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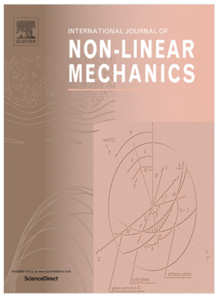

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On the nature of multitude scalings in decaying isotropic turbulence

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Abstract

We report multitude scaling laws for isotropic fully developed decaying turbulence through group theoretic method employing on the spectral equations both for modelling and without any modelling of nonlinear energy transfer. For modelling, besides the existence of classical power law scaling, an exponential decay of turbulent energy in time is obtained subject to exponentially decaying integral length scale at infinite Reynolds number limit. For the transfer without modelling, at finite Reynolds number, in addition to general power law decay of turbulence intensity with integral length scale growing as a square root of time, an exponential decay of energy in time is explored when integral length scale remains constant. Both the power and exponential decaying laws of energy agree to the theoretical results of George [Phys. Fluids, 4(7):1492, 1992], George and Wang [Phys. Fluids, 21:025108, 2009] and experimental results of fractal grid generated turbulence by Hurst and Vassilicos [Phys. Fluids, 19:035103, 2007]. At infinite Reynolds number limit, a general power law scaling is obtained from which all classical scaling laws are recovered. Further, in this limit, turbulence exhibits a general exponential decaying law of energy with exponential decaying integral length scale depending on two scaling group parameters. The role of symmetry group parameters on turbulence dynamics is discussed in this study.

Keywords: symmetry transformation; multitude scaling laws; isotropic turbulence

1 Introduction

Decaying of homogeneous and isotropic turbulence is a topic of much debate, in particular, whether it is universal or not. The early wind tunnel experiments for turbulence production using regular rectangular grids suggested that turbulence statistics forgot its initial conditions within a short time span and a single universal power law scaling independent of initial/upstream conditions is observed (see Monin and Yaglom [1]). The conclusion is that the initial conditions affect only the characteristic velocity scales and

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