Anomalous diffusion and FRAP dynamics in the random comb model

†S.B. Yuste[1], *E. Abad[2], and A. Baumgaertner[1]

[1]Departamento de Física and Instituto de Computación Científica Avanzada (ICCAEX), Universidad de Extremadura, E-06071 Badajoz, Spain
[2] Departamento de Física Aplicada and Instituto de Computación Científica Avanzada (ICCAEX), Centro Universitario de Mérida, Universidad de Extremadura, Mérida, Spain

*Presenting author: eabad@unex.es
†Corresponding author: santos@unex.es

Abstract

We address the problem of diffusion on a comb whose teeth display a varying length. Specifically, the length ℓ of each tooth is drawn from a power-law distribution displaying the large-ℓ behavior $P(\ell) \sim \ell^{-\alpha-1}$ ($\alpha > 0$). Our method relies on the mean-field description provided by the well-tested CTRW approach for the random comb model, and the obtained analytical results are confirmed by numerical simulations. We subsequently incorporate retardation effects arising from binding/unbinding kinetics into our model and obtain a scaling law characterizing the corresponding change in the diffusion coefficient. Finally, our results for the diffusion coefficient are used as an input to compute concentration recovery curves mimicking FRAP experiments in comb-like geometries such as spiny dendrites. We show that such curves cannot be fitted perfectly by a model based on scaled Brownian motion, i.e., a standard diffusion equation with a time-dependent diffusion coefficient. However, differences between the exact curves and such fits are small, thereby providing justification for the practical use of models relying on scaled Brownian motion as a fitting procedure for recovery curves arising from particle diffusion in comb-like systems.

Keywords: Comb-like models, CTRW approach, FRAP experiments, spiny dendrites