Intermittency Measurement in Two-Dimensional-Like Bacterial Turbulence

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ABSTRACT

Locomotion and transport of microorganisms in fluids is an essential aspect of life. Search for food, orientation toward light, spreading of offspring, and the formation of colonies are only possible due to locomotion. Swimming at the microscale occurs at low Reynolds numbers, where fluid friction and viscosity dominates over inertia. Specifically for a bacterial suspension in a thin fluid, it could be approximated as a 2D fluid system. In such system, the fluid is stirred by the bacterial activities at their body length *R*. Due to the hydrodynamic interaction or other mechanisms the flow exhibits a turbulent-like movement, showing multiscale statistics. Such flows are then called as bacterial turbulence or active turbulence.

To quantify the multifractality, one of the most important features of turbulence, in a two-dimensional bacterial turbulence, a Hilbert-based methodology without the β -limitation, the slope of the Fourier spectrum, is applied to the velocity field obtained experimentally. A dual-power-law behavior, which is separated by the viscosity scale, is observed for the qth-order Hilbert moment $L_q(\omega)$. The measured scaling exponents $\zeta(q)$ of both the small-scale and large-scale motions are convex, showing the multifractality of the active turbulence. A lognormal formula is put forward to characterize the intensity of the multifractality of the observed cascade. The measured intermittency parameters are respectively $\mu_S = 0.26$ and $\mu_L = 0.17$ for the small-scale and large-scale motions, showing the former cascade is more intermittent than the latter one. The corresponding singularity spectrum $f(\alpha)$ vs α confirms this finding.

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