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Virtual Modeling and Additive Manufacturing for Advanced Materials

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Parallel and scalable solvers in computational cardiology

This talk will focus on advanced mathematical and numerical models of the electro-mechanical activity of the heart. These range from the microscopic membrane models describing the myocyte ionic currents and active tension to the macroscopic anisotropic Bidomain and quasi-static finite elasticity models describing the electrical current flow and deformation of the cardiac tissue. The approximation and simulation of these complex nonlinear models are very demanding and expensive tasks, because of the very different space and time scales associated with the electrical and mechanical models, as well as their nonlinear and multiphysics interactions. Finite element or isogeometric discretizations in space and semi-implicit operator splitting finite differences in time require the solution of very large and ill-conditioned linear and nonlinear systems at each time step, which in turn require efficient iterative solvers accelerated by proper scalable preconditioners. Our parallel solver employs Multilevel Additive Schwarz preconditioners for the solution of the discretized Bidomain equations and Newton-Krylov methods with AMG or BDDC preconditioners for the solution of the discretized nonlinear finite elasticity equations.The results of several parallel simulations show the scalability of both linear and nonlinear solvers up to O(10^5) cores and their application to the study of the physiological excitation-contraction cardiac dynamics and of re-entrant waves in the presence of different mechano-electrical feedbacks.

This is joint work with Piero Colli Franzone (University of Pavia, Italy), Simone Scacchi (University of Milano, Italy) and Stefano Zampini (KAUST, Saudi Arabia).

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January 22nd, 2:30pm
DICAr MS1 Meeting Room
Via Ferrata, 3 – Pavia