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
## CONTENTS

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

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