
CHAPTER 1

Introduction

Optics today is responsible for many revolutions in science and technology. This has been brought about primarily by the invention of the laser in 1960 and subsequent development in realizing the extremely wide variety of lasers. One of the most interesting applications of lasers with a direct impact on our lives has been in communications. Use of electromagnetic waves in communication is quite old, and development of the laser gave communication engineers a source of electromagnetic waves of extremely high frequency compared to microwaves and millimeter waves. The development of low-loss optical fibers led to an explosion in the application of lasers in communication, and today we are able to communicate almost instantaneously between any two points on the globe. The backbone network providing this capability is based on optical fibers crisscrossing the Earth: under the seas, over land, and across mountains. Today, more than 10 terabits of information can be transmitted per second through one hair-thin optical fiber. This amount of information is equivalent to simultaneous transmission of about 150 million telephone calls—certainly one of the most important technological achievements of the twentieth century. We may also mention that in 1961, within one year of the demonstration of the first laser by Theodore Maiman, Elias Snitzer fabricated the first fiber laser, which is now finding extremely important applications in many diverse areas: from defense to sensor physics.

Since fiber optic communication systems are playing very important roles in our lives, an introduction to these topics, with a minimum amount of mathematics, should give many interested readers a glimpse of the developments that have taken place and that continue to take place. In Chapter 2 we introduce the reader to light waves and their characteristics and in Chapter 3 explain how it is possible to use light waves to carry information. Chapters 4 to 8 deal with various characteristics of the optical fiber relevant for applications in communication and sensing. The erbium-doped fiber amplifier has revolutionized high-speed communication; this is discussed in Chapter 9, where we also discuss fiber lasers, which have found extremely important industrial applications. Chapter 10 covers Raman fiber amplifiers, which are playing increasingly important roles in optical communication systems. In Chapter 11 we describe fiber Bragg grating, which is indeed a very beautiful device with numerous practical

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applications. In Chapter 12 we discuss some important fiber optic components, which are an integral part of many devices used in fiber optic communication systems.

When the light power within an optical fiber becomes substantial, the properties of the fiber change due to the high intensity of the light beam. Such an effect, called a nonlinear effect and discussed in Chapter 13, plays a very important role in the area of communication. There is also considerable research and development (R & D) effort to utilize such effects for signal processing of optical signals without converting them into electronic signals. Such an application should be very interesting when the speed of communications that use light waves goes up even further as electronic circuits become limited due to the extremely fast response required. Fiber optic sensors, discussed in Chapter 14, form another very important application of optical fibers, and some of the sensors discussed are already finding commercial applications. They are expected to outperform many conventional sensors in niche applications and there is a great deal of research effort in this direction.

In this book we introduce and explain various concepts and effects based on physical principles and examples while keeping the mathematical details to a minimum. The book should serve as an introduction to the field of fiber optics, one of the most important technological revolutions of the twentieth century. If it can stimulate the reader to further reading in this exciting field and help him or her follow developments as they are taking place, with applications in newer areas, it will have served its purpose.