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Viscous range of turbulent scalar of large Prandtl number

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The analytical theory of a turbulent scalar, developed in previous papers [Phys. Fluids 28 (1985) 1299; J. Fluid Mech. 217 (1990) 203], is extended to the case of large Prandtl number. The fluctuation character of the least principal rate of strain γ has an important effect upon the scalar spectrum. The scalar variance spectrum in the viscous range is $F(k)=4.472(\ν\/\ϵ)^{1/2}\ \χk^{\−1}H(x)$, $x\≡(k\/kb)^2$; H(x) is a dimensionless universal function and is determined by solving numerically the closed spectral dynamical equations. A simple fitting formula of the numerical result is $H(x)=0.7687\ \exp(\−3.79x)+0.2313\ \exp(\−11.13x)$, which corresponds a two-values fluctuation model of γ. Here ν is the kinematic viscosity, $kb\≡(\ϵ\/\ν\μ^2)^{1/4}$ is the Batchelor wavenumber, μ is the scalar diffusivity, and ϵ and χ are respectively the energy and variance dissipation rates.