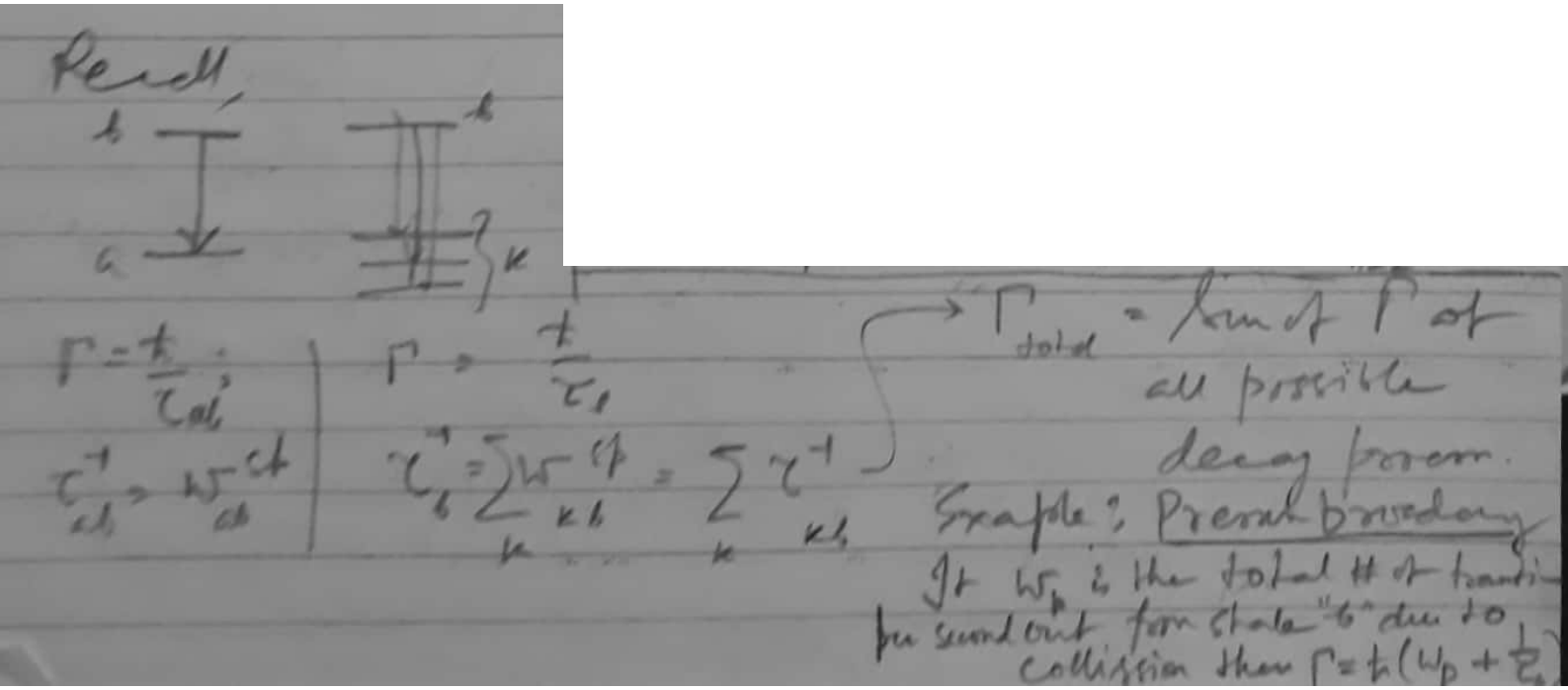
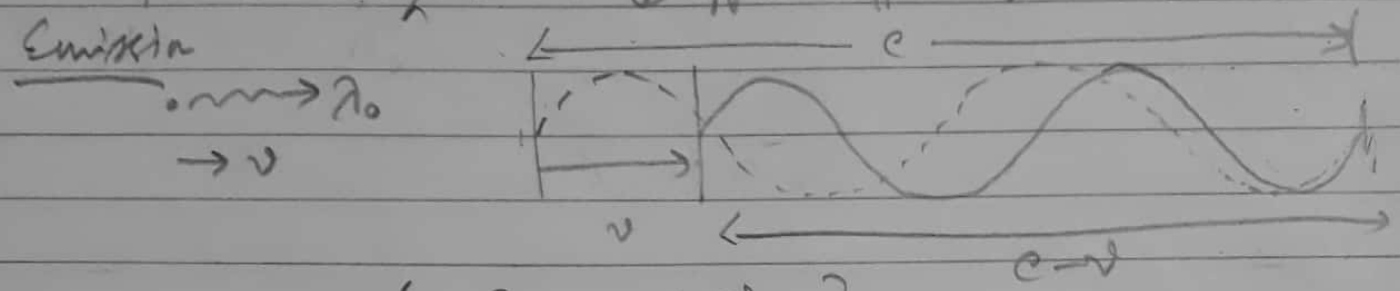
Pressure and thermal broadening



Thermal broadening: in gas phase

Thermal motion of atoms lead to modification of ω of the emitted (λ as well as radiated light) due to Doppler effect:

Emission



$$\therefore \frac{\lambda}{\lambda_0} = \frac{c-\nu}{c}$$

$$\Rightarrow \frac{\lambda}{\lambda_0} = \frac{c+\nu}{c}$$

$$\left.\begin{aligned} \lambda &= \lambda_0\left(1 \mp \frac{\nu}{c}\right) \\ \omega &= 2\pi\frac{c}{\lambda} = \frac{2\pi c}{\lambda_0\left(1 \mp \frac{\nu}{c}\right)} \end{aligned}\right\}$$

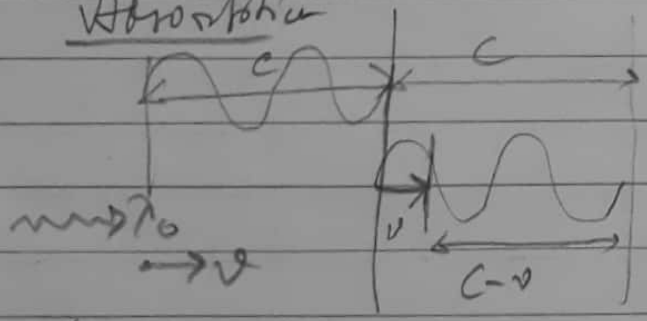
$$= \frac{\omega_0}{\left(1 \mp \frac{\nu}{c}\right)}$$

$$\simeq \omega_0\left(1 \pm \frac{\nu}{c}\right)$$

$+$ for $\hat{k} \parallel \hat{\nu}$

$-$ for $\hat{k} \parallel -\hat{\nu}$

Absorption



$$\Rightarrow \nu = \left(\frac{\omega-\omega_0}{\omega_0}\right)(\pm c)$$

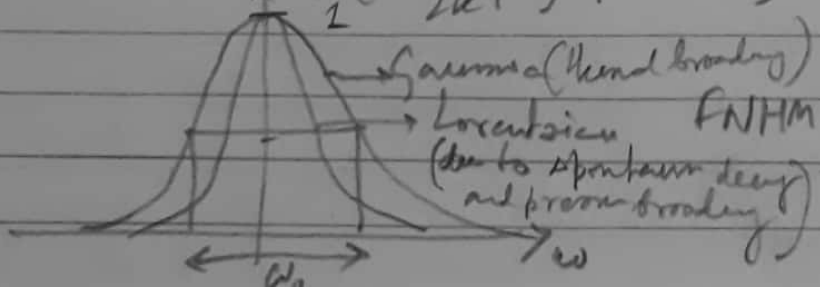
$$= \pm c\left(\frac{\omega-\omega_0}{\omega_0}\right)$$

$$dN(\nu) = N_0 \exp\left(-M\nu^2/2kT\right) d\nu$$

$N(\nu+d\nu) - N(\nu)$

N_0: spec $\nu = 0$

$$\Rightarrow I(\nu) = I(\nu=0)\exp\left(-\frac{M\nu^2}{2kT}\right) = I(\omega_0)\exp\left[-\frac{Mc^2}{2kT}\frac{(\omega-\omega_0)^2}{\omega_0^2}\cdots\right]$$



FWHM $\Delta\omega = \frac{2\omega_0}{c}\left[\frac{2kT\ln 2}{M}\right]^{1/2}$