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COMPUTATIONAL BRAIN MULTIPHYSICS

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ABSTRACT

The brain is a tightly coupled system in which electrical activity, fluid flow, biochemical transport, and tissue mechanics interact across a wide range of spatial and temporal scales. Capturing these multiphysics and multiscale interactions is essential for understanding physiological brain function as well as the onset and progression of neurological and neurodegenerative disorders. Computational multiphysics models provide a unified framework for investigating brain physiology, where spatial heterogeneity, complex geometries, strong physical couplings, and scale separation pose significant mathematical and computational challenges. Addressing these requires accurate discretizations, scalable algorithms and efficient solvers. In addition, information extracted from experimental and clinical data must be systematically incorporated through data-driven and data-assimilation strategies. This invited session brings together researchers in computational mechanics, applied mathematics, biomedical engineering, and neuroscience to present advances in brain multiphysics modeling. Topics include linear and nonlinear tissue mechanics; cerebrospinal and interstitial fluid dynamics; molecular transport and waste clearance, including glymphatic pathways; electrophysiology and neural activation; vascular dynamics; oxygen and nutrient perfusion; prion-like protein propagation. Contributions addressing robust numerical methods, efficient solvers, reduced-order and geometrical model reduction, and applications to epilepsy, stroke, traumatic brain injury, hydrocephalus, and neurodegeneration are particularly welcome.