

NUMERICAL CHALLENGES IN MULTISCALE AND MULTIPHYSICS BRAIN MODELING

MATTIA CORTI*, IVAN FUMAGALLI*, CATERINA B. LEIMER
SAGLIO*, STEFANO PAGANI*, MARIE E. ROGNES[†]

*MOX - Department of Mathematics, Politecnico di Milano
Piazza Leonardo da Vinci 32, 20133 Milano, Italy
[mattia.corti, ivan.fumagalli, caterinabeatrice.leimer, stefano.pagani]@polimi.it

[†]Department of Numerical Analysis and Scientific Computing,
Simula Research Laboratory
Kristian Augusts gate 23, 0164 Oslo, Norway
meg@simula.no

ABSTRACT

The brain is a highly complex, multiphysics system in which electrical, chemical, and mechanical processes interact across a wide range of spatial and temporal scales. Accurate computational modeling of such phenomena requires not only sophisticated physical descriptions, but also advanced numerical methods capable of resolving multiscale features and strong couplings with high fidelity and efficiency. This minisymposium brings together researchers developing and applying advanced numerical methods for multiscale and multiphysics brain modeling. Topics of interest include high-order finite element and discontinuous Galerkin methods, polygonal/polyhedral and agglomerated discretizations, isogeometric analysis, robust and scalable solvers for coupled systems, adaptivity (p-, h-, and hp-refinement), error estimation and control, and numerical methods for complex geometries and heterogeneous biological tissues.

Relevant application areas include the mechanics of brain tissue and cerebrospinal and interstitial fluids, transport and clearance processes (including glymphatic and perivascular pathways), electromechanical coupling, prion-like protein spreading, tissue atrophy, electrophysiology and network-scale dynamics. Contributions integrating physics-based modeling with data-driven approaches, including reduced-order modeling and data assimilation from imaging or clinical datasets, are especially encouraged.

SPEAKERS

1. Daniele Avitabile (Vrije Universiteit Amsterdam): Inverse problems in spatially-extended neurobiological networks.
2. Pietro Benedusi (Università della Svizzera Italiana): Electrodiffusion in cellular geometries: fast solvers, GPU computing, and spectral analysis.
3. Beatrice Caon (Politecnico di Milano): A high-order numerical method for mathematical modelling of Alzheimer's disease and its comparison with clinical data.
4. Francesco Daniele (Politecnico di Milano): A high-order discontinuous Galerkin method for modeling coupled neuronal dynamics.
5. Sami Laubo (Simula Research Laboratory): What is the correct regularity for PINNs?
6. Lukas Schmitz (University of Cologne): Neurodegeneration Forecast: Modelling Amyloid and Tau Pathology Spread by Graph-Based Methods and Numerical Simulations.
7. Ivan Yotov (University of Pittsburgh): A coupled fluid flow–multicompartment poroelasticity model for brain clearance.