Accademia delle Scienze di Torino
Euromech Colloquium 512
"Small scale Turbulence and Related Gradient Statistics"
Torino, October 26-29, 2009

Decay exponent of large and small scales in isotropic turbulence

DANIELA TORDELLA*, MICHELE IOVIENO*

The effect of the initial conditions on the decay of homogeneous and isotropic turbulence is still under debate [1]-[4], and there is a substantial body of experimental evidence which would seem to suggest that the initial conditions and the slope of the spectrum, at low wavenumbers, determine the value of the decay exponents. We consider it interesting to verify this hypothesis since, in such a way, it is possible to highlight the possible role played by the smaller scales. To do this, we consider the time decay of a turbulent flow with an initially uniform turbulent kinetic energy, but where the integral scale has been varied slightly in two adjacent regions. The simulations thus follow the temporal decay of two homogeneous and isotropic turbulent flows with uniform initial kinetic energy separated by a thin transition layer in a parallelepiped domain with periodic boundary conditions. The two fields are characterized by different shaped spectra in the low wavenumber range, obtained by applying a high-pass filter to the same homogeneous and isotropic turbulent field, which produces a k^{α} slope with α between 2 and 4. The simulations show that, for flows with an identical kinetic energy, those with smaller integral scales and thus comparatively richer in energy in the small scale range, decay faster and have higher decay exponents, which go from 1.1 up to 1.65: the smaller the macroscale, the higher the exponent. This is in qualitative agreement with [1], who suggests that the energy decay exponent n is a function of the low wavenumber exponent α of the spectrum, $n = (\alpha + 1)/2$, and with the measurements in [5]. We then focus on the decay rates of the large and the small scale ranges by dividing the spectrum into two parts: the left part – small wave numbers – initially contains 60% of the total energy, the right part – high wave numbers – the remaining 40%.

It can be observed that the decay rate of the full scale range is in-between that of the small scale range and that of the large scale range (see figure 1, where the variation of the decay exponents with the integral scale can be seen). It can be also seen that, at the lower values of the integral scale, in fields with the same initial kinetic energy, the full range exponent comes closer to the arithmetic mean of the two other exponents. This indicates that the actual decay rate of the isotropic turbulence is not only affected by the large scale properties, but also by the small scale properties.

*Dipartimento di Ingegneria Aeronautica e spaziale, Politecnico di Torino, Corso Duca degli Abruzzi 24, 10129 Torino, Italy.
E-mail: daniela.tordella@polito.it

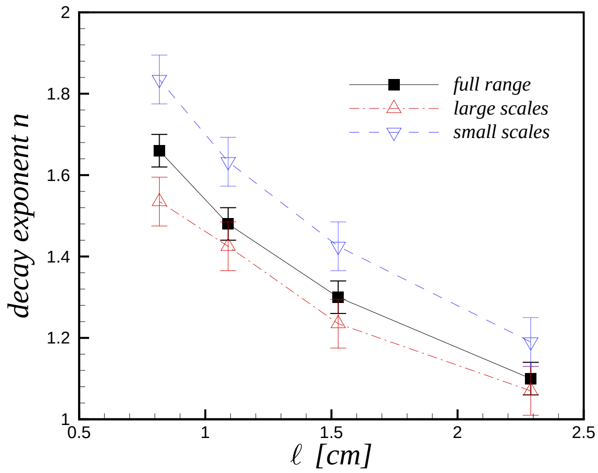

Figure 1: Energy decay exponents as function of the initial integral scale.

References

[1] GEORGE W.K., *The decay of homogeneous isotropic turbulence.* Phys. Fluids **4**(1992), 1492-1509.

[2] MANSOUR N.N. AND WRAY A., *Decay of isotropic turbulence at low Reynolds number*. Phys. Fluids **6**, 808-814 (1994).

[3] GEORGE W.K. AND DAVIDSON L., *Role of initial conditions in establishing asymptotic flow behavior.* AIAA J. **42**(2004), 438-446.

[4] LAVOIE P., DJENIDI L. AND ANTONIA R.A., *Effects of initial conditions in decaying turbulence generated by passive grids*. J.Fluid Mech. **585**(2007), 395-420.

[5] ANTONIA R.A., ZHOU T., DANAILA L. AND ANSELMET F., *Scaling of the mean energy dissipation rate equation in grid turbulence*. J. Turb. **3**(2002), 034/1-7.