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Multilevel Homogenization Techniques for the Cardiac Bidomain Equations

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The cardiac bidomain equations are a set of nonlinear partial differential equations that are used to model the flow of current within cardiac tissue by treating intracellular and extracellular space as two interpenetrating domains. In the past 10 years research groups around the world have been using the bidomain equations in a variety of sophisticated ways, from modelling fibrillation in the human heart to understanding how plunge electrodes affect potential fields during in vitro experiments on cardiac tissue. The Bioengineering Institute at the University of Auckland has been a world leader in imaging cardiac tissue at a microscale resolution, and discovering specialized features that can be incorporated into the bidomain model.

In this talk, I will briefly introduce the Bioengineering Institute's imaging work, and then focus on how we are using these imaging results in our modelling framework. This discussion will focus on how we are using Black Box Multigrid to generate homogenized models that take into account the discontinuities found at the mezoscale. Such models allow the effect of the discontinuous cardiac structures to be seen in the potential fields at a reduced cost. This work is founded upon the multilevel upscaling approach of MachLachlan and Moulton (Water Resources Research, 2005), and begins exploring their ideas in three-dimensions and in a time-dependent framework.