e small-scale ence

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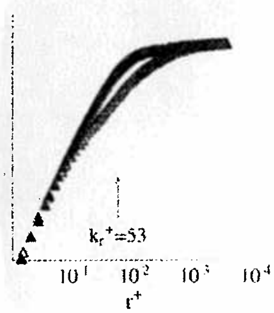
ncerning the small-scale turbu-
ı-wall conditions. The rough-
:d characteristic length scale to
in fully developed flows with
about 67000.
order structure functions corre-
he same distance from the wall
falls in the middle of the region
ompared to the inertial range of
ıll case, the roughness strongly
:gions and imposing its charac-
the turbulence energy could be
s, that would act as a forcing of



(b) corresponding to the rough-

Evidence for algebraic tails of probability distributions in laboratory-scale turbulence

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A little appreciated generic feature of canonical cascade processes is that in general there will be a critical order of divergence q_D such that: $Pr(\varepsilon_\lambda > s) \approx s^{-q_D}$, $\langle \varepsilon_\lambda{}^q \rangle \to \infty$ for $q \geq q_D$. Empirical studies of the divergence of moments in atmospheric turbulence have yielded $q_D \approx 2.4$ in the horizontal direction and $q_{D,V} \approx 5$ in the vertical direction. We experimentally verify the divergence of moments using well-controlled laboratory-scale measurements. We analyzed active grid wind tunnel turbulent velocity data at a Reynolds number of $R_\lambda = 582$, approaching those of the atmosphere ($\approx 10^3 - 10^4$). The tails of both probability distributions of $|\Delta U_r| = |U(x) - U(x+r)|$ display a distinctive power-law distribution, with absolute slopes of 5.4 and 7.7, respectively. This is confirmed from the compensated probability distributions by the tail exponent $q_{D,V}$. The observed power law tails in the probability distribution of velocity differences at IR separations imply that moments of velocity differences will diverge for orders greater than ≈ 7.7. Since the energy flux ε depends on the cube of velocity differences at IR spacings, moments of the energy flux will diverge for orders greater than $q_D \approx 7.7/3 \approx 2.6$. The experimental results are thus consistent both qualitatively and quantitatively with the log-Levy multifractal model for an intermittent energy cascade, which theoretically predicts the divergence of higher-order statistical moments. Furthermore, the algebraic distribution of probabilities of velocity differences at DR separations indicate that moments will diverge for orders greater than ≈ 5.4, lower by a factor of 3/2 than for IR separations. This is consistent with the fact that the energy dissipation rate at small scales, scales as the square of velocity differences, rather than the cube. Thus the empirical estimate $q_D \approx 5.4/2 \approx 2.7$, agrees within experimental scatter with the q_D for the energy flux.