Question

Zeeman effect: Find the minimum magnetic field needed for the Zeeman effect to be observed in a spectral line of 400 nm wavelength when a spectrometer whose resolution is 0.010 nm is used.

Solution

The separation of the Zeeman components is $\Delta\nu = \dfrac{eB}{4\pi m} \quad \rightarrow \quad B = \dfrac{4\pi m \Delta\nu}{e}$ (see text §6.10) *

$$\begin{aligned}\nu_0 = \frac{c}{\lambda_0} &= \frac{3\times 10^8}{400\times 10^{-9}} \\ &= 7.5\times 10^{14}\end{aligned}$$

$$\begin{aligned}\nu_1 = \frac{c}{\lambda_1} &= \frac{3\times 10^8}{(400\times 10^{-9}) + (0.010\times 10^{-9})} \\ &= \frac{3\times 10^8}{400\times 10^{-9}}\left(\frac{1}{1+.01/400}\right) \\ &\approx 7.5\times 10^{14}(1-2.5\times 10^{-5})\end{aligned}$$

$$\begin{aligned}\Delta\nu &= (7.5\times 10^{14})(2.5\times 10^{-5}) \\ &= 1.875\times 10^{10}\end{aligned}$$

$$\begin{aligned}B &= \frac{4\pi m\Delta\nu}{e} \\ &= \frac{4\pi(9.1095\times 10^{-31})(1.875\times 10^{10})}{1.602\times 10^{-19}} \\ &= 1.339\end{aligned}$$

The minimum magnetic field required is $1.34\ T$

** This is the formula for the normal Zeeman effect where a spectral line splits into just 3 components, lines often split into more components due to the intrinsic angular momentum or 'spin' of an electron. This is discussed in the next chapter.*