

# Large-scale resolution and finite-size effects.

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This post arises out of the one on local isotropy posted on 21 October 2021; and in particular relates to the comment posted by Alex Liberzon on the need to choose the size of volume  $G$  within which Kolmogorov's assumptions of localness may hold. In fact, as is so often the case, this resolves itself into a practical matter and raises the question of large-scale resolution in both experiment and numerical simulation.

In recent years there has been growing awareness of the need to fully resolve all scales in simulations of isotropic turbulence, with the emphasis initially being on the resolution of the small scales. In my post of 28 October 2021, I presented results from reference [1] showing that compensating for viscous effects and the effects of forcing on the third-order structure function  $S_3(r)$  could account for the differences between the four-fifths law and the DNS data at all scales. In this work, the small-scale resolution had been judged adequate using the criteria established by McComb *et al* [2].

However in [1], we noted that large-scale resolution had only recently received attention in the literature. We ensured that the ratio of box size to integral length-scale (i.e.  $L_{\text{box}}/L$ ) was always greater than four. This choice involved the usual trade-off between resolution requirements and the magnitude of Reynolds number achieved, but the results shown in our post of 28 October would indicate that this criterion for large-scale resolution was perfectly adequate. That could suggest that taking  $G \sim (4L)^3$  might be a satisfactory criterion. Nevertheless, I think it would be beneficial if someone were to carry out a more systematic investigation of this, in the same way as reference [1] did

for the small-scale resolution.

Some attempts have been made at doing this in experimental work on grid turbulence: see the discussion on pages 219-220 in reference [3], but it clearly is a subject that deserves more attention. As a final point, we should note that this topic can be seen as being related to finite-size effects which are nowadays of general interest in microscopic systems, because there the theory actually relies on the system size being infinite. I suppose that we have a similar problem in turbulence in that the derivation of the solenoidal Navier-Stokes equation requires an infinitely large system, as does the use of the Fourier transform.

[1] W. D. McComb, S. R. Yoffe, M. F. Linkmann, and A. Berera. Spectral analysis of structure functions and their scaling exponents in forced isotropic turbulence. *Phys. Rev. E*, 90:053010, 2014.

[2] W. D. McComb, A. Hunter, and C. Johnston. Conditional mode-elimination and the subgrid-modelling problem for isotropic turbulence. *Phys. Fluids*, 13:2030, 2001.

[3] W. David McComb. *Homogeneous, Isotropic Turbulence: Phenomenology, Renormalization and Statistical Closures*. Oxford University Press, 2014.