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SPECIAL ISSUE DEDICATED TO RAINER KRESS

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The investigation and simulation of acoustic, electromagnetic or elastic waves is an important task of Applied Mathematics. Often, waves are sent into an inaccessible region of space, into the human body or some material. Then the scattered fields are measured and it is the key task to gain information about the properties of the body or region of interest. In particular, this leads to shape reconstruction problems, where the location and boundary of some scattering body is reconstructed. Both direct and inverse problems for acoustic, electromagnetic or elastic waves involve many basic questions of mathematical analysis, numerical mathematics, applied mathematics and stochastics.

An important tool for modelling, simulation and reconstruction of waves and scattering bodies are integral equations. When a space is piecewise homogeneous, we can represent waves by layer potentials of the type

$$u(x) = \int_{\partial D} K(x,y)\varphi(y)\;ds(y), \quad x \in D,$$

living on the boundary ∂D of some domain. Here, $K(x,y)$ is either the fundamental solution of the underlying time-harmonic wave equation - i.e. for fixed y as a function of x it solves the wave equation in a particular domain - or its normal derivative. The density φ represents the source strength of each of the sources $K(\cdot,y)$ in y and the integral models a representation of the field by a superposition of sources (Huygen's principle). Matching boundary values of the function u leads to integral equations on the boundary ∂D of the scattering body.

Integral equations and their numerical simulation via the Boundary Element Method have been strongly evolving in the decades since World War II starting from the basic theory of Fredholm and Riesz. They have been used for inverse problems since the mid 80's with several new algorithms arising since the mid 90's.

This special issue reflects some important parts of the above developments. It has been initiated in connection with a workshop honouring

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Prof. Rainer Kress on the occasion of this 65th birthday at the University of Göttingen in early 2007. With a large number of papers, several highly influencial books, his work as teacher, and his personality Rainer Kress has contributed significantly to the above developments. His work includes many contributions to the area of boundary integral equations for solving scattering problems, the development of efficient high-order numerical methods for boundary integral equations, the use of boundary potentials for field and shape reconstruction and important contributions on iterative schemes and sampling and probe methods. Kress is author of several highly cited and widely used books on integral equations, scattering theory, inverse problems and numerical analysis.

In this isue you will find the numerical analysis branch of the work of Kress represented by the paper on singular value asymptotics of integration operators by Hofmann and Wolfersdorf. Papers of Kress on integral equations for scattering problems are the starting point for the contribution of Simon Chandler-Wilde, Ivan Graham, Stephen Langdon and Marko Lindner on condition number estimates for combined potential integral operators.

Kress' work on obstacle reconstruction via boundary potentials is the background of the papers of Alves and Martins on the Method of Fundamental Solutions. Liu and Potthast provide a new duality relation between the point source method of Potthast and the Kirsch-Kress potential method as a basic step to unify and systemize the collection of recent algorithms. In recent years Kress has generated important contributions to iterative schemes, which are the basis of the work of Tezel on Newton's method for detecting buried objects.

Finally, we have two contributions to the Linear Sampling Method of Colton and Kirsch by Arens and Lechleiter on basic convergence results and by Cakoni, Colton and Haddar on norm estimates of the refractive index of anisotropic media. These papers represent the class of sampling and probe methods which has been developed since 1996 by Colton, Kirsch, Kress, Potthast, Ikehata, Monk and others.

I would like to use the opportunity to express my personal thanks to Rainer Kress for his support and all I have learned from him over many years of interaction, first as a student, then later as a researcher and scientist. He is practicing science in its best sense: working at a leading international level, steadily developing a field using a broad range of ideas and tools, building a homogeneous complete analysis around a set of generic models. Combining model analysis, algorithms, numerical analysis and simulations with an equal weight has been one of the characteristics of his work. Kress' research group at the University of Göttingen has been highly successful in motivating and nurturing young researchers, building links to colleagues worldwide and driving developments which are relevant for important applications.

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