

Special issue “Mathematics of Porous Media,” dedicated to Professor C.J. van Duijn on the occasion of his 60th anniversary

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This special issue contains selected contributions from the conference “The Mathematics of Porous Media,” organized in Split (Croatia), June 13–15, 2011. This meeting has celebrated the 60th anniversary of Prof. Dr. Ir. Cornelis Johannes (Hans) van Duijn, who is one of the founding editors of this journal.

Hans van Duijn was born in 1950 in Rotterdam, The Netherlands, but he grew up in the city of Middelburg in Zeeland. Coming from a family background where high school education was not self-evident, Hans graduated only with a “middle” level which did not allow for university studies. After having gained a degree at a technical college only after 3 years in time, it was certainly a big step for him to enroll in 1972 at Eindhoven University of Technology in Physics. Three years later, having earned an “engineer” degree with distinction and with his interest in applied mathematics ignited, Hans made an even more fundamental step when he entered the office of Bert Peletier of the Mathematics Department of Delft University of Technology. Peletier was so impressed by this young man with the “wrong” degree that he offered him a position as PhD student. When in 1977 Peletier moved to Leiden University, Hans moved too, and in 1979,

after having already published several papers in highly renowned mathematical journals, Hans was awarded a PhD degree in “Mathematics and the Natural Sciences” at Leiden University for his thesis entitled “Nonlinear Diffusion Problems.” The early 1970s was the time where the porous medium equation and free boundary problems of Stefan type had opened up a new class of problems for applied analysis, where qualitative approaches were successful to dig deep into the structure of solutions with new phenomena like free boundaries, etc. In this decade, still one-dimensional problems were in the focus, which were then later enlarged to multi-dimensional versions. Hans’ thesis belongs to this field and one aspect became formative for his further scientific work: The mathematical models he investigated came from flow problems in porous media, i.e., in the underground. There is also another aspect of his work which became already apparent in his thesis. He not only insisted in having a mathematically “interesting” problem but he equally well insisted in having a soundly derived mathematical model describing a relevant aspect in science or technology. After a year as postdoc at the University of Minnesota, USA, Hans became a researcher at the Delft Soil Mechanics Laboratory, a time which laid a knowledge foundation in theory and experimental practice in hydraulics and geohydrology which later always helped him to distinguish between relevant and irrelevant problems. The professor for soil mechanics in Delft at that time was Gerard de Josselin de Jong who became as influential as Bert Peletier for the mathematical side for Hans’ view and estimation of a problem from the geosciences.

After 3 years, Hans left for a position as an associate professor in the Department of Mathematics at Delft University of Technology. In 1990, this profes-

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sorship was supplemented with a position of an honorary professor at the Mathematics Institute of Leiden University. In these years, Hans also became influential internationally. The reason for this was not only his, at this time, still rare combination of rigorous mathematics with, based on his sound knowledge in the applications, rigour in selecting and formulating the problem which also had “to make sense” outside of mathematics. A major role was also played by his personality. The reason that he was not only very soon well known but also liked and relied on was his enormous openness towards not only new problems but also new people. This positive attitude led to fruitful collaboration with colleagues from other disciplines (like Majid Hassanizadeh, Hans Bruining, or Rainer Helmig) and further infected and encouraged his coworkers. In these years, long-standing cooperations with Germany (Peter Knabner, Hans Wilhelm Alt) came to existence which in 1998 were rewarded and further facilitated by the Max Planck Research Award for International Cooperation. In these years, also his cooperation with research groups in the USA were established not only during his long-time visits at the Institute for Mathematics and its Applications in Minneapolis, in particular to mention the relation to the group of Mary F. Wheeler. This also shows the broad spectrum which Hans finally covered ranging from mathematical modeling over analysis as his core subject to numerical analysis of approximation schemes.

1995 was a year of major decisions: having all paper-work done and the house sold, Hans was ready to make a big step to the other side of the world, to Australia. Luckily, right before leaving, the Center for Mathematics and Computer Sciences (CWI) in Amsterdam offered him a position of senior researcher and group leader. Five years later, he obtained a full professorship in the Department of Mathematics and Computer Sciences at Eindhoven University of Technology. In these years, Hans again broadened his scientific interests and rigorous mathematical modeling via homogenization techniques became a major subject, again developing fruitful cooperations (Andro Mikelić, Sorin Pop). Teaching has always been an important concern of Hans, not only advising PhD students, from which now possibly Mark Peletier is the most well known of, but also in doing basic teaching in particular also for engineering students. Therefore, it is not astonishing that soon after starting in Eindhoven, Hans got involved in the shaping of the curricula in the framework of the Bologna Process and also in the management. Shortly after starting serving as dean, in 2005, he was elected Rector Magnificus (president), now being in his second term of office. Amazingly, also in this position,

Hans managed to find time for scientific work and also continued giving a lecture for bachelor students.

To summarize, since his starting in the end of the 1970s, Hans van Duijn has been influential in the field of applied analysis (free boundary problems, nonlinear and degenerate diffusion, conservation laws, homogenization, travelling waves). His work covers various aspects related to the modeling, analysis, upscaling, and computation of reactive and multiphase porous media flows, where he has made essential and pioneering contributions. In this sense, we mention results referring to the fresh-salt groundwater flow, solute and contaminant transport in porous media including equilibrium and nonequilibrium adsorption and (Taylor) dispersion, enhanced oil recovery, and nonequilibrium porous media flow models (hysteresis, dynamic capillarity effects). But what is maybe even more important is that he has set a new paradigm in combining rigorous mathematical analysis with a deep understanding of relevant problems from the geosciences and thus fostered the emergence of the new field “Mathematics of Porous Media,” combining an interdisciplinary fashion mathematics (modeling, analysis, simulation) with the experimental findings of geohydrology (or technical disciplines where also porous media appear).

This special issue includes papers related to the presentations given at the conference or submitted by close collaborators of Hans. In line with the coverage of Hans’ research work, the papers in this issue cover a broad scientific spectrum of mathematical and numerical analysis, upscaling, and applications, related mainly to actual problems of the society: ion transport in porous media, two-phase flows in heterogeneous media, coupled flow and geomechanics models, or soil reinforcement.

We are grateful to all authors who contributed to this special issue. All the papers went through the standard refereeing process and we thank the referees who helped us in doing the editorial work. We would also like to thank the Board of Computational Geosciences for the support for this special issue. And finally, our thanks to the participants and the speakers, who transformed the *Mathematics of Porous Media* conference into a successful event providing numerous cross-fertilizing ideas in a multidisciplinary context.

In the following, there is a complete list of talks given (in the order of the conference):

Applied Mathematics—the Van Duijn way

MARK A. PELETIER (Institute for Complex Molecular Systems, Department of Mathematics and Computer Science, Eindhoven University of Technology)

Solutions of the porous medium equation with holes in their support

JOOST HULSHOF (Analysis Group, Department of Mathematics, Faculty of Sciences, VU University Amsterdam)

Fluid flow in fissurized porous media

MICHEL BERTSCH (Dipartimento di Matematica, Università di Roma ‘Tor Vergata’)

An abstract existence theorem for parabolic systems

HANS WILHELM ALT (Division for Functional Analysis and Numerics, Institute of Applied Mathematics, University of Bonn)

Generalized Mixed Hybrid FE Approximation for Compositional Two-Phase Flow

TORSTEN MÜLLER (Chair of Applied Mathematics I, Department of Mathematics, Friedrich-Alexander University of Erlangen-Nuremberg)

A Mathematical Model for Biogrouting: A Way of Fortification of Soil

FRED VERMOLEN (Institute of Applied Mathematics, TU Delft)

Delft, Augsburg and the Mathematics of Adsorption—It was twenty years ago today

PETER KNABNER (Chair of Applied Mathematics 1, Department of Mathematics, University of Erlangen-Nuremberg)

Pharmacokinetics, or “How a drug reaches its target”

LAMBERTUS A. PELETIER (Faculty of Mathematics and Natural Sciences, Leiden University)

Mathematical Modelling and Simulation for Extraction of Geothermal Energy

WILLI JÄGER (Applied Analysis Group, Ruprecht-Karls-Universität Heidelberg)

Looking for the hot spot: homogenization and localization of a convection-diffusion equation in a bounded domain

GRÉGOIRE ALLAIRE (Centre de Mathématiques Appliquées, Ecole Polytechnique, Palaiseau Cedex)

Hyperbolic limit for two phase flows with discontinuous capillary pressure

CLÉMENT CANCÉS (Laboratoire Jacques-Louis Lions, Université Pierre et Marie CURIE, Paris)

Pricing convertible bonds with PDEs

DRAGAN BEZANOVIC (Leversys, Belgrade)

Upscaling work with Hans: flow trapping and Taylor’s dispersion

ANDRO MIKELIĆ (Université Lyon 1, Faculté des Sciences et Technologie, Département de Mathématiques, Institut Camille Jordan)

Accurate Cell-Centered Discretizations for Modeling Multiphase Flow in Porous Media on General Hexahedral and Simplicial Grids

MARY F. WHEELER (Center for Subsurface Modeling, Institute for Computational Engineering and Sciences, The University of Texas at Austin)

Similarity solutions for moisture redistribution, including the role of fluid-fluid interfacial area

S. MAJID HASSANIZADEH (Department of Earth Sciences, Faculty of Geosciences, Utrecht University)

An Analytical Method for Predicting the Performance of Gravitationally-Unstable Flow in Porous Media

JOHANNES BRUINING (Department of Geotechnology, Delft University of Technology)

Dynamic Capillarity in Porous Media

YABIN FAN (CASA, Dept of Mathematics and Computer Science, TU Eindhoven)

Colloidal Transport in Porous Media

NADJA RAY (Chair of Applied Mathematics I, Department of Mathematics, Friedrich-Alexander University of Erlangen-Nuremberg)