Mathematics of Nonequilibrium Phenomena and Industrial Applications

Abstract

In the past decades, the mathematical models of nonequilibrium natural phenomena has greatly advanced, profiting in particular from a deeper understanding of the microscopic foundations of the standard hydrodynamic and thermodynamic laws, which allows now to tackle practical problems on the microscopic scale. Industry has relied in the past on the macroscopic theories to design its products on the macroscopic scale, the scale of our daily experience. However, industry is now more and more interested in the nanoscopc scales, pushed by various needs and opportunities, including the ever growing need for miniaturization and energy efficiency, the discovery that nanostructured materials possess unexpected mechanical, thermal, optical, electrical properties. Indeed, the possibility of designing and using nanoscopic devices, e.g. in the biomedical field, is now a reality. The nanoscopic realm is however little understood and it is quite costly to investigate it experimentally. Therefore, mathematical models of various kinds, from discrete to ODE to PDE are being developed in order shed light on the phenomena of interest hence to provide indications for the design and use of nanodevices. The complexity of the problems to be tackled requires new numerical approaches, based on the mentioned advanced microscopic models, whose role is not only conceptual, but practical in the nanoworld. It is quite interesting to note that the approaches developed for the natural phenomena at small scales, are now considered also for problems of interest in the soft sciences, with applications ranging from socio-economic to telecommunications. We will briefly review the fundamental principles and the various problems of practical interest, pointing out the numerical issues that researchers are called to address.