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Mathematical and Numerical Modelling of Neurodegenerative Diseases

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Neurodegenerative diseases (NDs) comprise a varied group of disorders that primarily affect neurons within the brain and central nervous system, leading to a gradual and progressive deterioration of neuronal function. A pathological hallmark shared by numerous NDs is the accumulation of misfolded proteins unique to each disease, such as amyloid-beta and tau in Alzheimer's disease and alpha-synuclein in Parkinson's disease. This presentation discusses the mathematical and numerical modelling of misfolded protein dynamics in the context of neurodegenerative diseases, employing a sequence of increasingly sophisticated mathematical and computational models. To tackle the inherent complexity, we propose and analyse Machine Learning-enhanced high-order polytopal discontinuous Galerkin methods for the numerical discretisation of these models. The effectiveness of these methods is demonstrated through numerical simulations that integrate patient-specific brain geometries reconstructed from clinical data. In the second part of the talk, we investigate the computational modelling of waste removal (clearance) mechanisms in the brain, a crucial process involved in the onset and progression of NDs. We provide an extensive analysis of our numerical approach for simulating these clearance mechanisms, supplemented by patient-specific simulations to demonstrate the clinical relevance of our findings.

Place: Stremayrgasse 16/I, Seminar Room BMT 01046

Date: January 29, 2025 at 4:00 pm