Coupled Mathematical Models for Multi-Phase Materials: Nonlinear Dynamics and Numerical Approximations

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Coupled nonlinear mathematical models are essential in describing most natural phenomena, processes, and man-made systems. From large scale mathematical models of climate to modelling of quantum mechanical effects coupling and nonlinearity go often hand and hand. Coupled dynamic systems of partial differential equations (PDEs) provide a foundation for the description of many such systems, processes, and phenomena. In majority of cases, however, their solutions are not amenable to analytical treatments and the development, analysis, and applications of effective numerical approximations for such models become a core element in their studies.

In this talk we will focus on mathematical models that are based on the Landau framework of phase transformations based on non-monotone free energy functions. Phase transformations are universal phenomena, and one specific example that we will consider in this talk is motivated by mesoscopic mathematical models for the description of multi-phase solid materials. Such models provide an intermediate length scale description between the atomistic level and the level that is usually used for bulk materials. In particular, we will discuss several classes of problems where non-equilibrium phenomena such as phase transformations are important, focusing on the dynamics of materials with shape memory. The talk will provide further insight into their application areas, the development of computationally efficient reduction procedures for their 3D modelling, and the construction of fully conservative schemes for solving the associated problems.

Biography: Prof. Roderick Melnik, http://www.m2netlab.wlu.ca/

Roderick Melnik has been Full Professor and Tier I Canada Research Chair in Mathematical Modelling in the Faculty of Science at the Wilfrid Laurier University in Waterloo, Canada since 2004. He is affiliated with the Guelph-Waterloo Institute of Physics. Prior to this appointment, Dr. Melnik held full professorial positions at Louisiana Tech University in the USA and the University of Southern Denmark, where he was the Head of Mathematical Modelling and Engineering Mathematics. He received his M.Sc. degree in Applied Mathematics and Ph.D. degree in Computational Mathematics from Kiev State University in 1985 and 1989, respectively. Starting his academic career in Europe, he continued it in Australia until in the late 1990s he took the position of senior scientist at the Commonwealth Scientific and Industrial Research Organisation (CSIRO) in Sydney, working in the Division of Mathematical and Information Sciences. Dr. Melnik has published extensively in a variety of fields with his major focus on mathematical modelling for challenging problems in science and technology.