MGL’s translation of Balmer’s paper … beginning portion

Based on the measurements by H. W. Vogel and Huggins on the ultraviolet lines of hydrogen spectrum, I tried to find an equation which expresses the wavelengths of the different lines in a satisfactory way, I was encouraged by Mr.Prof. E. Hagenbach. The very precise measurements of Angstrom’s four hydrogen lines make it possible to look for a common factor for their wavelengths that is as close as possible to the wavelength’s simple numerical relationships. So, I succeeded gradually to a formula, which at least for these four Lines can be regarded as the expression of a law, by means of which the wavelengths of which can be represented with surprising accuracy. The common factor for this formula is how it is derived from Angström’s measurements:

(h = 3645.6)

One could call this number the basic number of hydrogen; and if it were to be possible to find the corresponding basic numbers of their spectral lines for other elements as well, then it would be permissible to assume that Between these basic numbers and the corresponding atomic weights there are certain relationships which can again be expressed by some function.

The wavelengths of the first four hydrogen lines result from the fact that the basic number h = 3645.6 followed with the coefficients 9/5; 4/3, 25/21; and 9/8, which it is multiplied. Apparently these four coefficients form no regular series; but as soon as you get the second and the fourth term multiplied by four over four, the regularity is established, and the coefficients have the numerator numbers of 3-squared, 4-squared, 5-squared, 6-squared and a number that is four smaller than the denominator.

For various reasons it is likely that the four coefficients just mentioned belong to two series, so that the second series is the members of the first Row again; and so I get to that To represent the formula for the coefficients more generally as follows: $(m^2 /(m^2 - n^2))$, where m and n are always integers.

For n = 1 we get the series 4/3, 9/8, 16/15, 25/24 etc.,

for n = 2 the series 9/5; 16/12; 25/21; 36/32; 49/45; 64/60; 81/77; 100/96 etc. In this second series, the second term already in the first series, but in a reduced form.

Comments: The equation that Balmer develops is for wavelength and it is based on Angstrom's measurement of the hydrogen spectrum (spark spectrum). The equation can be inverted to compare with the usual representation of E = (Rydberg Constant) * ($1/n^2$ – $1/m^2$) – if one determines a common denominator of n^2 * m^2 and inverts collecting terms gives 1/E = (Rydberg Constant)$^{-1}$ * n^2 * (m^2 / (m^2 – n^2)) – that is, we recover the formula that Balmer proposes and since E = (h * c) / (Wavelength) – where h is Planck's constant and c is the speed of light – we see that the constant that Balmer uses $3645.6\text{x}10^{-10}$ meters is equal to (h * c) * n^2 / (Rydberg Constant) – using known values of h = 6.626 x 10^{-34} meters^2-kgram/sec; c = 2.99792 x 10^8 meters/sec; and Rydberg Constant = 2.1799 x 10^{-18} Joules[kgram-meter^2/sec^2] gives $3646.628\text{x}10^{-10}$ meters which is very close to the value that Balmer used.

Vogel and Huggin's measurements of lines in the UV was from astronomical studies of stars – from Huggin's measurements, the spectrum of hydrogen is extended up to quantum number m=16 – we now know this is the n=16th quantum state decaying to the n=2nd level – The hydrogen spectral series that decays to n=2 is known as the Balmer Series. (The series that decays to n=1 is known as the Lyman Series.)