Intermittency in a turbulent model as consequence of stationary constraints

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In his seminal work of 1941, Kolmogorov derived the strongest theoretical prediction for the scaling exponent exponents in hydrodynamic turbulence using the hypothesis of the stationary mean energy transfers [1,2,3]. However, this theory fails to predict the intermittent behavior of hydrodynamic turbulence. This intermittency is well reproduced by some simplified models of turbulence like the GOY-shell model [4,5]. Here we use others constraints that stationary processes impose on the fluctuations during the energy transfers. To our knowledge, they were never used in the context of turbulence to capture intermittency. We first recall these constraints that affect the Power Density Spectra of the fluctuations of the injected power, the dissipated power and the energy flux at vanishing frequencies [6]. Then we show that the intermittent GOY–shell model fulfills these constraints. We demonstrate that this implies a relation between the scaling exponents. This relation does not hold in the non-intermittent framework of the 1941 Kolmogorov theory (K41). However it is fulfilled by the She-Leveque formula that correctly predicts the intermittent scaling exponent of hydrodynamic turbulence and of the GOY-shell model [7]. Moreover, it fixes the free "intermittent" parameter of the lognormal model to a realistic value [8]. The constraints on power fluctuations seem to enforce some intermittency in the case of the GOY-shell model. Some possible extensions to real turbulence are drawn in the concluding remarks.

This work is supported by the French National Research Agency (ANR DYSTURB Project No. ANR-17-CE30-0004).

Références

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