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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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