Schmidt-number dependence in turbulent mixing: very low Schmidt numbers and spectral transfer

P.K. YEUNG, Georgia Tech, K.R. SREENIVASAN, New York Univ, K.P. IYER, D. BUARIA, Georgia Tech — The physics of turbulent mixing depends on both the Reynolds number and Schmidt number ($Sc$), which varies widely in applications and leads to different scaling regimes. The case of $Sc \ll 1$, which is relevant in liquid metals and astrophysics, is perhaps the least understood since laboratory data are difficult to obtain. We have performed direct numerical simulations of passive scalars of $Sc$ from $1/32$ to $1/512$, on a periodic domain of larger size than usual to accommodate the growth of large scales in the scalar fields, and with a very small time step to resolve the time scales of molecular diffusion. For $Sc = 1/128$ and $1/512$ the spectrum obtained appears to support $k^{-17/3}$ inertial-diffusive behavior proposed by Batchelor, Howells & Townsend (1959) although results at higher Reynolds numbers are required. Calculations of spectral transfer, including the transfer flux, indicate that the spectral cascade is greatly suppressed, which implies a number of classical notions such as dissipative anomaly and local isotropy become inapplicable in this regime. Together with other recently published data the new results also enable progress towards a unified view of Schmidt number dependence for small-scale turbulent mixing.

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