The Computer in Optical Research

Methods and Applications

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With 92 Figures

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Preface

The ability to measure, and to *compute* with speed and accuracy, are hallmark requirements of the physical or exact sciences. Since its introduction in the late 1950 s, the digital computer has furthered the latter ability beyond man's wildest dreams. Today, the computer has uses ranging from mildly useful, to vital, in just about every field of research in optics. Any institution that calls itself a research facility in optics must have a large computer available.

The fields of optics that have particularly profited from the computer's existence are lens and thin film design, image processing and evaluation, and atmospheric optics including remote sensing. The general approaches to problem solving upon a computer fall into three overall areas: *deterministic* or direct calculation methods, as in the evaluation of diffraction integrals; *statistical* methods, as in the Monte Carlo calculation of photographic emulsion characteristics; and *iterative* methods, as in recursive image processing or in optimization problems of lens design. It is remarkable that all these methods stem from the computer's single, only real ability: to add very rapidly.

Of course, as is known to long-term "cybernauts", the machine does have its drawbacks. Computer terminal rooms are notoriously dull places, monopolized by the chatter of the high-speed printer and the visual blight of old Fortran manuals. Worse yet, the computer is the ultimate in harsh taskmasters, requiring a perfect program, with its own, sometimes unpredictable meaning of the word "perfect". Computer programmers often suffer the effects of years of interaction with a rigid and demanding machine. Nevertheless, computer based research has some definite advantages, a not insignificant one being *non*-reliance upon the purchase, delivery, and correct operation of expensive and complicated laboratory equipment. Many a research project and Ph. D. dissertation have foundered on the long time delays caused by these problems.

The aim of this volume is to bring together as wide and representative a scope of problem-solving techniques as can fit within the confines of a modest-sized text. Applications of the techniques to important problems in optics have been emphasized as well. We hope, in this way, to introduce use of "the machine" to newcomers in optics, and to encourage its wider use among even experienced cybernauts.

The following general areas of research techniques are covered. Chapter 1 is an overall survey of computer developments in optics, somewhat from a historical viewpoint, and with a survey of the other chapters. Chapter 2 treats modern methods of computing diffraction integrals. Chapter 3 introduces and develops probabilistic and statistical methods of analysis. Chapter 4 covers optimization techniques, and especially as they apply to lens and thin film design. Chapter 5 offers an introduction to computer uses in optical astronomy. And Chapter 6 surveys the field of computer-generated holograms.

I would like to thank Dr. Robert E. Hopkins of the University of Rochester for first introducing me to computer based research, and guiding my early career when it so acutely needed guidance.

I would also like to thank Dr. Helmut Lotsch for first suggesting the need for this kind of text. Many thanks are due the authors of the different chapters for their kindness in agreeing to contribute to the book, for their extreme kindness in actually carrying through with the promise, and finally, for their perseverence in meeting the various deadlines and revising and updating where these were necessary.

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