Applications of Mathematics

Radim Blaheta; Ivo Marek
Laudatio to Owe Axelsson

LAUDATIO TO OWE AXELSSON

Radim Blaheta, Ivo Marek

Owe Axelsson was born on February 16, 1934 in Gothenburg (Göteborg, Sweden) and his professional carrier also began in this town. During the period 1964–1971, he held the position of Chairman of the Department of Computer Science, including Numerical Analysis, at the Chalmers University of Technology and the University of Gothenburg. There, he was appointed Associate Professor in 1964 and Full Professor in 1973. For the past twenty-five years, from 1979 till 2004, he held the position of Professor of Numerical Analysis at the University of Nijmegen. There, he is continuing as Professor Emeritus. Beside Gothenburg and Nijmegen, Owe also spent a lot of time as visiting professor at many famous institutions, such as CERN, Geneva, Ecole Polytechnique Federale, Lausanne, University of Texas at Austin, Rice University, Houston, Texas, University of Lund, Sweden, Bulgarian Academy of Sciences, Sofia, Florida State University, Tallahassee, Lawrence Livermore National Laboratory, Livermore, California. Presently, Owe Axelsson has accepted an invitation from the Academy of Sciences of the Czech Republic to a collaboration in the Applied Mathematics Centre of the Institute of Geonics, Ostrava.

It is a challenge to describe the extent of works of Owe Axelsson due to its wide spectrum, complexity and because it consists of a number of substantial results and findings in various fields of numerical analysis. But without doubt, we should start with the highest appreciation of Owe Axelsson's merits in the development of the concept of preconditioning. His fundamental work started by publishing the paper *A generalized SSOR method, BIT 12(1972)* and has continued up to the present days. Let us quote from the paper *An introduction of Professor Owe Axelsson and Professor Miloš Zlámal, Journal of Computational and Applied Mathematics 63 (1995), 5–8 by Ivo Marek* written on the occasion of the Modelling 1994 conference: *...Owe is the father of the concept of preconditioning. He also perfected the preconditioning techniques via various further tools like block incomplete factorization, the multi-level approach and diagonal balancing, so that it became a powerful and almost univer-*

sal means of solving algebraic problems induced by discretization of boundary value problems.

The quoted paper also contains a list of fields where the scientific achievements of Owe were considered the most profound and visible:

- the concept of preconditioning,
- the diagonal perturbation and balancing,
- the incomplete factorization, block incomplete factorization,
- multi-grid methods, optimal multi-level preconditioners,
- black box methods of solving linear algebraic systems of equations,
- parallel algorithms,
- the conjugate gradient and generalized conjugate gradient methods,
- multilevel Newton-like methods,
- approximate methods for initial—boundary value problems.

Owe's achievements in the period preceding 1994 were published in a very large number of journal papers and conference proceedings. Moreover, they were summarized in two excellent monographs: *Finite Element Solution of Boundary Value Problems: Theory and Computation* (Academic Press, 1984, jointly with V. A. Barker) and *Iterative Solution Methods* (Cambridge University Press, 1994).

Now, we shall concentrate on what has happened during the most recent ten years. Owe could have given up his hard scientific work and enjoy the glory adjudged to him by the world mathematical community for his distinguished accomplishments. Instead, we are witnessing just the opposite. Owe continues to work hard, evolving and amplifying the flow of his ideas and bringing forth new ones, simply, he is extremely productive, perhaps even more than before. In particular, he has achieved new important results in the following fields:

- further development of multilevel methods,
- preconditioning techniques exploiting augmented matrix and deflation,
- investigation of convergence behaviour of CG and generalized CG methods,
- study of methods for solving nonlinear systems arising from the discretization of boundary value problems,
- solution of convection-diffusion problems,
- finite element technology,
- iterative solution of systems from mixed formulation of boundary value problems.

These results made their appearance in more than fifty journal papers and were presented in many principal lectures at conferences worldwide.

We will be more specific only in the case of some particular topics. In the field of multilevel methods, Owe applied his experience with preconditioning in both the

diagonal and factorized form to hierarchically decomposed finite element matrices. He developed preconditioners which became competitors to multigrid methods and allowed specific algebraic investigation. Such preconditioners were introduced in early 1980s. Later, in cooperation with P. Vassilevski, these two-level preconditioners were extended to multilevel preconditioners that were optimal in the sense of mesh independent convergence and optimal complexity. These preconditioners and the corresponding polynomial stabilization were further substantially developed in the last decade. It was shown that these preconditioners can provide solvers which are not only optimal, but also robust with respect to problem anisotropy and the shape of the finite elements. The robustness relies on the strengthened C. B. S. inequality and one of the authors had good luck to be present in Nijmegen just the time when Owe was deeply interested in this problem.

Owe succeeded in cooperating with many people, giving them lot of inspiration and transferring to them his unceasing energy and enthusiasm for the research work. We can witness the influence of his authority, which also encouraged one of the authors of this laudatio to believe in success of his investigation of the behaviour of the Newton-like methods for the solution of plasticity problems discretized by the return mapping scheme. And really, this work was fruitful and led to several journal papers.

Giving examples of Owe's results, we should not forget to mention evolution problems and his results concerning their approximate solution and error estimates. These topics were considered by Owe in the early stages of his academic career and have continued occasionally till the present time. In the case of evolution problems, as in other situations, Owe has proven his mastership in exploiting deep knowledge for analyzing a given problem in order to achieve optimal results. In the context of evolution problems, the tools were subtle properties of rational approximants of the exponential function and an unfailing feeling for choosing the right way how to solve the problem, in this case by proposing nonuniform stepping.

We should also add that in the last decade Owe has led seven international projects, four projects supported by the national Dutch foundation and six doctoral projects. All these projects were fully successful. In two of his international projects, High Performance Computing in Geosciences I and II, groups from the Institute of Geonics and the Institute of Computer Science of the Academy of Sciences of the Czech Republic successfully participated.

The number of international projects caused that the Department of Mathematics at University of Nijmegen was frequently crowded by visitors from many countries. This made Owe very busy not only as a scientific coordinator but also as a kind and careful host, who devoted to colleagues much of his free time, who organized trips and parties, and who served as an obliging driver of his Chrysler Voyager that was able

to carry a pretty big group of visitors. University of Nijmegen also hosted several conferences devoted to iterative methods and related topics. Owe also supervised excellent Ph.D. theses of many talented mathematicians. In the last decade, they were M. Neytcheva, Hao Lu, M. Nikolova, A. Padiy and L. Vijfinkel.

Very important ones of Owe's activities are connected with editing the journal *Numerical Linear Algebra with Applications* published by J. Wiley. He is the founder and General Editor of this journal, which started in 1994. In the course of ten years of existence, *Numerical Linear Algebra with Applications* has grown to a journal with a very high impact factor and is highly appreciated by the scientific community centered around numerical linear algebra, mathematical modelling and scientific computing.

High appreciation to Owe was expressed by SIAM that reprinted his book *Finite Element Solution of Boundary Value Problems, Theory and Computation* written with A. Barker in the series Classics in Applied Mathematics. This book is nicely characterized by M. B. Reed in the IMET 2004 proceedings. He wrote: *His 1984 textbook ... brought the conjugate gradient method with incomplete factorization preconditioning into the mainstream FE community, as a means of analysing meshes which were too large to solve by conventional direct methods.*

Up to now, we have concentrated on Owe's work and achievements. What we have to add is that despite of the hard and very successful work, Owe has remained a kind, modest and generous gentleman, anytime willing to help others and to enjoy the plain delights of life.

On behalf of the conference participants, his friends and the whole scientific community working in numerical analysis, we would like to wish him many happy returns of the day, good health and many new scientific achievements in the future.

For more about Owe Axelsson, in particular for a list of his publications, see his web page http://www.math.ru.nl/medewerkers/axelsson.