Preface

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The application of numerical methods and computer usage in mathematical modelling of environmental and technological processes has a very long tradition at the *University of Latvia (LU)*. The history of these activities traces back to the end of the 50-ies when the University of Latvia *Computing Centre* is established, and the first mainframe computers appear there. From the very beginning, physicists were among the most active users of these facilities. Since some of those computers had a different architecture, they were mutually incompatible, and no ready software was available to be used to solve the problems of interest, the physicists actively participated in development of the programs tailored for calculations in the sphere of engineering physics using the program languages available at the time – initially *Algol* and later – *FORTRAN*.

These activities led to the establishment of the chair of *Electrodynamics and Continuum Mechanics* in *UL* in 1970. From the very beginning among the founders of that chair were physicists not only from the University but also from the *Institute of Physics* and *Institute of Polymer Mechanics* with ideas for different industrial applications of numerical models. The contacts established with researchers in engineer sciences and active collaboration with leading applied research and development institutions in Moscow, Leningrad and Kiev during the 70-ies and 80-ies were very fruitful and probably were among the major reasons for the success of this research direction at *UL*.

In this period the programme applications developed by various groups of authors and even though the modelling of programmes just began to become commercialised, the limits posed by computer productivity and compatibility, the complicated and essential multiphysical models and numerical solutions were rather an exception – they were used in military and space research spheres, but were unavailable for the multiform applications to be used by university researchers. However, taking into account the orientation of UL researchers toward the study of the magnetohydrodynamic (MHD) processes, the first beginnings of multiphysical approach to modelling appeared, mutually connecting the numerical research of the electromagnetic field, heat processes and liquid metal flow.

In the beginning of the 90-ies, when all organizational structures of research in our country underwent dramatic changes, not all ideas and institutions managed to adapt successfully to the new conditions. Fortunately, the people who were involved in computer modelling-related research were among the most successful – the development of already existing and newly established contacts in Western Europe and reorientation of their applied research to the directions actively studied in partner universities was also an important factor for financing our research activities. The first agreement of scientific collaboration with a Western university was signed in 1988 – this was the agreement between the University of Latvia Faculty of Physics and Mathematics and the University of Hannover *Institute of Electroheat* (nowadays - the *Institute of Electrotechnology)* in field of numerical modelling for solution of various engineering problems in metallurgy and semiconductor industry. A logical next step for concentration of research activities in this field at the Faculty of Physics and Mathematics was the foundation of the *Laboratory for Mathematical Modelling of Environmental and Technological Processes* in 1994. Research groups involved in this study

successfully joined the international effort related to the application of computer models – self-developed and also commercial codes - to industrial processes.

The complexity of models for simulation of turbulent heat and mass exchange in liquid metal flows in different melting technologies, for crystallization of alloys and single crystal growth under electromagnetic impact has significantly grown. An adequate description of occurring physical phenomena, their interaction and the use of high performance computer clusters allow to essentially reduce the number of experiments in industrial facilities needed for parameter studies. A new trend is the use of the licence-free codes like *OpenFOAM* in addition to the user specific implementations commercial modelling software like *ANSYS* (*FLUENT, CFX*), *COMSOL* or self-developed specific software for particular applications. This approach increasingly succeeds both in researches performed at universities, and in the industrial companies. In all cases, the success in numerical modelling and in achieving industrially relevant results, particularly in case of multiphysical models with a complex system geometry, is determined by optimal solutions of "technical" problems, e.g., the creation of well-balanced meshes with high resolution in relevant sub-regions but with a moderate total number of nodes; optimal parallelization of the calculation scheme for a given number of processors and structure of the cluster; highly efficient coupling from different solvers and accelerating of data exchange between the system components, and, the last but not the least, the development of effective methods for post processing and visualization of transient 3D multi-field calculation results for their further physical interpretation and for application in engineer designs of equipment.

The European Union co-financed (*ERDF* and *ESF*) research projects in the field of numerical modelling realised at the Faculty of Physics and Mathematics since 2006 have a very high positive effect on involvement and motivation of PhD students and young scientists to make industrial-orientated MHD researches, to develop and to implement the special codes for solving of complex industrial heat and mass exchange problems. The use and development of the existing experience and also *OpenFOAM* program libraries is very important in this process. EU co-financing is a great contribution to promotion of successful collaboration between Latvian scientists and the universities as well as the industrial companies in Germany, France, United Kingdom, Sweden, Switzerland and lately also in Russia. Currently, engineering physics, the core of which is the computer modelling of technological and environmental processes, is one of the largest and most successfully developing trends of research at the *UL* Physics Department with very good perspectives in the future.

This first workshop "Multiphysical modelling in *OpenFOAM*" (October 20 –21, 2011) in Riga is organised by the Laboratory of Mathematical Modelling of Environmental and Technological Processes, *UL*, in cooperation with the Institute of Electrotechnology, Leibniz University of Hannover. It is a continuation of a very long tradition of multiform cooperation between both institutions. The workshop will offer the invited presentations by competent *OpenFOAM* experts, and in parallel - the results of numerical research activities with using of licence-free (especially *OpenFOAM*) codes in the field of industrial processing technologies for creating high quality and purity materials.

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