This Week's Citation Classic

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Bloembergen N. *Nonlinear optics.* Reading, MA: W.A. Benjamin, Inc., 1977 (1965). 229 p.

The general principles of the field of nonlinear optics, which deals with phenomena that occur at very high light intensities obtainable in laser beams are described. The central feature is the introduction of nonlinear complex susceptibilities to describe the coherent nonlinear interactions between light and matter. [The *SCI*® indicates that this book has been cited over 695 times since 1965.]

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"This monograph was written during eight hectic weeks in April, May, and June of 1964. I remember some days when I wrote for 12 to 14 hours. A friend commented at the time that a book written in such a hurry could be no good. The monograph was based on lecture notes prepared for **a** special course on quantum electronics at Harvard University in 1963. It also served as a basis for a series of lectures delivered at the International Summer School in Les Houches, July 1964.

"During the years 1961-64 my associates, J.A. Armstrong, J. Ducuing, P.S. Pershan, and Y.R. Shen, and I had developed a rather general formalism to describe nonlinear couplings between electromagnetic waves based on nonlinear susceptibilities of various orders. The book *Nonlinear Optics* contains reprints of three fundamental research papers as appendices.[1-3] Perhaps these should have been cited more frequently than the book. The citation of the latter is probably a matter of convenience. In addition to the theoretical investigations, we also had a very active experimental program at Harvard in those early years of nonlinear optics. This program is still alive and well.

"In 1964 I wrote in the preface, 'It is perhaps foolhardy to write a monograph about nonlinear optics at this time, when new results are still announced at a high rate in scientific journals. It could be argued that such a monograph would at best contribute to its own rapid obsolescence. Nevertheless, it is hoped that it may have some more lasting value. The general principles of Maxwell's electromagnetic theory and of quantum mechanics are well established. Their domain of application is extended to include higher order interactions between light and matter in terms of nonlinear susceptibilities.'

"History has proved these last statements to be correct. The field of nonlinear optics is booming, and the size of its scientific literature has grown by at least a factor of one hundred since 1964. The general theoretical framework of *Nonlinear Optics* provides a useful take-off position for many of the current more sophisticated investigations in this field, which have found applications in optical communications, information processing, chemical analysis, as well as in various branches of nonlinear spectroscopy. In particular, the current activity in four-wave mixing based on the third-order nonlinear susceptibility $x^{(3)}$ is a source of personal satisfaction. Thus, I could write in the preface to the third printing in 1977: 'Obviously, a better and more comprehensive textbook could now be written. Lacking time and effort to accomplish that needed task, I am gratified that these original notes still provide a general framework suitable for the description of many new developments in nonlinear optics.'

"While some basic experimental results described in *Nonlinear Optics,* notably on nonlinear reflection and refraction, on harmonic generation and on parametric conversion, have lasting significance, the far-reaching advances in instrumentation and techniques since 1964 make the book outdated as far as experimental methods and results are concerned. It continues to be used and cited in the research literature as a 'basic background' reference.

"I am still at Harvard University as Rumford Professor of Physics. My present research interest remains in various aspects of nonlinear optics."

1. **Armstrong J A, Bloembergen N, Ducuing J & Pershan P S**. Interactions between light waves in a nonlinear dielectric. *Phys. Rev.* **127**:1918-39, 1962.
2. **Bloembergen N & Pershan P S.** Light waves at the boundary of nonlinear media. *Phys. Rev.* **128**:606-22, 1962.
3. **Bloembergen N & Shen Y R.** Quantum-theoretical comparison of nonlinear susceptibilities in parametric media, lasers and Raman lasers. *Phys. Rev.* **133**:A37-49, 1963.