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Intermittency in Complex Flows

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Experimental results of the complex turbulent wake of a cilinder in 2D [1] and 3D flows [2] were used to investigate the scaling of structure functions, similar research was also performed on wave propagation and breaking in the Ocean [3], in the the stratified Atmosphere (ABL) [4] and in a 100large flume (UPC) for both regular and irregular waves, where long time series of waves propagating and generating breaking turbulence velocity rms and higher order measurements were taken in depth. [3,5] by means of a velocimeter SONTEK3-D. The probability distribution functions of the velocity differences and their non Gaussian distribution related to the energy spectrum indicate that irregularity is an important source of turbulence. From Kolmogorov's K41 and K61 intermittency correction: the p th-order longitudinal velocity structure function δu_l at scale l in the inertial range of three-dimensional fully developed turbulence is related by

$$\langle \delta u_l^p \rangle = \langle (u(x+l) - u(x))^p \rangle \sim \epsilon_0^{p/3} l^{p/3}$$

where $\langle ... \rangle$ represents the spatial average over flow domain, with ϵ_0 the mean energy dissipation per unit mass and l is the separation distance. The importance of the random nature of the energy dissipation led to the K62 theory of intermittency, but locality and non-homogeneity are key issues.

$$\langle \delta u_l^p \rangle \sim \langle \epsilon_l^{p/3} \rangle l^{p/3} \sim l^{\xi_d}$$

and $\xi_p = \frac{p}{3} + \tau_{p/3}$, where now ϵ_l is a fractal energy dissipation at scale l, $\tau_{p/3}$ is the scaling of $< \varepsilon_\ell^{p/3} >$ and ξ_p is the scaling exponent of the velocity structure function of order p. Both in K41 and K62, the structure functions of third order related to skewness is $\xi_3 = 1$. But this is not true either.

We show that scaling exponents ξ_p do deviate from early studies that only investigated homogeneous turbulence, where a large inertial range dominates. The use of multi-fractal analysis and improvements on Structure function calculations on standard Enhanced mixing is an essential property of turbulence and efforts to alter and to control turbulent mixing is a subject of great importance because it has a broad range of practical applications. In the chemical industry in particular mixing is desirable to facilitate fast mixing of reactants coupled with PIV, and on other methods used in experimental fluids mechanics, both in Eulerian and Lagrangian frameworks towards the understanding of molecular mixing and the role of vorticity and helicity in the analysis of stream function parameter oundaries of spatial dynamic features. Already we used multi-fractal analysis techniques and apply these techniques to understand the scale to scale transport related to mixing and the velocity structure function,used by [1, 2] in the form

$$\langle \mid \delta u_l \mid^p \rangle \propto \langle \mid \delta u_l \mid^s \rangle^{\zeta_p/\zeta_s}$$

where ζ_p/ζ_s is a general relative scaling exponent that can be expressed as

$$\zeta_p/\zeta_s = \frac{d \log \langle \mid \delta u_l \mid^p \rangle}{d \log \langle \mid \delta u_l \mid^s \rangle}$$

In these relations ζ_p can be different from ξ_p for odd values of p because absolute values of velocity increments are used. Clearly, the scale-invariance for relative exponents when ζ_p and ζ_s are scale-dependent cannot be easily interpreted.

We estimate different intermittency parameters as a function of local instability e.g. Kelvin/Helmholtz, Rayleigh-Taylor or Holbmoe. Different scalar interfaces show different structures, that also depend on local Richardsons numbers, this may be due to different levels of intermittency and thus different spectra, which are not necessarily inertial nor in equilibrium. the analysis of the statistical properties of the velocity structure function is performed using a relative scaling. In the areas of breaking-induced turbulence and foam, which corespond to active, highly intermittent, turbulent regions, using(ESS), we define local intermittency at different depths and horizontal positions.

The deviation from the -5/3 law for the power spectra at certain positions is clear, (PDF) of velocity differences highly deviate from a gaussian distribution, and depend on the depth or with downstream distance for intermediate Reynolds numbers.

[1] A. Babiano, B. Dubrulle. and P. Frick; Phys. Rev. E. 55(3): 2693-2706 (1997).

[2] E. Gaudin, B. Protas, S. Goujon-Durand, J. Wojciechowski, J. E. Wesfreid; Phys. Rev. E. 57, 9-12 (1998).

[3] O. B. Mahjoub; Non-local dynamics and intermittency in non-homogeneous flows. PhD Thesis UPC Barcelona Tech. 139 p.(2000)

[4] Vindel J.M. Yague C and Redondo J.M.; Relationship between intermittency and stratification. Il. Nuovo Cimento 31, C. 669-678. (2008).

[5] J.M. Redondo; Mixing efficiencies of different kinds of turbulent processes and instabilities, Applications to the environment, Turbulent mixing in geophysical flows. Eds. Linden P.F. and Redondo J.M. 131-157. (2001).

[6] J.M. Redondo; Turbulent mixing in the Atmosphere and Ocean ,Fluid Physics. 5: 584-597. World Scientific. New York. (1994).

[7] O. B. Mahjoub, J. M. Redondo and A. Babiano; Applied Scientific R8search, 59, 299-313 (1998).

[8] O. B. Mahjoub, J. M. Redondo and A. Babiano; Self simmilarity and intermittency in a turbulent non-homogeneous wake. Ed. C. Dopazo et al. Advances in Turbulence VIII. 783-786. (2000)