Selected papers of the Seventh Conference on the Numerical Treatment of Differential Equations, September 1994, Halle (Germany)

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Preface

When organizing the seventh NUMDIFF conference on the Numerical Treatment of Differential Equations (held at the Martin-Luther University at Halle-Wittenberg, 19–23 September 1994), it soon became clear that again a large number of contributions was to be expected. As in the NUMDIFF-6 meeting, we planned to exploit this concentration of research papers by collecting a selection of them in a special issue of the IMACS journal *Applied Numerical Mathematics* (*APNUM*) published by Elsevier Science (North-Holland). We are grateful to Professor R. Vichnevetsky, the president of IMACS (International Association for Mathematics and Computers in Simulation) and editor in chief of *APNUM*, who offered us the possibility to publish the proceedings of NUMDIFF-7 in his journal and to announce this meeting as an IMACS-sponsored conference in the worldwide distributed "Calendar of IMACS Events".

NUMDIFF-7 was not only sponsored by IMACS, but also by the Martin-Luther University Halle-Wittenberg, the German Research Society (Deutsche Forschungsgemeinschaft), Mercedes Benz and IBM Germany. We gratefully acknowledge their support.

At the NUMDIFF-7 meeting, 14 invited and 76 contributed papers were presented. Of these papers, 41 were submitted for publication in the special NUMDIFF-7 issue of *APNUM*. The refereeing of the papers was handled by the members of the organizing committee who also acted as editors. We are grateful to the referees for their help in the refereeing process and for their quick response which speeded up the publication of this issue considerably.

Our final selection consists of 29 papers. Since we tried to achieve early publication of the proceedings, we could not include papers the revision of which took too much time. These authors were advised to submit their papers to forthcoming issues of *APNUM*.

The papers of the present special issue can be classified into five groups:

(i) 10 papers on initial-value problem (IVP) methods for ordinary differential equations (ODEs),
(ii) 7 papers on initial-value problem (IVP) methods for partial differential equations (PDEs),
(iii) 4 papers on methods for differential-algebraic equations (DAEs),
(iv) 4 papers on methods for boundary-value problems (BVPs),
(v) 4 papers on modeling and implementation questions, and other numerical methods.

As in previous NUMDIFF meetings, a considerable part of the contributions was devoted to IVPs for ODEs and fit into the first group. Three papers are devoted to so-called boundary-value methods for solving IVPs. Such methods may be viewed as global methods in which the IVP is
replaced by a BVP. The authors of these papers, Amodio and Mazzia, Amodio, Golik and Mazzia, and Ghelardoni and Marzulli, study topics like stability, orders of convergence and variable-step strategies. The paper of Auzinger and Kirlinger discusses the Kreiss matrix theorem and reformulates the resolvent conditions as certain “strengthened” Cauchy–Schwarz inequalities, to obtain generalizations of the notions of logarithmic norm and numerical radius of a matrix. The two papers of Calvo and Hairer are devoted to symplectic (or symmetric) methods for the numerical integration of Hamiltonian systems of ordinary differential equations and respectively discuss long-term integration and the order conditions of Runge–Kutta(–Nyström) methods. Another topic that is in the main stream of international research is the design of parallel integration methods. The paper of in ’t Hout addresses waveform relaxation techniques and presents convergence results for the continuous time and discrete time iteration processes. De Swart constructs multivalue methods based on Adams–Bashforth and Radau-type formulas, to be used as corrector method in a parallel, fixed-point iteration process for solving nonstiff IVPs. Parallel methods for stiff IVPs are studied in the paper of van der Veen, de Swart and van der Houwen. Using conventional Runge–Kutta methods as the corrector, the paper investigates the convergence of step-parallel iteration methods using the theory of $\epsilon$-pseudo-spectra. The last paper in this IVP-ODE group is the paper of Spijker who analyses the effect of stopping modified Newton iteration when solving the implicit relations arising in linear multistep methods for stiff IVPs.

Via the method of lines, ODE-IVP methods can also be applied to PDEs. In this second group, we have seven papers. The papers of Higham and Sardar and of Lang are devoted to the time integration of reaction–diffusion equations. Higham and Sardar consider the long-time behaviour of numerical methods and analyse the effect when introducing a delay term. Lang concentrates on an adaptive method consisting of an embedded Runge–Kutta method for the time integration and a multilevel finite element method for the spatial discretization. Another class of partial differential equations is studied by Hundsdorfer and Verwer, who focus on convection–reaction equations arising in air pollution models. In their paper, they analyze operator splitting methods of the fractional step type in which the splitting is tuned to the convection part and to the stiff chemical reaction part. Two other papers on air pollution models are those of Knoth and Wolke and of Verwer and Simpson. In these papers, the chemistry part of the model is treated by solving the two-step BDF by Gauss–Seidel-type iteration processes. IVPs for parabolic equations are considered by Lubich and Ostermann who investigate the phenomenon of order reduction induced by the boundary conditions when applying Runge–Kutta methods. The paper shows that the full nonstiff order of temporal convergence is attained in the interior of the spatial domain. A second paper on solving parabolic equations is that of Schwitzer who studies the temporal convergence behaviour of W-methods using the framework of analytic semigroups of linear operators and perturbation techniques of such operators.

The third group of papers is devoted to DAE methods and consists of four papers. The paper of Arnold deals with the dynamical behaviour of mechanical multibody systems and compares various approaches with respect to the sensitivity of the numerical solution to e.g. rounding errors. Kauthen analyses the convergence of extended Pouzet–Volterra–Runge–Kutta methods for singularly perturbed systems of Volterra integro-differential equations and for the related integro-differential-algebraic systems. A deep theoretical treatment for linearizations of
nonlinear index-2 systems is given in the paper of März. More practical aspects of solving DAEs are discussed in the paper of Schwerin and Bock, where a Runge–Kutta starter for an Adams–Bashforth–Moulton predictor–corrector method is constructed.

The fourth group of papers on BVP methods consists of four papers. The paper of Brugnano and Trigiante shows that boundary value methods are not only applicable to IVPs, but can also be used for high-accuracy approximations to (one-dimensional) BVPs. A related paper is that of Ghelardoni, Gheri and Marzulli, where the boundary value method is combined with a shooting method. The solution of higher-dimensional BVPs is the subject of the paper by Lucht. This paper gives error estimates and condition numbers for finite element discretizations of a class of ill-posed problems originating from e.g. electro-cardiology. Another topic associated with BVPs is the computation of eigenvalues of Sturm–Liouville problems. Vanden Berghe, van Daele and de Meyer compute these eigenvalues by applying linear multistep methods whose local errors are minimized.

The last group of papers is devoted to modeling and implementation questions, and other numerical methods. It consists of four papers. The paper of Gerstberger and Günther deals with the implementation and parallel aspects of extrapolation methods based on the linearly implicit Euler scheme for solving circuit simulation equations. Neumeyer, Engl and Rentrop report on the numerical modeling of the compressible flow in a benchmark engine using a network formulation. The resulting DAE system is solved by a predictor–corrector method. Schmitt and Weiner present an adaptation of the Arnoldi iteration process to the case of multi-stage W-methods and compare its performance with the code VODE of Brown, Byrne and Hindmarsh on three parabolic problems. The paper of Schropp applies ODE-IVP methods for solving the gradient differential equation associated with the problem of finding local minima of real-valued functions. A convergence result is derived based on one-step methods with fixed stepsizes.

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