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Book Review: *Statistical Optics*

Statistical Optics. J. W. Goodman. Wiley-Interscience, New York, 1985, 550 pp.

This book is a text for the advanced student in optics and, as the author acknowledges in the preface, "the tools of probability and statistics... should be included as a standard part of any advanced optics curriculum." Dr. Goodman has successfully blended the relevant mathematics for describing stochastic processes with the underlying physical concepts in such a way that the reader is left with the impression that the marriage is a natural one. This is, of course, the hallmark of a good teacher—the difficulty in the preparation of the material is not apparent in the presented text.

The statistical concepts are introduced through physical arguments such as random walks and an intuition for such difficult notions as ergodicity is developed by means of examples. The concepts of Fourier analysis and linear systems theory are developed in the context of random processes, which is the appropriate background for understanding analytic signals such as thermal or laser light. A number of statistical measures for the properties of light are used, such as the second-order averages known as coherence functions. Such coherence functions can be determined in time at a point in space (temporal coherence) or throughout space at a given point in time (spatial coherence), or both (mutual coherence). The multidimensional Fourier transforms of the various coherence functions give the various forms of the spctral density of the light signal.

Not all the properties of light can be relegated to second-order statistical measures. Dr. Goodman gives convincing physical arguments as to why higher order coherence functions are important for the complete characterization of polarized thermal light. The statistical properties of the intensity of the measurements are discussed in great detail, including the dependence on the integration time of the signal and the correltion time of the temporal fluctuations of the signal at two points in space. These properties are shown to be important in relating an object to its image, and deciding when an imaging system is *coherent* (linear in amplitude), *incoherent* (linear in intensity), or intermediate. A number of explicit imaging systems (lenses) are worked out in detail. The concept of "speckle" in coherent systems and its relation to the small-scale roughness of materials is also presented.

The discussion of imaging through randomly inhomogeneous media includes thin, random screens with Gaussian statistics and extended random media. The review of line-of-sight propagation through turbulence is not intended to be exhaustive, but it does present the more salient features of this hoary problem. Of particular interest is the separate discussion of long and short exposure times compared with the time scale of the turbulent motion in the atmosphere.

The final chapter in the book addresses the fundamental problem of the generation of fluctuations in light due to its interaction with matter. This basically quantum mechanical effect is discussed cogently in terms of the semiclassical theory of the photoelectric effect. The discussion is both clear and physically appealing.

I find this book to be well written, including historical background where appropriate, and with mention of the limitations of the discussion being presented where necessary. I strongly recommend this book both as a text for advanced students in optics and as a preliminary research volume for anyone interested in understanding the fluctuations in light.

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