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Objective Quantification of Turbulent Particle Pair Diffusion

NADEEM MALIK, FAZLE HUSSAIN, Texas Tech University, Department of Mechanical Engineering — Turbulence consists of interacting flow structures extending over a wide range of length and time scales. But what range of turbulence length scales governs pair diffusion in close proximity? We address this question by both fine scales and larger scale coherent structures - we encounter a combination of both local and non-local interactions associated with the small and large length scales. The local structures possess length scales of the same order of magnitude as the pair separation l, and they induce strong relative motion between the particle pair; the non-local structures possess length scales much larger than l and also induce (via Biot-Savart) significant relative motion (ignored in prior studies). This leads to the prediction of the pair diffusivity K scaling as $K \sim l^{1.556}$ – agreeing within 1% of experimental data. The 'Richardson-Obukhov constant' g_l is shown to be not a constant, although widely assumed to be a constant. But new constants G_K and G_l (representing, respectively, pair diffusivity and pair separation) are identified which we show to asymptote to, respectively, 0.73 and 0.01 at high Reynolds numbers. Our findings are important for improving turbulent diffusion modelling.

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