On local isotropy and scale dependence of pair dispersion in a wind tunnel canopy flow

Ron Shnapp[*], Yardena Bohbot-Raviv[†], Eyal Fattal[†], Alex Liberzon[‡]

Canopy flows are inhomogeneous and anisotropic turbulent flows that play important economical and ecological roles due their strong effect on the atmospheric surface-layer flow and temperature, and on the dispersion of pollutants. In canopy flows the interaction of high velocity fluid with large-scale surface-mounted obstacles produces strong drag and intense turbulence[1]. In this work, we analyse the relative motion of pairs of particles, so-called pair dispersion, using the results from a 3D particle-tracking experiment in a wind-tunnel canopy flow[2]. We focus on small turbulent scales, confirming that pair dispersion is locally isotropic at scales smaller than a characteristic shear length scale $L_\Gamma = (\epsilon/\Gamma^3)^{1/2}$, where ϵ and Γ are the mean dissipation rate and the mean velocity vertical gradient, respectively. Furthermore, we show that pair dispersion in the locally isotropic regime is a scale-dependent accelerating process. These observations extend the fundamental phenomenology of turbulent pair dispersion to certain anisotropic and inhomogeneous turbulent flows with sufficiently high turbulence intensity.

Fig. 1 demonstrates the scale-dependent diffusivity for the pair dispersion in our canopy flow measurements, in accordance with Richardson's theory. In addition to that, the locality hypothesis was used to explain the different scaling regimes that depended on both τ and r_0 for the variance of the separation $\overline{\Delta r^2}$. Furthermore, the observations are in agreement with Richardson's 4/3's scaling for the diffusivity of the pair's separation. The observations of scale dependence and the 4/3 law in the canopy flow are key results of this work.

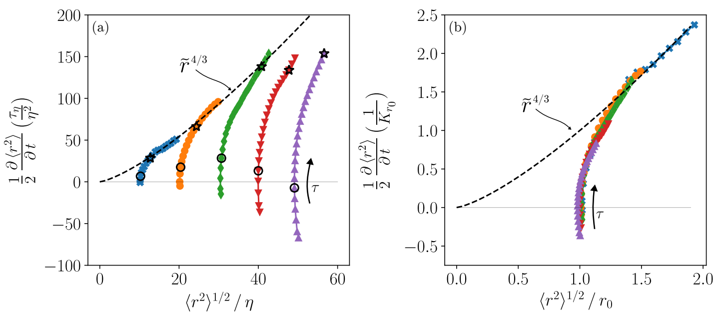

Figure 1: The diffusivity of pair dispersion defined for various r_0 cases, plotted against the RMS of the separation distance; (a) data normalized by dissipation scales and (b) by inertial range scaling. Dashed lines correspond to the 4/3s law scaling regime

[*]Dep. Mechanical Engineering, Ben Gurion University, Beer-Sheva, Israel
[†]Israel Institute for Biological Research, Nes Tziona, Israel
[‡]School of Mechanical Engineering, Tel Aviv University, Tel Aviv Jaffo, Israel

[1]Shnapp et al. *J. Fluid Mech* **913** R2, 2021
[2]Shnapp et al., *Sci. Rep.* **9**, 7405, 2019