy' modes with k_z = 2. Moreover, we find that, apart from the dominant 2D modes[2,3] (1, 1, 0), (1, 0, 0), (0, 1, 0), other modes such as (0,1,2) and (-1,0,2) receive energy during the bursting cycle leading to enhancement of their amplitudes before bursting (Fig. 1b). Energy transfer to k_z = 2 modes is also corroborated in the mode-to-mode energy transfer. Earlier, periodic bursting of columnar vortices with forcing at small wavenumbers has been reported for rotating Taylor-Green flow[4].

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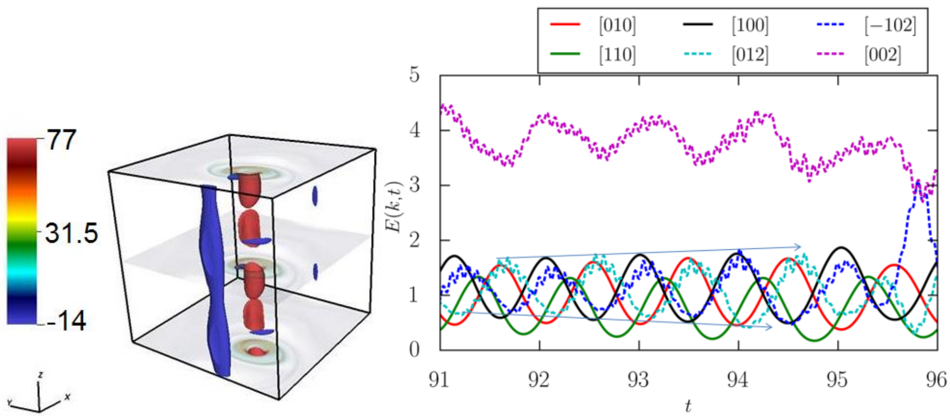

(a) (b)

Figure 1: (a) Columnar flow structures at t = 94. Red (blue) is cyclone (anticyclone). (b) Time-series of energy in modes for t = 91-96. For [002], [012] and [-102], $E(k,t)$ is multiplied by 500.