Preface

Nature is intrinsically multiscale and multiphysics. Phenomena at all spatial and temporal scales coexist and interact to produce the endless variety of the surrounding physical world. From atoms to galaxies, from amino acids to living organisms, nature exhibits systems built out of objects spanning many orders of magnitude.

Although physicists propose to describe all interactions as four fundamental forces, at large scales a wide range of different processes emerge, leading to multiphysics. Complex flows, fluid-structure interactions, phase transitions, plasma, and reaction-diffusion processes are just a few examples.

Ideally, we could think of a description of all phenomena at their smaller scale. Then, as nature does, let the correct behavior emerge from computer simulation at all larger scales. However, this approach is intractable in general. No computer has enough memory or CPU power to describe all macroscopic phenomena in terms of the underlying dynamics of elementary particles only.

Therefore, numerical methods based on mathematical abstractions of the real world must be worked out for each scale. Many efficient numerical techniques are currently known, such as molecular dynamics when addressing the microscopic scales or finite element methods to solve a partial differential equation representing a macroscopic system. Mesoscopic approaches, such as the lattice Boltzmann method, were also developed in the hope to cover a larger range of scales.

However, no single method will be appropriate to describe all the parts of a system made of many components, each with its own characteristic scales and its own mechanisms. Thus, the coupling of different techniques within one simulation becomes a crucial issue in modern computational science.

Currently, as computers become more and more powerful, the ambition and need for solving larger and more complex problems arise, forcing scientists to devise more sophisticated coupling techniques or new solvers spanning a wider range of scales. General methodologies for combining processes with or without a clear scale separation must be proposed in order to address the new challenging problems.

This special issue aims at collecting state-of-the-art methods for multiscale and multiphysics applications, covering a large spectrum of topics such as multiphase flows, discharge plasmas, turbulent combustion, chemical vapor deposition, fluid-structure interaction, thermomechanical and magnetostrictive systems, and astrophysics simulation. These contributions have been presented during the 1st International Workshop on Simulation of Multiphysics Multiscale Systems (SMMS) hosted by the ICCS conference. The papers have been rigorously reviewed and should be an important source of ideas and stimulation for those involved in the development of new numerical methods or in the solution of demanding multiphysics/multiscale problems.

We would like to thank the authors for their inspiring contributions, and the members of the workshop Program Committee for their diligent work, which led to the very high quality of the conference and formed the basis for selection of papers for this special issue.

We invite you to visit the website, http://www.science.uva.nl/~valeria/SMMS, of the SMMS workshop and participate in the forthcoming events.

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Guest Editors