Mathematical Methods and Models in Biosciences
June 15–20, 2025, Sofia, Bulgaria
https://biomath.math.bas.bg/biomath/index.php/bmcs

Mathematical Insights into Alzheimer's Disease: A Multiscale Modeling Approach

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In this presentation, we study the progression of Alzheimer's disease through a multiscale modeling approach. We begin by formulating a system of partial differential equations that captures the underlying biological mechanisms. The evolution of the system is analyzed within a thin porous heterogeneous medium, reflecting the complex structure of brain tissue. To address the multiscale nature of the problem, we adopt a finite element heterogeneous multiscale method (FE-HMM), which enables us to accurately approximate the macroscopic behavior by systematically incorporating microscale effects. Numerical simulations are carried out to validate the theoretical analysis and to illustrate the impact of tissue heterogeneity on disease progression.

Keywords: Alzheimer's disease; Multiscale modeling; Heterogeneous multiscale method; Two-scale convergence; Numerical simulation

MSC2020: 35B27, 35Q92, 65M60

References

[1] A. Abdulle and W. E. Holzapfel, A finite element heterogeneous multiscale method for elliptic homogenization problems, *Numerische Mathematik*, 117(1):1–28, 2011.

[2] B. Franchi and S. Lorenzani, From a microscopic to a macroscopic model for Alzheimer's disease: two-scale homogenization of the Smoluchowski equation in perforated domains, *Journal of Nonlinear Science*, 26(3):717–753, 2016.

[3] A.L. Pokam Kakeu and J.L. Woukeng, Homogenization of nonlinear parabolic equations with hysteresis, *ZAMM – Journal of Applied Mathematics and Mechanics*, 100(8):e201900323, 2020.

[4] G. Nguetseng, A general convergence result for a functional related to the theory of homogenization, *SIAM Journal on Mathematical Analysis*, 20(3):608–623, 1989.

[5] Y. Efendiev and A. Pankov, Numerical homogenization of nonlinear random parabolic operators, *SIAM Multiscale Modeling and Simulation*, 2(2):237–268, 2004.