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Scaling Laws for Transport in Active Turbulence

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Understanding the role of frictional drag in diffusive transport is an important problem in the field of active turbulence. Using a generic continuum model that applies well to living systems, we investigate the role of Ekman friction on the passive transport of Lagrangian tracers that go with the local flow. We find that the crossover from ballistic to diffusive regime happens at a timescale τ_c that attains a minimum at zero friction, meaning that both injection and dissipation of energy delay the relaxation of tracers. We explain this by proposing that $\tau_c \sim \ell^*/u_{\text{rms}}$, where ℓ^* is a dominant length scale extracted from energy spectrum peak, and u_{rms} is a velocity scale that sets the kinetic energy at steady state; both scales monotonically decrease with friction. Finally, we predict friction scaling laws for ℓ^*, u_{rms}, and the diffusion coefficient $\mathcal{D} \sim \ell^* u_{\text{rms}}/2$, that are valid over a wide range of fluid friction. The findings of our report should apply to transport phenomena in generic active systems such as dense bacterial suspensions, microtubule networks, or even artificial swimmers, to name a few.

References:

Friction Scaling Laws for Transport in Bacterial Turbulence,
Sanjay CP and Ashwin Joy,
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Editors' Suggestion [arXiv:1905.11124]