DISSIPATION AND DECAY IN HIT STUDIED USING LET, EDQNM AND DNS

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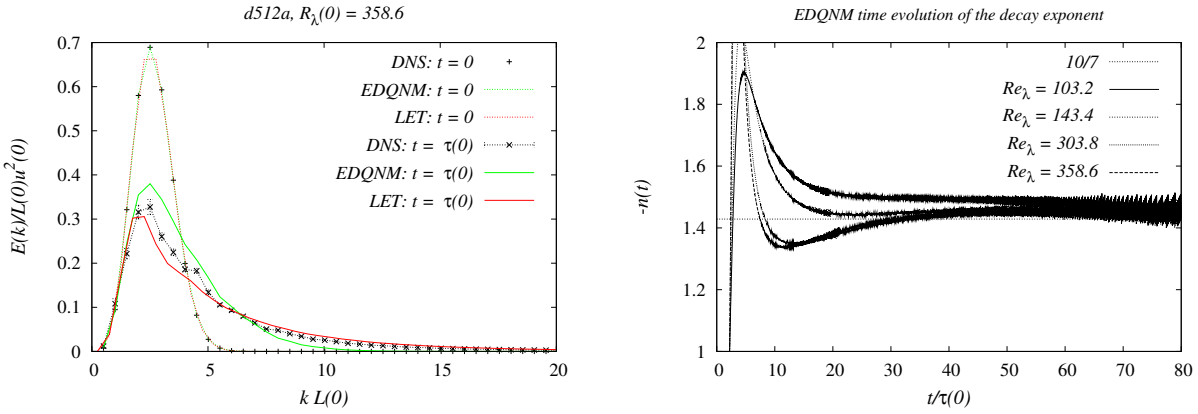
Abstract We present results from numerical simulations of freely decaying homogeneous isotropic turbulence using the EDQNM and LET closures in comparison to results obtained from DNS. The closure simulations have been initialised not only from prescribed initial spectra, but also from ensemble averaged spectra obtained by DNS of forced turbulence once it had reached steady state. In both cases energy and dissipation exponents, as well as structure functions and their exponents, are calculated.
The present work also includes a theoretical analysis of the mathematical properties of the spectra and correlation functions, which leads to interesting results for their limiting behaviours.

DECAY FROM PRESCRIBED INITIAL SPECTRA

For comparison reasons the closure simulations and the DNS have been initialised from the same initial spectrum

$$E(k,0) = C_1 k^4 e^{C_2 k^2} \ , \tag{1}$$

where $C_1 = 0.001702$ and $C_2 = -0.08$.
The adjustable parameter of the EDQNM eddy damping function has been set following the procedure in [1] to obtain a value of 1.6 for the Kolmogorov constant, as opposed to 1.4 as in [3]. A comparison between LET, EDQNM and DNS for identical initial data can be seen in figure 1(a). We have found that although EDQNM overestimates the dissipation spectrum, it produces energy and dissipation exponents that are in agreement with K41. LET is in better agreement with DNS data for all spectra, the decay and dissipation exponents obtained so far seem to tend towards a slightly lower value than K41. Figure 1(b) shows the time evolution of the energy exponent for EDQNM. With increasing Reynolds number one observes the convergence of the energy exponents to the Kolmogorov value of -10/7, which is indicated by the dashed line in figure 1(b). We obtain similar results to Lesieur and Ossia in [3], where a slightly lower value of the energy exponent has been observed, although for much higher Reynolds numbers than in the present study.



(a) Comparison between EDQNM, LET and DNS.

(b) Time evolution of the energy exponent for EDQNM.

Figure 1.

DECAY FROM DNS ENSEMBLE AVERAGED SPECTRA

The closure simulations have also been initalised from ensemble averaged spectra obtained by direct numerical simulation of forced turbulence. This ensures that our initial spectra represent evolved turbulence, unlike the prescribed spectra. The adjustable parameter in the EDQNM eddy damping function has been set to the same value as for the decay from a prescribed initial spectrum.
Here we present preliminary results for closure simulations with intermediate Reynolds numbers. Since the DNS must reach steady-state before the spectra can be used to initialise our closure simulations, generating high Reynolds number initial spectra requires considerable computational cost, beyond our current capabilities. For this reason we have obtained access to the National Supercomputer HECToR at Edinburgh. This will enable us to generate higher Reynolds number

initial spectra in a few months time.
As can been seen in figure 2, both the EDQNM and LET simulations performed so far indicate the onset of an inertial subrange, although the Kolmogorov $k^{-5/3}$ behaviour has not been found. Instead we find lower exponents, in the range of $k^{-1.4}$ to $k^{-1.49}$ for EDQNM, for LET the range of $k^{-1.3}$ to $k^{-1.32}$. This might be due to finite Reynolds number (FRN) effects as studied in [4] and [2], and is the subject of further investigation.

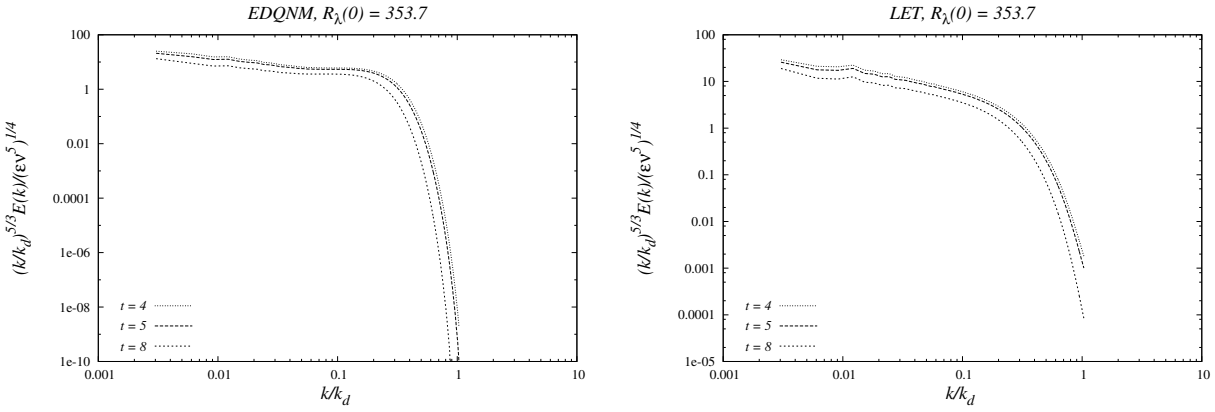


Figure 2. Kolmogorov compensated spectra

THEORETICAL ANALYSIS OF SPECTRA AND CORRELATION FUNCTIONS

We have performed an investigation into the mathematical properties of the spectral and real space correlation tensors in terms of necessary Lebesgue integrability conditions for duality under the Fourier transform operator. This has led us to interesting results for the long-time behaviour of the spectra, which we have further studied numerically using DNS initialised with energy spectra which exhibit small wavenumber dependence other than k^2 or k^4.

References

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