INVERSE PROBLEMS AND IMAGING

by

Habib Ammari & Josselin Garnier

The workshop "Inverse problems and imaging" took place in Paris at the Institut Henri Poincaré on February 20-22, 2013. It was organized under the auspices of the French Mathematical Society (SMF) as a session of the "Etats de la Recherche". Its main objective was to present recent developments on inverse problems and imaging. Most of these developements result from interactions between several domains of mathematics: analysis and control of partial differential equations, stochastic analysis, statistics, multi-scale analysis. The three mini-courses given by Liliana Borcea (University of Michigan, USA), Hyeonbae Kang (Inha University, Korea), and Gunther Uhlmann (University of Washington, USA) can be considered as perfect illustrations of these fruitful interactions.

Liliana Borcea's lecture addresses sensor array imaging in random media. She describes how sensor array imaging has become an important technology with a wide range of applications in underwater acoustics, seismology, non-destructive evaluation of materials, medical ultrasound. She insists on the analogy and differences between coherent wave imaging and physical time reversal for waves and she explains the main challenges in terms of resolution and robustness. In particular she underlines that scattering of the waves by the random inhomogeneities in the medium can be a strong limitation for sensor array imaging, and that techniques to mitigate the effects of random scattering can be efficiently implemented. Her lecture notes give a detailed analysis in the case of imaging in randomly perturbed waveguides. Wave propagation and imaging can then be characterized by a few important length scales and asymptotic analysis based on separation of scales techniques can be applied to motivate and study appropriate imaging functions.

Hyeonbae Kang's lecture reviews recent progress on imaging by generalized polarization tensors (GPTs), enhancement of near-cloaking by GPT-vanishing structures, cloaking by anomalous localized resonance, and analysis of stress concentration. It turns out that all these problems can be expressed as interface problems in which an

integral operator called the Neumann-Poincaré operator arises naturally. The purpose of the lecture notes is to discuss about boundedness, invertibility, and spectral properties of this operator, and then relate these properties with the above mentioned problems.

Gunther Uhlmann's lecture is concerned with invisibility cloaking for acoustic and electromagnetic waves. Cloaking has become an important topic in inverse problems and imaging, as it is a positive way to interpret situations in which imaging is not possible. A region is said to be cloaked if its content together with the cloak is indistinguishable from the background space with respect to exterior wave measurements. In his lecture Gunther Uhlmann considers transformation-optics based cloaking in acoustic and electromagnetic scattering. The blueprints for an ideal cloak use singular acoustic and electromagnetic materials, posing a challenge to both theoretical analysis and practical fabrication. In order to avoid the singular structures, various regularized approximate cloaking schemes have been developed and are presented in the lecture notes.

Habib Ammari, Department of Mathematics and Applications, Ecole Normale Supérieure, 45 Rue d'Ulm, 75005 Paris, France. • *E-mail :* habib.ammari@ens.fr

Josselin Garnier, Laboratoire de Probabilités et Modèles Aléatoires & Laboratoire Jacques-Louis Lions, Université Paris Diderot, 75205 Paris Cedex 13, France.
E-mail : garnier@math.univ-paris-diderot.fr