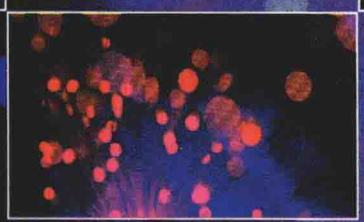
Govind Agrawal

Nonlinear Fiber Optics

Fifth Edition

非线性光纤光学

第5版



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The Institute of Optics
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In the memory of my mother and
for Anne, Spira, Caroline, and Claire

Author Biography

Govind Agrawal holds positions of Professor of Optics and Professor of Physics at the University of Rochester, USA. His previous appointments were at Ecole Polytechnique, France, City University of New York, and AT & T Bell Laboratories. He is an author or coauthor of more than 400 research papers and eight books. He is also involved in planning of international conferences and is a frequent speaker at such meetings. Professor Agrawal is a Fellow of both the Optical society of America and IEEE. He served as an associate Editor of the Journal of the Optical Society of America from 1993 to 1998 and of Optics Express from 2001 to 2004. He is currently serving on the Editorial board of the OSA journal Advances in Optics and Photonics. Prof. Agrawal chaired the Publication Council of Optical society of America and was also a member of its Board of Directors during 2009 and He is also the recipient of the 2012 IEEE Photonics Society Quantum Electronics Award.

Preface

Since the publication of the first edition of this book in 1989, the field of *nonlinear fiber optics* has remained an active area of research and has thus continued to grow at a rapid pace. During the 1990s, a major factor behind such a sustained growth was the advent of fiber amplifiers and lasers, made by doping silica fibers with rare-earth materials such as erbium and ytterbium. Erbium-doped fiber amplifiers revolutionized the design of fiber-optic communication systems, including those making use of optical solitons, whose very existence stems from the presence of nonlinear effects in optical fibers. Optical amplifiers permit propagation of lightwave signals over thousands of kilometers as they can compensate for all losses encountered by the signal in the optical domain. At the same time, fiber amplifiers enable the use of massive wavelength-division multiplexing, a technique that led, by 1999, to the development of lightwave systems with capacities exceeding 1~Tb/s. Nonlinear fiber optics plays an important role in the design of such high-capacity lightwave systems. In fact, an understanding of various nonlinear effects occurring inside optical fibers is almost a prerequisite for a lightwave-system designer.

Starting around 2000, a new development occurred in the field of *nonlinear fiber optics* that changed the focus of research and led to a number of advances and novel applications in recent years. Several kinds of new fibers, classified as highly nonlinear fibers, have been developed. They are referred to with names such as microstructured fibers, holey fibers, or photonic crystal fibers, and share the common property that a relatively narrow core is surrounded by a cladding containing a large number of air holes. The nonlinear effects are enhanced dramatically in such fibers to the extent that they can be observed even when the fiber is only a few centimeters long. Their dispersive properties are also quite different compared with those of conventional fibers developed for telecommunication applications. Because of these changes, microstructured fibers exhibit a variety of novel nonlinear effects that are finding applications in fields as diverse as optical coherence tomography and high-precision frequency metrology.

The fifth edition is intended to bring the book up-to-date so that it remains a unique source of comprehensive coverage on the subject of nonlinear fiber optics. It retains most of the material that appeared in the fourth edition. However, an attempt was made to include recent research results on most topics relevant to the field of nonlinear fiber optics, resulting in an increase in the size of the book. Major changes occur in Chapters 11 and 12. In particular Chapter 12 has been split into two chapters such that the new Chapter 13 is now wholly devoted to the phenomenon of supercontinuum generation. In the fifth edition, Chapters 11 and 12 have seen major additions because of recent advances in the design of photonic crystal and other microstructure fibers. All other chapters have also been updated, as found appropriate for improving the book. For example, a new subsection of Chapter 2 is now devoted to the nonlinear effects in multimode fibers. Polarization issues are discussed in detail in Chapters 6 to 10 because of their importance. Chapters 8 to

10 required major changes because of continuing advances in the research areas covered by them.

The potential readers of this book are likely to consist of senior undergraduate students, graduate students enrolled in the M.S. and Ph.D. degree programs, engineers and technicians involved with the fiber-optics industry, and scientists working in the fields of fiber optics and optical communications. This revised edition should continue to be a useful text for graduate and senior-level courses dealing with nonlinear optics, fiber optics, or optical communications that are designed to provide mastery of the fundamental aspects. Some universities may even opt to offer a high-level graduate course devoted to solely nonlinear fiber optics. The problems provided at the end of each chapter should be useful to instructors of such a course.

Many individuals have contributed, either directly or indirectly, to the completion of the fifth edition. I am thankful to all of them, especially to my graduate students whose curiosity and involvement led to several improvements. Several of my colleagues have helped me in preparing the fifth edition, and I thank them for reading drafts of selected chapters and for making helpful suggestions. I am grateful to many readers for their occasional feedback. Last, but not least, I thank my wife, Anne, and my daughters, Sipra, Caroline, and Claire, for their understanding and support for this project.

Govind P. Agrawal
Rochester, New York

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