THE THEORY OF SCINTILLATION AND ITS APPLICATIONS IN REMOTE SENSING

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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," synonomous 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 proofreading and editing the manuscript.