

Unifying heterogeneous diffusion in living cells

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Will be discussed thermal diffusion in heterogeneous media through the lenses of stochastic processes. Transport in living cells is largely dominated by thermal fluctuations. However, the crowding and polydispersity induce statistical deviations from Brownian motion. Anomalous diffusion where the mean squared displacement displays a power-law scaling and non-Gaussian displacement statistics do occur either independently or at the same time. We will discuss how anomalous and non-Gaussian articulate.

To do so, will be introduced the concept of Randomly Modulated Gaussian Processes [1] as a unifying framework for modelling, analysing and classifying anomalous diffusion models in heterogeneous media. This formulation incorporates correlations in the displacements together with correlated fluctuations of their amplitudes. Most known models of anomalous diffusion (including Continuous-Time Random Walk and fractional Brownian motion) and random diffusivity can be described and generalized within this framework. Moreover, the unified view identifies the main statistical properties to be probed experimentally for a reliable classification of diffusive dynamics.

[1] A unifying approach to diffusive transport in heterogeneous media. Y. Lanoiselée, D. S. Grebenkov, G. Pagnini, arXiv:2603.12775 (2026)