Multiscale Analysis of Wave Propagation and Imaging in Random Media

Josselin Garnier

Centre de Mathematiques Appliquees, Ecole Polytechnique, 91128 Palaiseau Cedex, France

Email: josselin.garnier@polytechnique.edu

When waves propagate through random media the energy is transferred to the incoherent wave part by scattering. The wave intensity then forms a random speckle pattern seemingly without much useful information. However, a number of recent physical experiments show that it is possible to extract useful information from this speckle pattern and to image an object buried in a random medium. Here we present the mathematical analysis that explains the quite stunning performance of speckle imaging. Our analysis identifies a scaling regime where these schemes work well. This regime is the white-noise paraxial regime, which leads to the Ito-Schrodinger model for the wave amplitude. Our results conform with the sophisticated physical intuition that has motivated these schemes, but give a more detailed characterization of the performance. The analysis gives a description of (i) the information that can be extracted and with what resolution (ii) the statistical stability or signal-to-noise ratio with which the information can be extracted.