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NEW TRENDS IN MODEL COUPLING THEORY, NUMERICS AND APPLICATIONS

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Special Issue from the workshop *New Trends in Model Coupling, Theory, Numerics and Applications (NTMC'09), Paris, September* $2-4$ *2009.*

This special issue comprises selected papers from the workshop New Trends in Model Coupling, Theory, Numerics and Applications (NTMC'09) which took place in Paris, September 2 - 4, 2009. The research of optimal technological solutions in a large amount of industrial systems requires to perform numerical simulations of complex phenomena which are often characterized by the coupling of models related to various space and/or time scales. Thus, the so-called multiscale modelling has been a thriving scientific activity which connects applied mathematics and other disciplines such as physics, chemistry, biology or even social sciences. To illustrate the variety of fields concerned by the natural occurrence of model coupling we may quote:

- meteorology where it is required to take into account several turbulence scales or the interaction between oceans and atmosphere, but also regional models in a global description,
- solid mechanics where a thorough understanding of complex phenomena such as propagation of cracks needs to couple various models from the atomistic level to the macroscopic level;
- plasma physics for fusion energy for instance where dense plasmas and collisionless plasma coexist;
- multiphase fluid dynamics when several types of flow corresponding to several types of models are present simultaneously in complex circuits;
- social behaviour analysis with interaction between individual actions and collective behaviour.

In this context there is an increasing research activity in applied mathematics to deal with coupled problems coming from many physical situations such as those mentioned above. For example, the numerical simulation of a complex system frequently requires using different models corresponding to the different parts of the system. Using different models can be motivated by an expected gain in computation time or in accuracy or even simply to use existing numerical codes dedicated to some particular elements of the system. In the framework of the French nuclear energy industry the issue of model coupling has been one of the main topics in the Neptune Project funded by CEA (Commissariat à l'Energie Atomique), EDF (Electricité de France), IRSN (Institut de Radioprotection et de Sureté Nucléaire) and AREVA-NP and dedicated to the simulation of a pressurized water reactor as a whole. In this context a working group between

Jacques-Louis Lions Laboratory of UPMC-Univ Paris 6 (Pierre et Marie Curie University) and CEA/DEN-Saclay has been studying for several years theoretically and numerically the topics of model coupling in two-phase thermal hydraulics (see http://www.ann.jussieu.fr/groupes/cea/).

The NTMC'09 workshop is a by-product of this working group and several of its members have taken part in its organisation. The goal of this workshop was to present some of the latest progress on this issue and to compare the methods and technics developed in the working group with those developed in other laboratories interested in this topic. It consisted of more than a dozen of invited lectures and some submitted posters. This special issue of *Networks and Heterogeneous Media* comprises a selection of extended papers from the contributions to NTMC'09 workshop with a series of 20 page long papers from the invited speakers and a second series of shorter communications from the posters. Among these articles the reader will find either descriptions of studies on general theories and technics dedicated to the problem of coupling itself, some of them pertaining to the neighbouring theme of domain decomposition, or illustrations of the numerous applications where a model coupling is necessary. In every case the mathematical aspects are thoroughly described.

Thus this issue, if it is far from being exhaustive on the subject, presents a variety of works, linked to a wide range of applications (concerning mostly fluid mechanics and material science, cement media, petroleum engineering, mutiphase flow in nuclear reactor, CO_2 geological storage, but also traffic flow, networks, and human bronchial tree) developing new mathematical tools and technics, following new approaches, all devoted to the modelling of complex physical problems and involving some coupling or multiscale procedure.

In conclusion, we thank all the contributors for their very interesting papers, which are the best illustration that the theme of the NTMC'09 conference was well-grounded.

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