
THE THEORY OF SCINTILLATION AND ITS APPLICATIONS IN REMOTE SENSING

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CONTENTS

1	Introduction	1
1.1	Electromagnetic Propagation Theory	9
1.1.1	Freely Propagating Waves	10
1.1.2	Bistatic Scattering Functions	14
1.2	Anticipating Scintillation Theory	16
1.2.1	Received Signal Power	16
1.2.2	Noise Power	17
1.2.3	System Constant	17
1.2.4	Propagation Disturbances	18
2	The Forward Propagation Equation	21
2.1	Weakly Inhomogeneous Media	24
2.1.1	Integral-Equation Form	24
2.1.2	Weak-Scatter Approximation	25
2.1.3	Forward Approximation	27
2.1.4	Parabolic Wave Equation	29
2.1.5	Ray Optics	29

2.2	Numerical Simulations	30
2.2.1	Beam Propagation	32
2.2.2	Refraction	34
2.2.3	FPE and Ray Optics	38
2.2.4	Scintillation	39
3	The Statistical Theory of Scintillation	47
3.1	Background	52
3.1.1	Structure Sources	52
3.1.2	Stochastic Processes	56
3.1.3	Spectral Representation	57
3.1.4	Power-Law Spectral Models	58
3.1.5	Phase Structure	62
3.1.6	Anisotropy	64
3.2	Calculation of Field Moments	64
3.3	Second-Order Moments	66
3.4	Fourth-Order Moments	69
3.4.1	Solutions to the Fourth-Order Moment Equation	71
3.4.2	Power-Law Scintillation Regimes	72
3.4.3	Summary	77
3.5	Intensity Statistics	78
3.5.1	Intensity PDFs and Moments	80
3.5.2	Simplified Scattering Models	81
3.6	Numerical Simulations	84
3.6.1	Small-Slope Regime	86
3.6.2	Large-Slope Scintillation Regime	89
3.6.3	Two-Slope Power-Law Scintillation	93
3.7	Statistical Theory Limitations	95
4	Beacon Satellite Scintillation	101
4.1	Geometric Considerations	105
4.2	Phase Structure Revisited	107
4.2.1	Anisotropy	107
4.2.2	Weak Scatter	109
4.3	Complex Field Coherence Revisited	111
4.3.1	Space-Time Mutual Coherence	113
4.3.2	Time Series Measurement	114
4.3.3	Frequency Coherence	115

4.3.4	Spherical Wave Correction	118
4.4	Satellite Orbit & Earth Magnetic Field Calculation	118
4.4.1	Satellite Orbit Computation	119
4.4.2	Magnetic Field Computation	122
4.5	Examples	123
4.5.1	Geometric Dependence of Anisotropy	126
4.5.2	Geometric Dependence of Intensity Scintillation	128
4.5.3	Beacon Satellite Simulations	128
4.6	Theory and Simulations	136
5	System Applications of Scintillation Theory	141
5.1	An Introduction to Waveforms	144
5.1.1	Signal Structure	144
5.1.2	Signal Processing	145
5.2	Scintillation Channel Model	148
5.2.1	Applications to Non-Dispersive Fading	150
5.3	System Performance Analysis	153
5.3.1	System Sensitivity and Processing Intervals	155
5.3.2	Coherence Bandwidth	155
5.3.3	Temporal Coherence	157
5.3.4	Spatial Coherence	165
5.4	Scintillation Data Processing	165
5.4.1	Background	166
5.4.2	Digital Signal Processing	168
5.4.3	Multi-Frequency Data	170
5.4.4	Frequency Tracking	172
5.4.5	Signal Intensity	174
5.4.6	Signal Doppler	174
5.5	Scintillation Data Interpretation	177
5.5.1	Scintillation Intensity Analysis	179
5.5.2	Spectral Analysis	179
5.6	Beacon Satellite Research	182
6	Scattering and Boundaries	185
6.1	Embedded Compact Scattering Objects	188
6.1.1	Mutual Interaction Formulation	189
6.1.2	Double-Passage Propagation	190
6.1.3	Radar Imaging Through Disturbed Media	193

iv CONTENTS

6.1.4	SAR Example	195
6.2	Boundary Surfaces	198
6.2.1	Boundary Scattering Theory	199
6.2.2	FPE Solution with Boundary Example	205
6.2.3	Concluding Remarks	209
Appendix A		213
A.1	Far-Field Approximation	213
A.2	Backscatter	215
A.3	Anisotropy Transformations	216
A.4	Wavefront Curvature Correction	220
A.5	Two-Dimensional Boundary Integrals	221
A.5.1	Field Observables	224
A.5.2	Highly Conducting Media	225
A.5.3	Numerical Solution	226
References		227
Index		235

Dedicated to Dr. Walter A. Flood for his unwavering support of university and industry scientists collaboratively engaged in propagation and scattering research from 1981 to 1995.

PREFACE

This book evolved from a seminar on scintillation I presented at the International School on Atmospheric-Ionospheric Remote Sounding and Modelling (ISAR) held at the National Central University of Taiwan in October 2008. It was particularly rewarding to speak at the opening session, which was a tribute to Chao-Han Liu who was retiring as president of the National Central University after decades of contributions and leadership in the fields of remote sensing and scintillation.

In preparing material for the seminar it became clear that a theory of scintillation distinct from well-established theories of propagation and scattering had been largely taken for granted. Theoretical analyses developed to explain random fluctuations in galactic radio emissions, trans-ionospheric radio signals, optical images, and ocean acoustics signals have been collected and reviewed. Moreover, scintillation as a nuisance in radio communications, optical imaging, radar, and sonar has stimulated numerous application-specific theoretical developments. These developments have been strongly influenced by the diverse observational and analytical methodologies specific to each field. However, a unified theory of scintillation that builds on the common underpinnings of this large body of published material had been neglected.

Dialogue that took place during the seminar series suggested that the development of a theory of scintillation was a worthwhile endeavor. The basic material is well established, for example in the review paper written in 1982 by Chao-Han Liu and his long-time colleague Kung Chie Yeh [1]. Experiments and observations that stimulated the developments are also well documented in the Yeh-Liu review and in the 1982 review by Jules Aarons [2], who initiated many of the ionospheric global scintillation observation programs that followed the launch of Sputnik in 1957.

The fact that the ISAR theme was “remote sounding,” synonymous with remote sensing, is noteworthy. The weak-scatter theory used extensively in radar remote sensing applications accommodates both forward scatter and backscatter in a simple and intuitive way. Scintillation theory neglects backscatter altogether, but it can accommodate modification of the forward-propagating excitation wave field that is neglected in the weak-scatter theory. When the media structure itself generates significant backscatter, both the weak-scatter theory of remote sensing and the theory of scintillation break down. Under such extreme conditions the theory of radiative transport must be used. The applications of radiative transport theory to remote sensing have been surveyed by Akira Ishimaru in a review paper [3] and in a two-volume series on the entire subject of remote sensing [4] [5]. Thus, scintillation theory is uniquely situated between scatter theory and radiative transport.

The material presented in this book was influenced by more than a decade of satellite scintillation research that began with the 1976 launch of the P76-5 satellite [6]. I had the good fortune to start my professional career working on this program and related projects involving radar sounding of the ionosphere.

I am deeply indebted to my teachers, my co-workers, and numerous colleagues who freely shared their ideas, their data, and their critiques of my work.

I am pleased to acknowledge the meticulous checking of the analysis presented in Chapters 3 and 4 by Charles Carrano at the Institute for Scientific Research, Boston College. The data used in Chapter 5 were provided with generous help by Robert Livingston at Scion Associates. Susan Hoover, a long-time colleague at Vista Research, Inc., provided invaluable help in proof-reading and editing the manuscript.