The Johns Hopkins Turbulence Databases (*JHTDB*)

FORCED ISOTROPIC TURBULENCE DATA SET ON 8192^3 grid

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FileDB and Web Services:
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The data is from direct numerical simulations of forced isotropic turbulence on a 8192^3 periodic grid, using a pseudo-spectral parallel code. The simulations are documented in Ref. [1-2]. Time integration uses second-order Runge-Kutta. The simulation is de-aliased using phase-shifting and truncation. Energy is injected by keeping the energy density in the lowest wavenumber modes prescribed following the approach of Donzis & Yeung[4]. After the simulation has reached a statistical stationary state, a frame of data, which includes the 3 components of the velocity vector and the pressure, are generated and written in files that can be accessed directly by the database (FileDB system).

A total of 6 snapshots are available. Five snapshots (snapshots # 0-4) are at higher Reynolds number, while snapshot #5 is from a highly resolved simulation at a lower Reynolds number.

Simulation parameters and resulting statistics for snapshots 0-4:

Domain: $2\pi \times 2\pi \times 2\pi$ (i.e. range of x_1 , x_2 and x_3 is $[0,2\pi]$)
Grid: 8192^3
Viscosity ν = 4.385e-05
Number of snapshots available: 5

Snapshot #	0 (7N.apr03)	1 (6A.dec22)	2 (q6.lag)	3 (F6.lag)	4 (Q5.lag)
time	3.7952	2.3938	4.2912	4.9124	5.33
u_1'	1.5147	1.5065	1.4746	1.4054	1.4741
u_2'	1.4674	1.4986	1.5160	1.6543	1.6663
u_3'	1.7573	1.7055	1.7644	1.7245	1.6700
$u'=(2k/3)^{1/2}$	1.5849	1.5731	1.5902	1.6006	1.6061
Reynolds number	1256.8	1285.3	1271.5	1284.6	1300.8
dissipation ε	1.3668	1.2683	1.3536	1.3612	1.3462
Longitudinal integral scale (averaged over 3 directions) L_l	1.2438	1.1862	1.2792	1.3192	1.3115
Kolmogorov scale η	4.9837E-04	5.0778E-04	4.9958E-04	4.9888E-04	5.0026E-04
$k_{max}\ \eta$	1.92	1.96	1.93	1.93	1.93
$<\varepsilon>L_l/u'^3$	0.4270	0.3865	0.4306	0.4379	0.4261

Simulation parameters and resulting statistics for snapshot 5:

Domain: $2\pi \times 2\pi \times 2\pi$ (i.e. range of x_1 , x_2 and x_3 is $[0,2\pi]$)
Grid: 8192^3
Viscosity $\nu = 1.732\text{e-}04$
Number of snapshots available: 1
Time = 8.24606E-02
RMS velocities u_1', u_2', u_3' = 1.6148, 1.4816, 1.6029
$u'=(2k/3)^{1/2}$= 1.5769
Reynolds number = 613.37
Dissipation ε = 1.4245
Longitudinal integral scale (averaged over 3 directions) L_1 = 1.2983
Kolmogorov scale η = 1.3819E-03
$k_{max}\,\eta$ = 5.3357
$\langle\varepsilon\rangle L_1/u'^3$ = 0.4717

Note: The divergence-free condition in the simulation is enforced using spectral representation of the derivatives. JHTDB analysis tools for gradients are based on finite differencing or splines of various orders. Therefore, when evaluating the divergence using these spatially more localized derivative operators, a non-negligible (but for the well-resolved DNS very small) error in the divergence is obtained, as expected.

References:

1. Snapshots 0-1 : Yeung, P.K., Zhai, X.M. and Sreenivasan, K.R. (2015) "Extreme events in computational turbulence." Proceedings of the National Academy of Sciences, Vol **112**, 12633-12638. Snapshots 2-4 taken from related work by D. Buaria.
2. Snapshot 5 : Yeung, P.K., Sreenivasan, K.R. and Pope, S.B. (2018) "Effects of finite spatial and temporal resolution on extreme events in direct numerical simulations of incompressible isotropic turbulence." Physical Review Fluids Vol. **3**, 064603.
3. Yeung, P.K., D.A. Donzis, and K.R. Sreenivasan. (2012) "Dissipation, enstrophy and pressure statistics in turbulence simulations at high Reynolds numbers." Journal of Fluid Mechanics **700**, 5-15.
4. Donzis, D.A., and P.K. Yeung (2010). "Resolution effects and scaling in numerical simulations of passive scalar mixing in turbulence." Physica D: Nonlinear Phenomena **239**, 1278-1287.

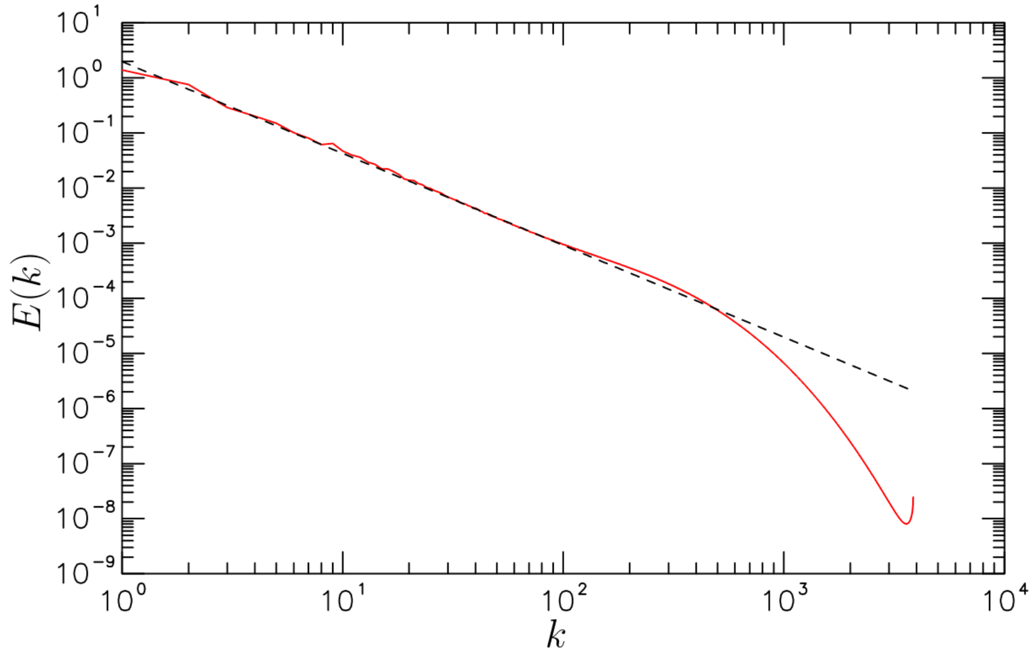

Figure 2: Three dimensional energy spectrum for snapshot 0. Dashed line corresponds to 1.6E(k) $\varepsilon^{(2/3)}k^{(-5/3)}$

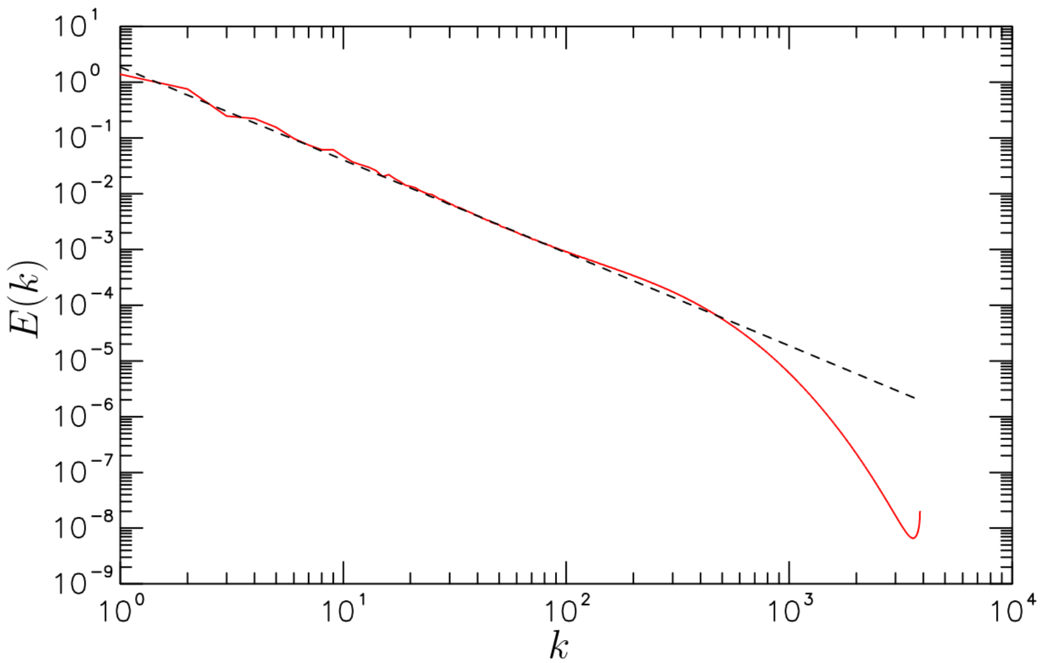

Figure 1: Three dimensional energy spectrum for snapshot 1. Dashed line corresponds to 1.6E(k) $\varepsilon^{(2/3)}k^{(-5/3)}$

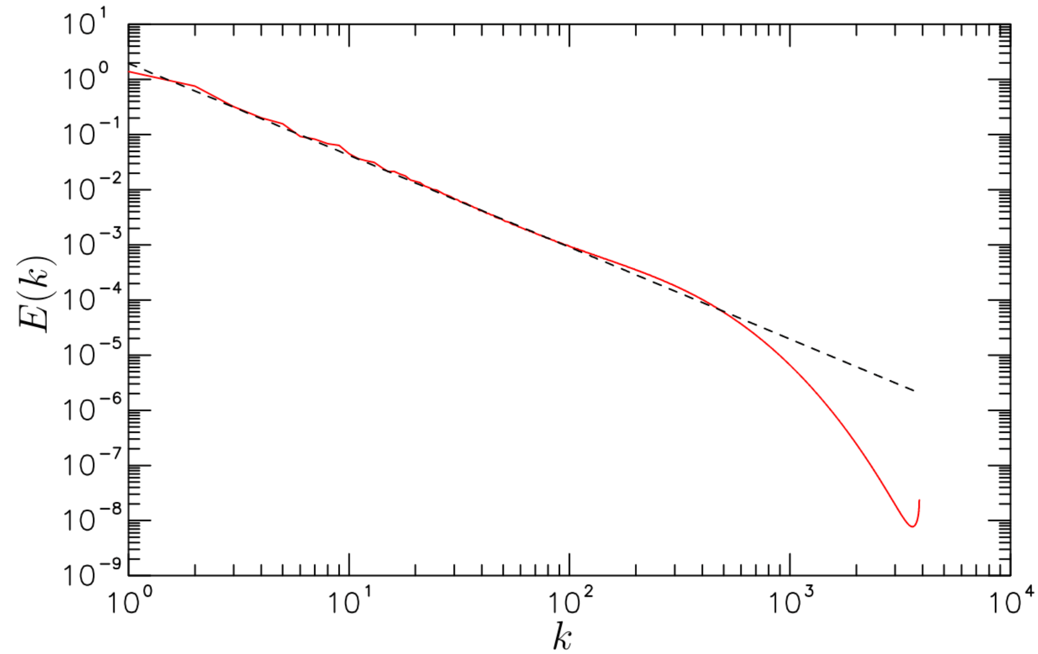

Figure 3: Three dimensional energy spectrum for snapshot 2. Dashed line corresponds to 1.6E(k) $\varepsilon^{(2/3)}k^{(-5/3)}$

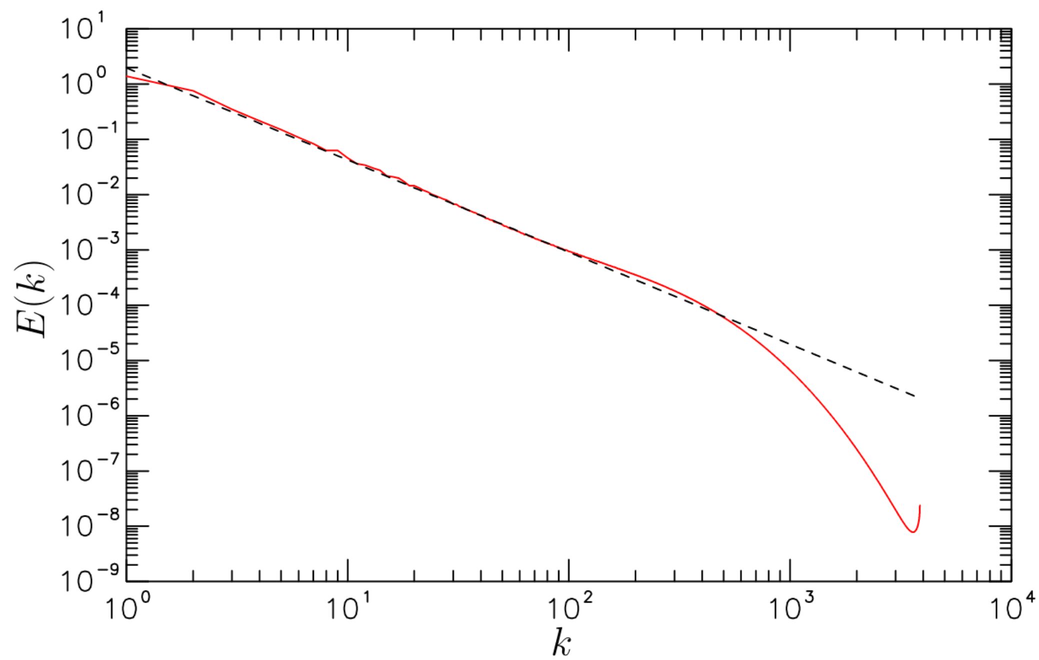

Figure 4: Three dimensional energy spectrum for snapshot 3. Dashed line corresponds to 1.6E(k) $\varepsilon^{(2/3)}k^{(-5/3)}$

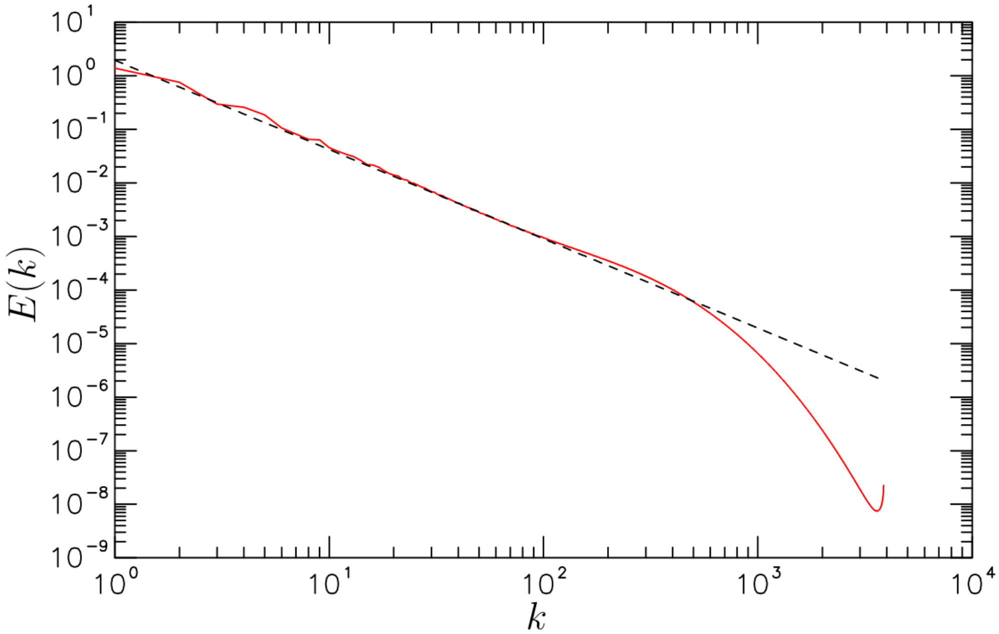

Figure 6: Three dimensional energy spectrum for snapshot 4. Dashed line corresponds to $1.6E(k)\ \varepsilon^{(2/3)}k^{(-5/3)}$

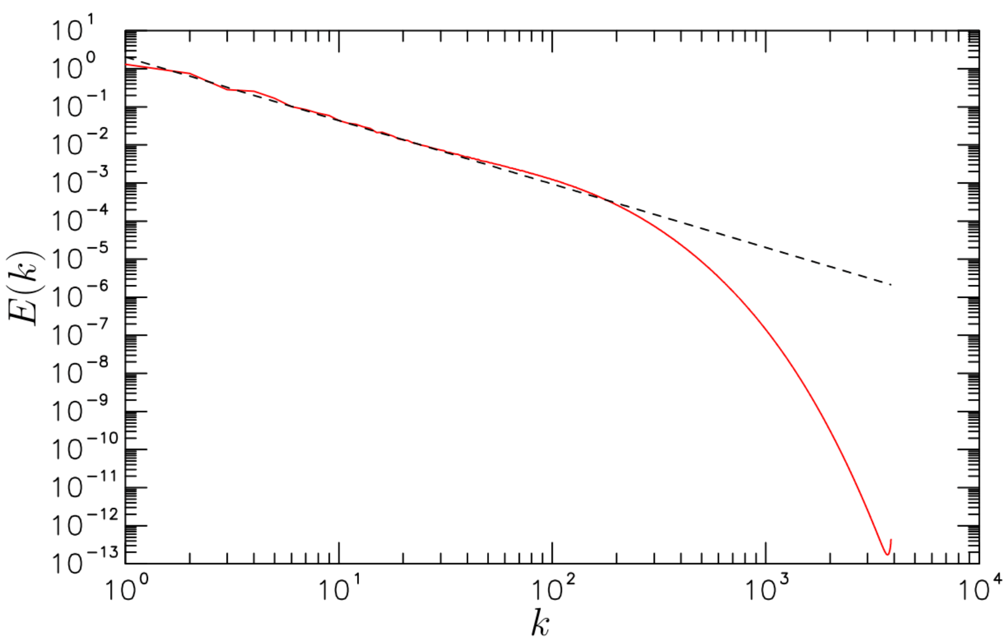

Figure 5: Three dimensional energy spectrum for snapshot 5. Dashed line corresponds to $1.6E(k)\ \varepsilon^{(2/3)}k^{(-5/3)}$

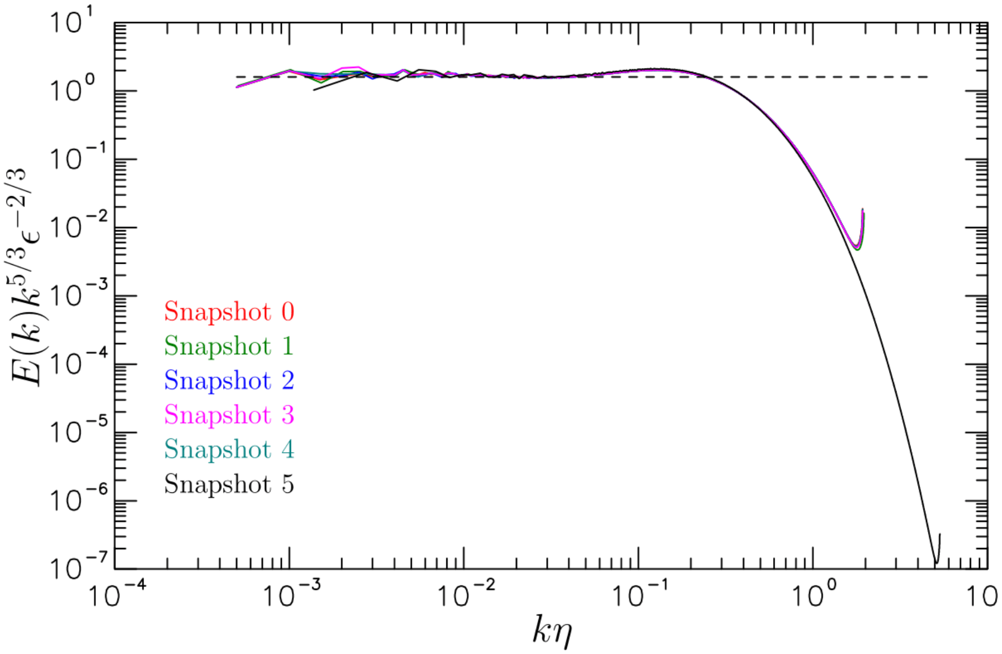

Figure 8: Pre-multiplied three dimensional energy spectrum for all snapshots. Dashed line corresponds to a value of 1.6.

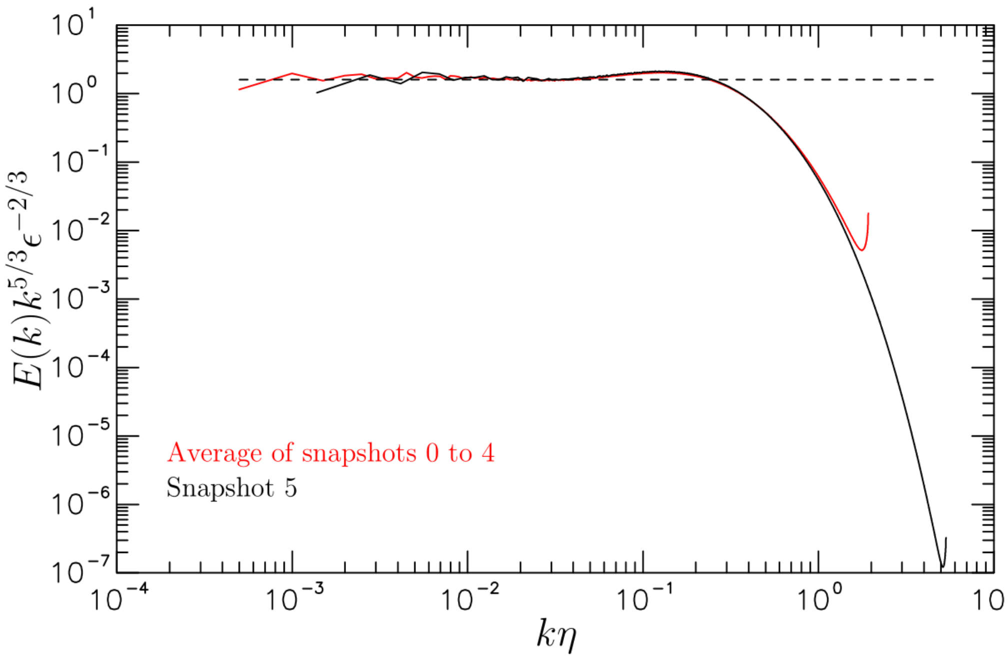

Figure 7: Pre-multiplied three dimensional energy spectrum. Average of snapshots 0 to 4 shown by line in red. Dashed line corresponds to a value of 1.6.