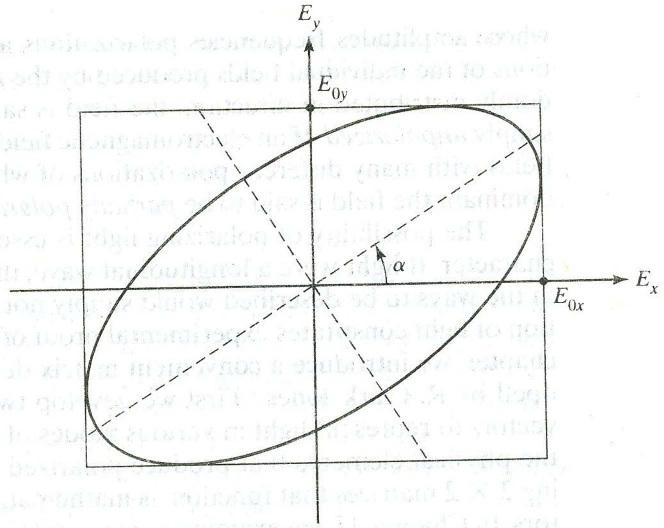

14 Matrix Treatment of Polarization

INTRODUCTION

The polarization of an electromagnetic wave was introduced in Chapter 4. There we noted that the *direction of the electric field vector* $\vec{\mathbf{E}}$ is known as the *polarization* of the electromagnetic wave. In this and the following chapter we extend our discussion of the properties and production of polarized light. As we noted in Chapter 4, the electric field associated with a plane monochromatic electromagnetic wave is perpendicular to the direction of the propagation of the energy carried by the wave. The same can be said of the magnetic field vector, which also maintains an orientation perpendicular to the electric field vector such that the direction of $\vec{\mathbf{E}} \times \vec{\mathbf{B}}$ is everywhere the direction of wave propagation. In general, plane monochromatic waves are *elliptically polarized*, in the sense that, over time, the tip of the electric field vector in a given plane perpendicular to the direction of energy propagation traces out an ellipse. Special cases of electromagnetic waves with elliptical polarization include *linearly polarized* waves in which the electric field vector always oscillates back and forth along a given direction in space and *circularly polarized* waves in which, over time, the tip of the electric field vector traces out a circle. These special cases are shown in Figure 4-12 and are worth reviewing. Monochromatic plane waves are idealized models of the electromagnetic waves produced by, for example, laser sources or a distant single-dipole oscillator. Any electromagnetic wave can be regarded as a superposition of plane electromagnetic waves with various frequencies, amplitudes, phases, and polarizations. "Ordinary" light, such as that produced by a hot filament, is typically produced by a number of independent atomic sources whose radiation is not synchronized. The resultant $\vec{\mathbf{E}}$-field vector consists of many components