Preface

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The application of splitting procedures in the treatment of large scientific and engineering problems is an excellent tool (and, very often, the only tool) by which huge computational tasks can be made tractable on the available computers by dividing them into a sequence of smaller and simpler tasks. As an illustration of this fact it should be mentioned that splitting techniques are, to our knowledge, used in all large-scale air pollution models, which are

- to be discretised by using fine resolution grids (which often leads to tasks containing many millions of equations that are to be treated during several hundred thousand time-steps)
- to be run over long time-intervals i.e. over time-intervals of ten or more successive years
- to be run operationally with many scenarios (emission scenarios, meteorological scenarios, climatic scenarios, etc).

The treatment of a sequence of smaller and simpler tasks instead of the large-scale mathematical model under consideration has several advantages:

- It is in general much easier to find optimal (or, at least, good) numerical methods for the simpler systems that are generated by the operators in the resulting after the application of the splitting procedure sub-models than for the big system arising after the direct discretisation of the operator contained in the original large-scale model.
- It is easy to replace some of the numerical algorithms and physical mechanisms used in the different sub-models arising as a result of the implementation of the splitting procedure chosen with a new and better one when this is desirable. Thus, modifications and improvements of the code can easily be achieved.
- The application of a splitting procedure facilitates the preparation of efficient codes for different parallel computers. In many cases, the splitting procedure is leading directly to parallel tasks.

However, it must also be emphasised here that, while the use of splitting procedures facilitates the treatment of large-scale mathematical models arising in different fields of science and engineering, the use of a splitting procedure will in general introduce splitting errors. It is difficult to control these errors. Many of the problems related to avoid and/or reduce the errors caused by the application of splitting procedures are still open. Therefore, it is worthwhile to carry out work on the solution of the following important problems:

- to construct sufficiently accurate, but still computationally cheap and robust, splitting procedures (preferably splitting procedures of order two and, if possible, even splitting procedures of order higher than two)
- to search for optimal combinations of splitting procedures and numerical methods such that the order of the combined methods is as high as possible
- to find reliable and robust methods for evaluating the splitting errors.

Success in the solution of any of these three important problems is a very desirable, but also a very challenging task. It should be noted that even a partial solution of any of these three problems will lead to a very considerable progress in the numerical treatment of many large-scale mathematical models arising in different fields of science and engineering.

Better understanding of the interference of errors due to the splitting procedures and errors that are caused by other reasons (numerical methods, uncertainties of the input data, uncertainties in the description of different physical and chemical processes by mathematical terms, etc.) is also highly desirable. Research efforts in these directions are needed.

The above discussion demonstrates clearly both the fact that splitting techniques are playing a key role in the treatment of many large-scale mathematical models and the fact that there are still many open questions in this area. Several presentations at the special session on 'Advanced splitting techniques and their applications' (which was organised within the Fifth Conference on Large-scale Scientific Computations held in Sozopol in June 2005) were devoted to the solution of some of the open problems that are connected both to the theory of the splitting methods and to the application of splitting methods in the treatment of several particular mathematical models. Most of these presentations were selected for this special issue of the *Int. J. Computational Science and Engineering*.