I. The Nature of Light

Spectrochemical Analysis: Sections 1-1, 3-2
Optics: Sections 2.2, 2.3, 3.2
Instrumental Analysis: Sections 6B, 6B-1, 6B-3, 6C-1
Quantitative Chemical Analysis: Section 19-1

There are two equally useful descriptions of electromagnetic radiation (EMR): the classical, or wave theory, of light and the quantum or particle theory of light. Fortunately, accurate descriptions of spectroscopic events can be based on a semi-classical viewpoint: material properties are described quantum mechanically while radiation is viewed classically. Of course, this strict demarcation has its limits; it is convenient to consider light absorbed and emitted by materials in packets.

In the classical view, EMR traveling (propagating) in a vacuum is described by wave equations derived from Maxwell's equations. The wave equations describe the motion of the electric, E, and magnetic, B, fields of EMR:

$$\nabla^2 \mathrm{E} = \left(\frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2} + \frac{\partial^2}{\partial z^2} \right) \mathrm{E} = \frac{1}{\mathrm{c}^2} \frac{\partial^2 \mathrm{E}}{\partial \mathrm{t}^2} \qquad \nabla^2 \mathrm{B} = \frac{1}{\mathrm{c}^2} \frac{\partial^2 \mathrm{B}}{\partial \mathrm{t}^2}.$$

Solutions to these equations are oscillations, hence the name 'the wave equation'. The waves are mutually perpendicular oscillating electric and magnetic fields, perpendicular to the direction of light propagation. True EMR waves are three dimensional entities, but these fields can be represented using single variable expressions: they are written as

$$\mathrm{E}(z,t) = \mathrm{E}_{\max} \cos(\omega t - kz + \phi_o) \qquad \mathrm{B}(z,t) = \mathrm{B}_{\max} \cos(\omega t - kz + \phi_o)$$

To define terms, the wavevector k is $\omega/c = 2\pi/\lambda$, where c is the speed of light in a vacuum, λ is the wavelength of light, and ω is the angular frequency, $2\pi\nu$, where ν is the linear frequency, $\lambda\nu = c$. ϕ_0 represents the initial phase. The following drawing shows a wave that has the electric field polarized in the y-direction and propagates in the z-direction. The magnetic field (not shown) must be polarized in the x-direction, which comes out of the plane of the paper.

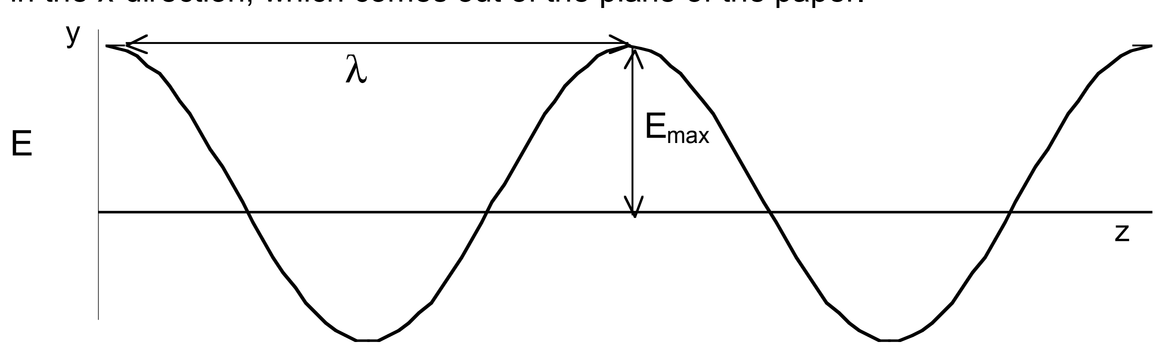

Figure 1:Electric field vector

Ordinarily, light rays consist of a combination of waves vibrating in all the directions perpendicular to its direction of propagation (unpolarized). When the wave oscillates and propagates in a fixed plane, the light is called plane or linearly polarized. Polarized light always can be described as a combination of two orthogonal components. If the light is propagating through free space, horizontal and vertical components are useful reference axes. When the light is propagating across an interface, the orthogonal components are defined relative to the plane of incidence: s-polarized is perpendicular to plane of incidence and p-polarized isparallel to plane of incidence. The phase relationship and relative size of these components define the EMR polarization. If the components have equal lengths and a phase difference of 0^o or 180^o, the resultant is linearly polarized. If the components have equal lengths and a phase difference of 90^o or 270^o, the resultant is circularly polarized. Elliptically polarized light results from other length combinations and/or phase differences.