Direct and Inverse Scattering of Waves (L16)

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The study of wave scattering is concerned with how the propagation of waves is affected by objects, and has a variety of applications in many fields, from environmental science to seismology, medicine, telecommunications, materials science, military applications, and many others. If we know the nature of the objects and we want to find how an incident wave is scattered, we call this a ‘direct scattering problem’ and practical applications will include for example underwater sound propagation, light transmission through the atmosphere, or the effect of noise in built-up areas. If we measure and know the scattered field produced by an incident wave, but we do not know the nature of the objects that have scattered it, we call this an ‘inverse scattering problem’ and applications will include for example non-destructive testing of materials, remote sensing with radar or lidar, or medical imaging.

This course will provide the basic theory of wave propagation and scattering and an overview of the main mathematical methods and approximations, with particular emphasis on inhomogeneous and random media, and on the regularisation of inverse scattering problems. Only time-harmonic waves will be normally considered.

Topics covered will include:

1. Boundary value problems and the integral form of the wave equation.
2. The parabolic equation and Born and Rytov approximations for the scattering problem.
3. Scattering by randomly rough surfaces and propagation in inhomogeneous media.
5. Regularisation methods and methods for solving some inverse scattering problems.
6. Time reversal and focusing in inhomogeneous media.

Pre-requisites

This course assumes basic knowledge of ODEs and PDEs, and of Fourier transforms. Some familiarity with linear algebra and with basic concepts in functional analysis is helpful, though by no means necessary.

Students doing this course might find it helpful, though by no means necessary, to attend also the following Part III courses: “Topics in Convex Optimisation”, and “Inverse Problems”.

Preliminary Reading

2. L.D. Landau and E.M. Lifschitz Fluid Dynamics. Pergamon 1987 [Chapter 8]. Also available at

users-phys.au.dk/srf/hydro/Landau+Lifschitz.pdf
Literature


Additional support

Three examples sheets will be provided and three associated examples classes will be given. There will be a two-hour revision class in the Easter Term.