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The Eddy-Diffusivity in Turbulent Two-Particle Dispersion DAMIEN BENVENISTE, Physics, Johns Hopkins University, GREGORY EYINK, Applied Mathematics, Johns Hopkins University — R. H. Kraichnan (1966) and T. S. Lundgren (1981) derived a formula for the eddy-diffusivity in Richardson's theory of turbulent 2-particle dispersion:

$$\eta_{ij}(\mathbf{r},t) = \int_0^t ds \langle (u_i(\mathbf{x}+\mathbf{r},t) - u_i(\mathbf{x},t))(u_i(\mathbf{x}+\mathbf{r},t|s) - u_j(\mathbf{x},t|s)\rangle.$$

This formula involves the Lagrangian velocity field $\mathbf{u}(\mathbf{x},t|s)$ experienced at time $s < t$ by the fluid particle which is at point $\mathbf{x}$ at time t. Evaluating this formula requires tracking fluid particles backward in time, a difficult task with standard DNS. We compute the formula using the JHU Turbulence Database,[1] which stores the entire spacetime history of a 1024^3 DNS of homogeneous, isotropic turbulence at $Re_\lambda = 433$. We average over particle pairs started at many different initial positions $\mathbf{x}$ with initial separations $\mathbf{r}$. We obtain a time-dependent eddy-diffusivity $\eta_{ij}(\mathbf{r},t)$ which has Batchelor scaling $(\varepsilon r)^{2/3}t$ for short time and Richardson scaling $\varepsilon^{1/3}r^{4/3}$ for long time. Our resulting diffusion model describes both the Batchelor and Richardson regimes and also predicts new phenomena not yet seen in experiment or simulations.

[1]http://turbulence.pha.jhu.edu/

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