Inverse Problems and Applications

14 January – 15 May 2013

Institut Mittag-Leffler, Djursholm, Sweden

A large number of real world problems lead to the mathematical problem of determining a coefficient in a differential equation from information about a family of its solutions. This group of problems is commonly called "inverse problems". A well known example is the problem of inverse scattering (classical or quantum mechanical), which is concerned with determining a potential from a family of scattering data. The problem to produce a picture from a family of X-ray scans in a large number of directions, which was solved in the 1960:ies, belongs also to this group of problems. As is well known, this technique, now called Computerized Tomography, has been implemented in hospitals on a large scale for medical diagnostics.

The great success of Computerized Tomography and the rapid development of computer technology has turned the interest of engineers and physicists into development of a large variety of new measurement techniques that lead to new kinds of inverse problems. A common feature of all those methods is that some kind of radiation is emitted in many different directions into the medium to be examined, and the intensity of the transmitted or reflected radiation is measured. Here are some examples:

In *geophysics* tomographic methods are used both for fundamental investigation of the interior of the Earth and for oil and ore prospecting;

Electrical Impedance imaging means that the electric current on the surface of a region is measured for a large number of applied voltages, and from those data one calculates the electric conductivity at each point in the region;

Magnetic resonance imaging is a very powerful tool both for medical diagnostics and for chemical analysis;

Design of nanoelectronic devices has motivated extensive research on inverse scattering problems for *quantum graphs* — Schrödinger equations on metric graphs;

Electron tomography combines electron microscopy with tomography to make images of parts of protein molecules, which is crucial for instance for pharmaceutical research;

Multislice tomography: in traditional Computerized Tomography the engineers want to collect data in new ways in order to improve images and minimize radiation dose, and this leads to new mathematical problems;

New Hybrid Methods: for example *Photoacoustic Tomography* combines the high resolution of acoustic waves with the large contrast of optical waves.

Analysis of such problems brings together diverse areas of mathematics such as partial differential equations, complex analysis, differential geometry, harmonic analysis, integral geometry, microlocal analysis, numerical analysis, optimization, probability, scientific computing, statistics, etc. One of the attractive features of the field is the fruitful interaction between theory and application. Many important technological advances have been achieved that had not been possible without the development of new sophisticated mathematics. And conversely, challenging mathematical problems coming from the applications have stimulated important progress in fundamental mathematical research.

Organizing committee

Jan Boman, Stockholm University
Maarten de Hoop, Purdue University and MIT
Pavel Kurasov, Stockholm University
Yaroslav Kurylev, University college, London
Lassi Päivärinta, Rolf Nevanlinna Institute, Helsinki
Gunther Uhlmann, University of Washington, Seattle