



FIGURE 1.13 Transitions between the energy levels of a hydrogen atom. The lines L_α , L_β , etc., belong to the Lyman series, B_α , B_β , etc., to the Balmer series, and P_α , P_β , etc., to the Paschen series, and so forth.

and

$$\frac{1}{\lambda_{if}} = R_\infty \left(\frac{1}{n_f^2} - \frac{1}{n_i^2} \right). \quad (1.15)$$

Indeed, the simple expression of Eq. (1.15) is verified by experiment to a high degree of accuracy.

From Eq. (1.14) (or from Fig. 1.13) we note that the spectral lines of hydrogen will form groups depending on the final state of the transition, and that within these groups many common regularities will exist; for example, in the notation of Fig. 1.13

$$\nu(L_\beta) - \nu(L_\alpha) = \nu(B_\alpha).$$

If $n_f = 1$, then

$$\lambda_{i1} = 91.1 \left(\frac{n_i^2}{n_i^2 - 1} \right) \text{ nm} \quad n_i \geq 2$$

and all lines fall in the far ultraviolet; they form the (so-called) Lyman series. Correspondingly if $n_f = 2$, then

$$\lambda_{i2} = 364.4 \left(\frac{n_i^2}{n_i^2 - 4} \right) \text{ nm} \quad n_i \geq 3$$

and all lines fall in the visible part of the spectrum, forming the Balmer series. For $n_f = 3$ the series is named after Paschen and falls in the infrared.

1.5. EXPERIMENT ON THE HYDROGEN SPECTRUM

1.5.1. General

To measure the frequency of the radiation emitted by atoms one can use either a grating or a prism to disperse the different wavelengths. When using a prism, one exploits the variation, with wavelength, of the refractive index of certain media. Prism spectrometers are limited to wavelength regions for which they are able to transmit the radiation; for example, in the infrared, special fluoride or sodium chloride prisms and lenses are used. In the ultraviolet, the optical elements are made of quartz. Also, the sensitivity of the detectors varies with wavelength, so that different types are used in each case (thermopile, photographic emulsion, phototube, etc.).

In this laboratory a small constant-deviation prism spectrograph and a 2-in. reflection grating spectrometer were used. We will consider in detail a measurement of the hydrogen spectrum with the grating, since an absolute value for the wavelengths can be obtained and visual detection is used. A brief discussion of prism spectrographs is given in Section 1.5.4.

From Fig. 1.14, it is evident that the path difference between rays 1 and 2 after reflection is

$$BD - AC = CB \sin \theta_r - CB \sin \theta_i,$$

where CB is the grating spacing d . The angles θ_i and θ_r are both taken as positive when they lie on opposite sides of the normal. Since for constructive interference the path difference must be a multiple of the wavelength, we obtain the condition

$$n\lambda = d (\sin \theta_r - \sin \theta_i). \quad (1.16)$$

It can be shown¹¹ that the resolution of the grating is given by

$$\frac{\lambda}{\Delta\lambda} = nN,$$

where n is the order of diffraction and N the total number of rulings. The same considerations apply to a transmission grating.

¹¹See Chapter 5, Section 5.5.

