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MATHEMATICAL MODELLING ALL THE WAY TO THE NANOSCALE AND COUPLED MULTISCALE PHENOMENA

As matter is organized at the nanoscale, we want to understand, control, and take advantage of the phenomena that take place at that level. Not only we aim at utilizing the unique properties of matter that naturally occur at small elementary scales, but also we seek fundamental knowledge of matter and its interactions with other phenomena such as light. Mathematics is a discipline that contributes to this knowledge, and the development of novel mathematical models plays a key role in this process.

Coupled 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) often 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 discuss three examples of coupled mathematical models. Starting from nanoscale low dimensional systems such as quantum dots (QDs), we’ll move to mesoscopic models for phase transformations (PTs), and we’ll conclude with coupled multiscale problems in studying biological structures constructed from ribonucleic acid (RNA), focusing on the fundamental scale at which much of biology occurs. As we go, we will also provide further insight into their application areas and the development of computationally efficient procedures.