David Colton • Rainer Kress

Inverse Acoustic and Electromagnetic Scattering Theory

Third Edition

Springer

Contents

1	Introduction	1
1.1	The Direct Scattering Problem	2
1.2	The Inverse Scattering Problem	7
2	The Helmholtz Equation	13
2.1	Acoustic Waves	13
2.2	Green's Theorem and Formula	16
2.3	Spherical Harmonics	22
2.4	Spherical Bessel Functions	28
2.5	The Far Field Pattern	33
3	Direct Acoustic Obstacle Scattering	39
3.1	Single- and Double-Layer Potentials	40
3.2	Scattering from a Sound-Soft Obstacle	48
3.3	Herglotz Wave Functions and the Far Field Operator	58
3.4	The Two-Dimensional Case	72
3.5	On the Numerical Solution in $\mathbb{R}^2$	75
3.6	On the Numerical Solution in $\mathbb{R}^3$	86
4	Ill-Posed Problems	95
4.1	The Concept of Ill-Posedness	96
4.2	Regularization Methods	97
4.3	Singular Value Decomposition	99
4.4	Tikhonov Regularization	107
4.5	Nonlinear Operators	114
5	Inverse Acoustic Obstacle Scattering	119
5.1	Uniqueness	120
5.2	Physical Optics Approximation	127
5.3	Continuity and Differentiability of the Far Field Mapping	129
5.4	Iterative Solution Methods	146

5.5	Decomposition Methods	155
5.6	Sampling Methods	173
6	The Maxwell Equations	187
6.1	Electromagnetic Waves	188
6.2	Green's Theorem and Formula	190
6.3	Vector Potentials	200
6.4	Scattering from a Perfect Conductor	209
6.5	Vector Wave Functions	215
6.6	Herglotz Pairs and the Far Field Operator	224
7	Inverse Electromagnetic Obstacle Scattering	237
7.1	Uniqueness	237
7.2	Continuity and Differentiability of the Far Field Mapping	241
7.3	Iterative Solution Methods	249
7.4	Decomposition Methods	252
7.5	Sampling Methods	260
8	Acoustic Waves in an Inhomogeneous Medium	265
8.1	Physical Background	266
8.2	The Lippmann–Schwinger Equation	268
8.3	The Unique Continuation Principle	273
8.4	The Far Field Pattern	277
8.5	The Analytic Fredholm Theory	286
8.6	Transmission Eigenvalues	291
8.7	Numerical Methods	299
9	Electromagnetic Waves in an Inhomogeneous Medium	303
9.1	Physical Background	304
9.2	Existence and Uniqueness	305
9.3	The Far Field Patterns	310
9.4	The Spherically Stratified Dielectric Medium	313
9.5	The Exterior Impedance Boundary Value Problem	318
10	The Inverse Medium Problem	325
10.1	The Inverse Medium Problem for Acoustic Waves	325
10.2	Uniqueness	327
10.3	Iterative Solution Methods	333
10.4	Decomposition Methods	336
10.5	Sampling Methods and Transmission Eigenvalues	346
10.6	The Inverse Medium Problem for Electromagnetic Waves	370
10.7	Numerical Examples	382
	References	389
	Index	403