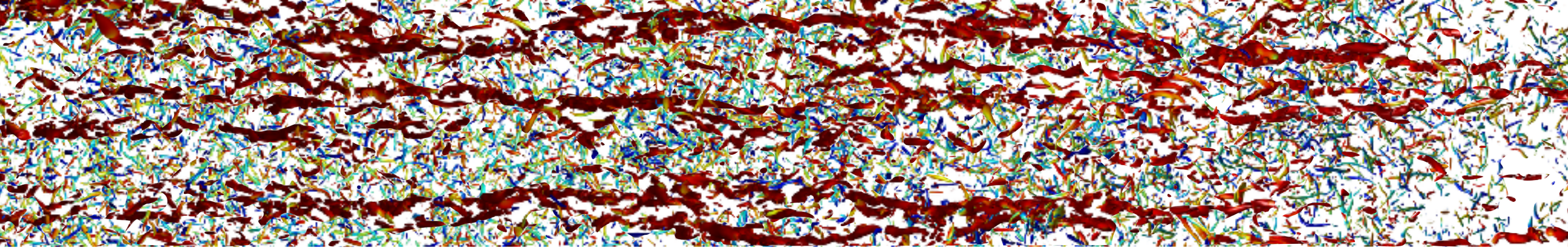

Linear Growth of Columnar Eddies in Homogeneous Rotating Turbulence

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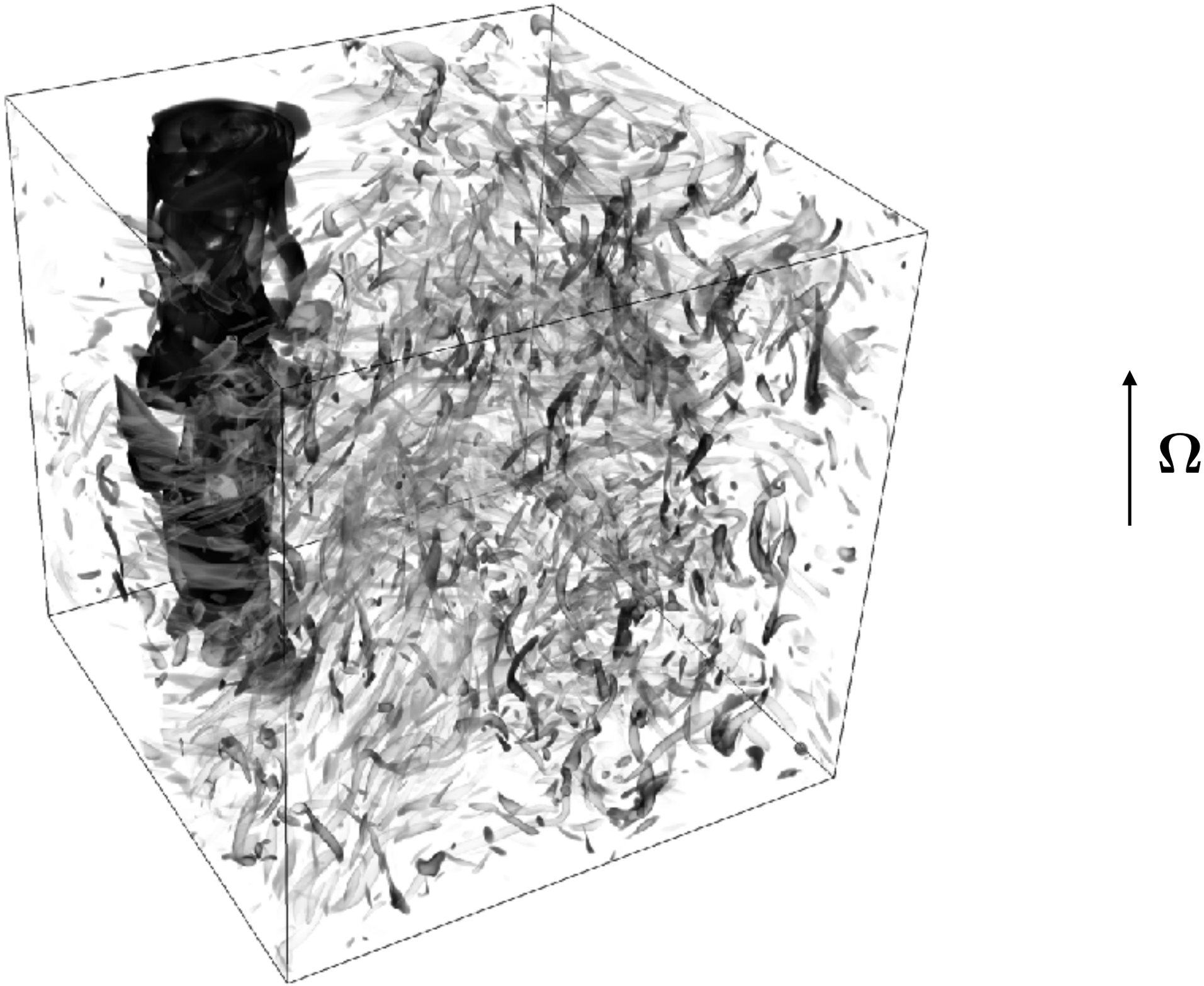
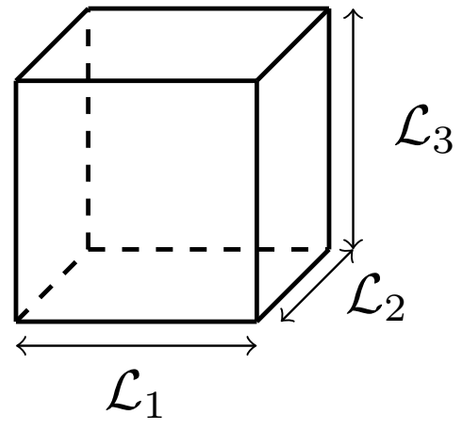
IHPCSS: International HPC Summer School


Ω

Methodology & Numerical Set-up

- DNS in a three-dimensional periodic-box
- Pseudo-spectral + de-aliasing (2/3-rule)
- Time integration: 3rd order Runge-Kutta and exact integration (Rogallo)



$$\nabla \cdot \mathbf{u} = 0$$

$$\frac{\partial \mathbf{u}}{\partial t} + (\boldsymbol{\omega} \times \mathbf{u}) + \frac{1}{Ro}(\hat{\mathbf{e}}_\Omega \times \mathbf{u}) = -\nabla \tilde{p} + \frac{1}{Re}\nabla^2 \mathbf{u} + \mathbf{f}$$

external body force

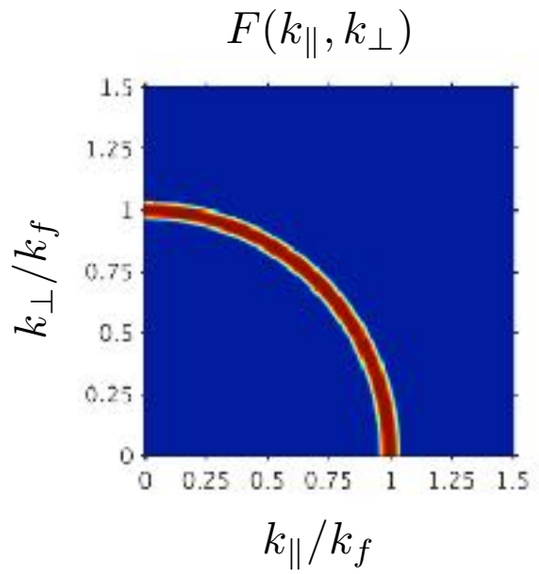
Stochastic Gaussian Forcing: Alvelius (1999) (zero force-velocity correlation)

Force Spectrum:

$$F(\kappa) = A \exp\left(-\frac{(\kappa - \kappa_f)^2}{c}\right)$$

Forcing wave-number

Amplitude



Performed Simulations

- $Re_\lambda \approx 70$
- $Ro_T = \varepsilon/(2\Omega u') = 0.027$
- $k_\Omega \eta = (\Omega^3/\varepsilon)^{1/2}\eta \approx 1.1$

~70% of the scales are affected by rotation

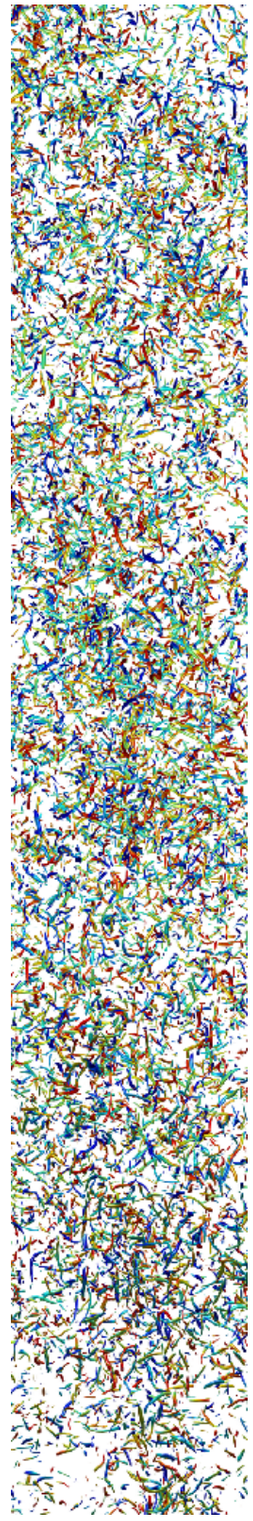
Case	k_f	A_z	$L_z/L_{\|\|}$	N_p
KF02-E01	2	1	9.7	192^3
KF04-E01	4	1	20.1	384^3
KF04-E02	4	2	40.0	$384^2 \times 768$
KF04-E04	4	4	80.0	$384^2 \times 1536$
KF04-E08	4	8	164.7	$384^2 \times 3072$
KF04-E16	4	16	329.4	$384^2 \times 6144$
KF04-E32	4	32	640.9	$384^2 \times 12288$
KF08-E01	8	1	41.4	768^3
KF08-E02	8	2	81.0	$768^2 \times 1536$
KF08-E04	8	4	164.0	$768^2 \times 3072$
KF08-E08	8	8	323.6	$768^2 \times 6144$
KF08-E16	8	16	661.9	$768^2 \times 12288$
KF16-E01	16	1	82.3	1536^3
KF16-E02	16	2	166.0	$1536^2 \times 3072$
KF16-E04	16	4	330.9	$1536^2 \times 6144$
KF32-E01	32	1	166.2	3072^3

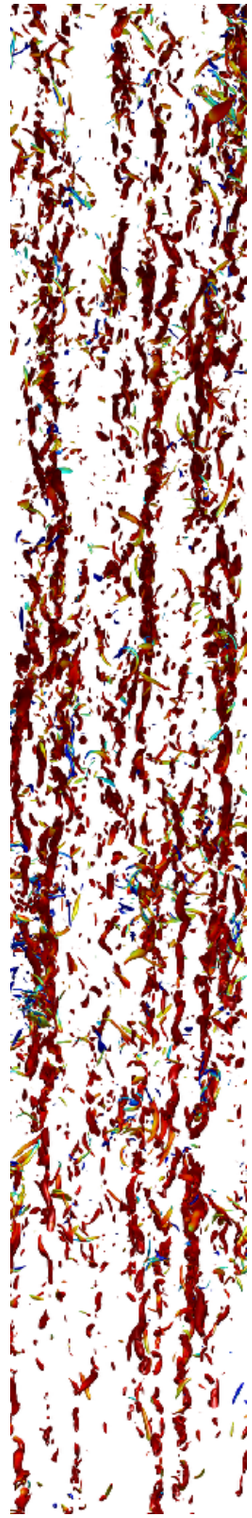
Extensive Database!!

~ 50 DNS

Isotropic

Rotating

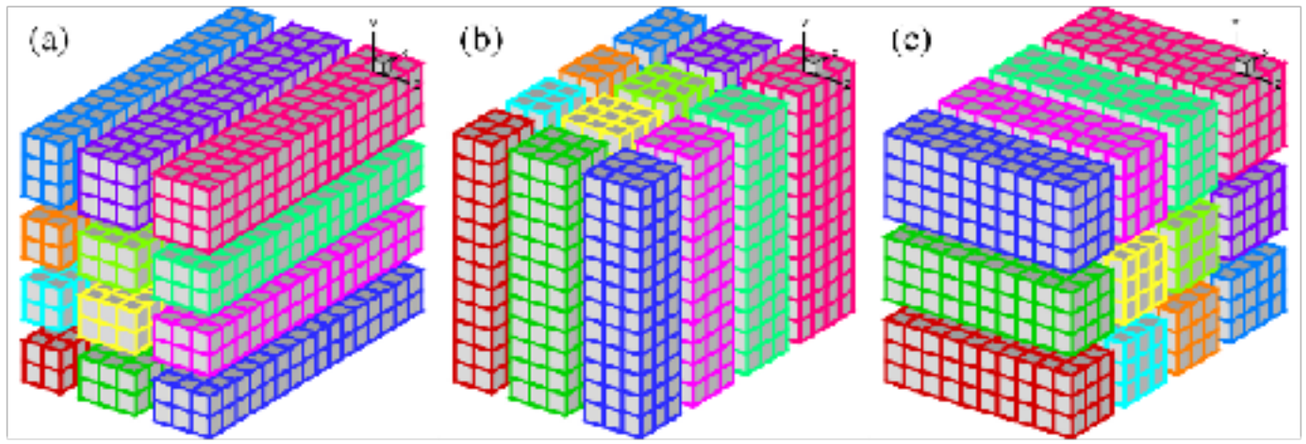




Iso-surfaces of Q colored by $\frac{\omega_z}{\|\boldsymbol{\omega}\|}$

Domain Decomposition Technique

- 80% of the computational time is spent on computing 3D Fourier Transforms
- P3DFFT (communication and data transpose) together with FFTW (actual computation)
- Hybrid Parallelization (MPI-OpenMP)
- Production Runs on up to 28 Billion Grid points and 4800 cores



Cartesius @ Amsterdam