Principles of Lasers
THIRD EDITION

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Laser... inter eximia naturae dona numeratum plurimis compositionibus inseritur

The Laser is numbered among the most miraculous gifts of nature and lends itself to a variety of applications

Plinius, Naturalis Historia, XXII, 49 (*first century A.D.*)

An Elaboration of the Quotation from Pliny the Elder: The Laser during the Greco-Roman Civilization

During the Greco-Roman civilization (roughly from the sixth century B.C. to the second century A.D.) the Laser was well known and much celebrated. Unlike its present-day homonym, it was actually a plant, but with no less wonderful properties. This plant, perhaps belonging to the *Umbelliferae*, grew wild over a large area around Cyrene, in present-day Libya. Sometimes also called *Laserpitium*, it was considered to be a gift of God because of its almost miraculous properties. It was used to cure a variety of diseases, from pleurisy to various epidemic infections. It was an effective antidote against the poison of snakes, scorpions, and enemy arrows. Its delicate flavor led to its use as an exquisite dressing in the best cuisine. It was so valuable as to be the main source of Cyrenaean prosperity and it was exported to both Greeks and Romans. During the period of Roman domination, it was the only tribute paid by the Cyrenaeans to the Romans, who kept the Laser in their coffers together with their golden ingots. What is perhaps the best testimony to the Laser of those days is to be found on the celebrated Arcesilao cup (now in the Cyrene Museum), where porters can be seen loading the Laser onto a ship under the supervision of King Arcesilao. Both Greeks and Romans tried hard, but without success, to grow the Laser in various parts of *Apulia* and *Ionia* (in the south of Italy). Consequently the Laser became more and more rare and seems to have disappeared around the second century A.D. Ever since then, despite several efforts, no one has been able to find the Laser in the deserts south of Cyrene, and so it remains the lost treasure of the Greco-Roman civilization.

Preface to the Third Edition

This third edition, motivated by the numerous and significant developments in the laser field since the publication of the second edition in 1982, is a substantially revised version of the previous edition. The basic philosophy has, however, remained the same, namely, to provide a broad and unified description of laser behavior at the simplest level that is compatible with a correct physical understanding. The basic organization of the book has also remained the same. The book is therefore aimed at both classroom teaching and self-study by students in electrical engineering, physics, and chemistry who have an interest in understanding the principles of laser operation.

The major additions to this edition are the following:

1. New sections dealing with laser types, in particular x-ray lasers and new solid-state lasers, including alexandrite devices, and a greatly extended description of semiconductor lasers.
2. A more extended treatment of laser mode-locking, including new sections on cavity dumping and pulse compression.
3. A more extended and greatly simplified description of the coherence and statistical properties of laser light as opposed to those of conventional light.
4. A greatly extended discussion of the physics of gas discharges.

Other important additions include a discussion of some topics from conventional optics (e.g., ray matrix methods, Fabry–Perot interferometers, and multilayer dielectric mirrors), Gaussian beam propagation (e.g., the ABCD law), and the theory of relaxation oscillations and active mode-locking.

Although the net result has been a considerable increase in the size of the book, I hope that this new edition can now better serve the need for a general introduction to the laser field.

I wish to acknowledge the following friends and colleagues, whose suggestions and encouragement have certainly contributed toward improving the book in a number of ways: Rodolfo Bonifacio, Ian W. Boyd, Richard K. Chang, Vittorio Degiorgio, Richard H. Pantell, Fritz P. Schäfter, Ian J. Spalding, and Boris Stoicheff. I wish also to acknowledge the critical editing of David C. Hanna, who has acted as much more than simply a translator. The careful reading of the manuscript and critical comments by P. Laporta were also helpful. Finally I wish to thank Dante Cigni for kindly providing me with the material concerning the history of the Laser during the Greco-Roman civilization.

Orazio Svelto

Milan

Contents

1. Introductory Concepts

2. Interaction of Radiation with Matter

3. *Pumping Processes*

4. *Passive Optical Resonators*

5. Continuous Wave and Transient Laser Behavior

6. *Types of Lasers*

7. *Properties of Laser Beams*