Multifractal Probability Density Function Theory and Its Application to Fully Developed Turbulence
- A Detailed Study of PDFs from Experiment and DNS -

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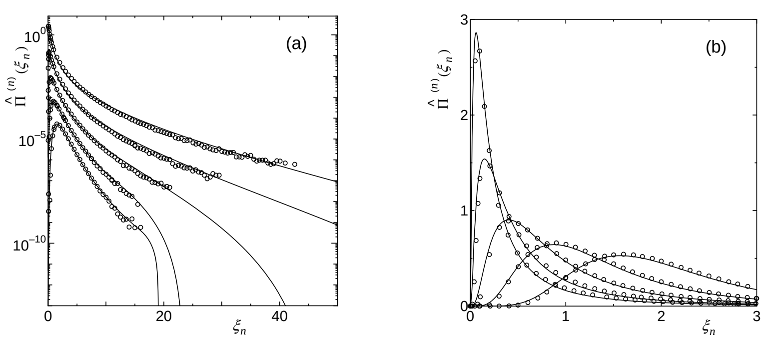
ABSTRACT

The probability density functions (PDFs) for energy dissipation rates extracted from the experiment of fully developed turbulence in a wind tunnel and from DNS with 4096^3 grid points are analyzed within the framework of multifractal probability density function theory (MPDFT) to a high accuracy in order to test the validity of a new scaling relation. MPDFT is a statistical mechanical ensemble theory provided by the authors in order to analyze intermittent phenomena providing fat-tail PDFs. The new scaling relation is introduced so as to be able to analyze intermittency through any series of PDFs with arbitrary magnification $\delta\ (> 1)$. Since the value of δ can be determined freely by observers, the choice of δ should not affect observables. The validity of the generalized MPDFT is verified successfully through the precise analyses of several series of PDFs with different values of δ. In the course of the verification, it is revealed that the system of fully developed turbulence has much wider area representing scaling behaviors than the inertial range.



The above figures are the PDFs of energy dissipation rates extracted from the experiment of fully developed turbulence in a wind tunnel for $\delta = 3$ on (a) log and (b) linear scale in the vertical axes. For better visibility, each PDF in (a) is shifted by -1 unit along the vertical axis. Open circles are the experimental PDFs for $r/\eta = 6.57,\ 21.9,\ 65.7,\ 197,\ 591$ from the smallest value (top) to the largest value (bottom) where r is the length of regions in which the physical quantities are coarse-grained. Solid lines represent the curves given by the present theory.

REFERENCES

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