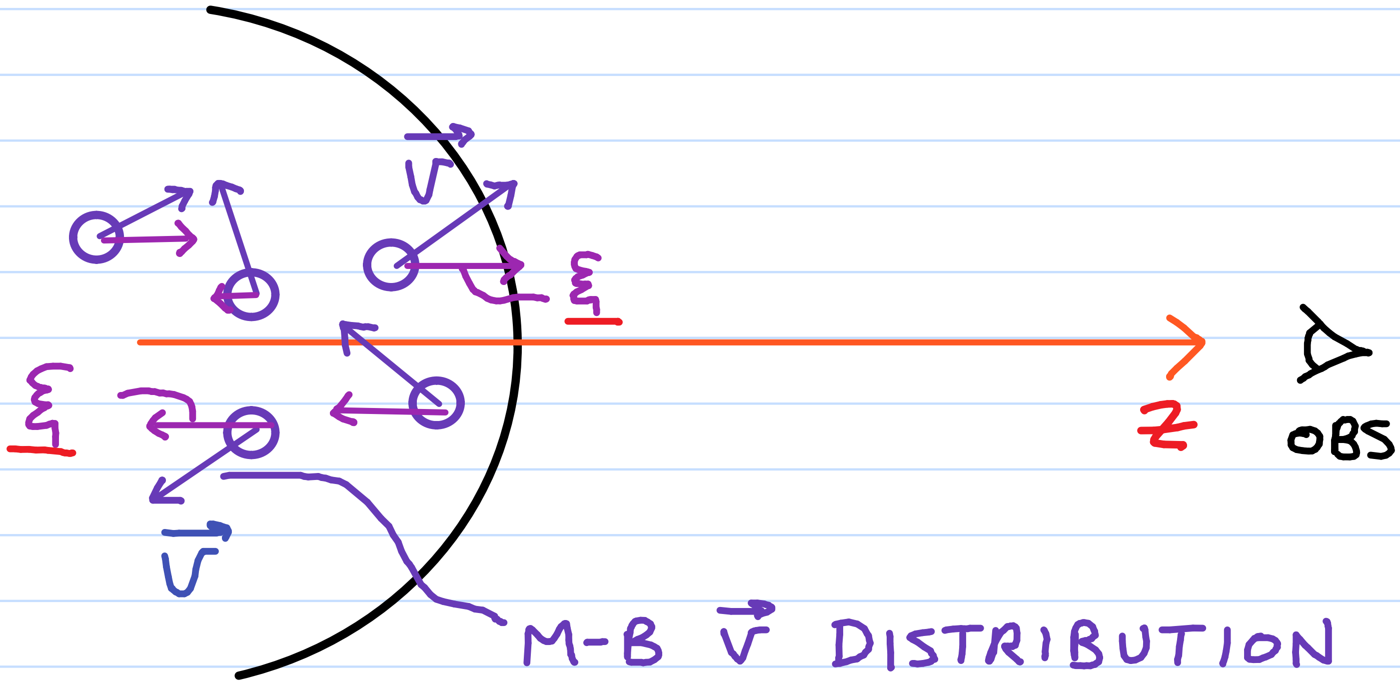
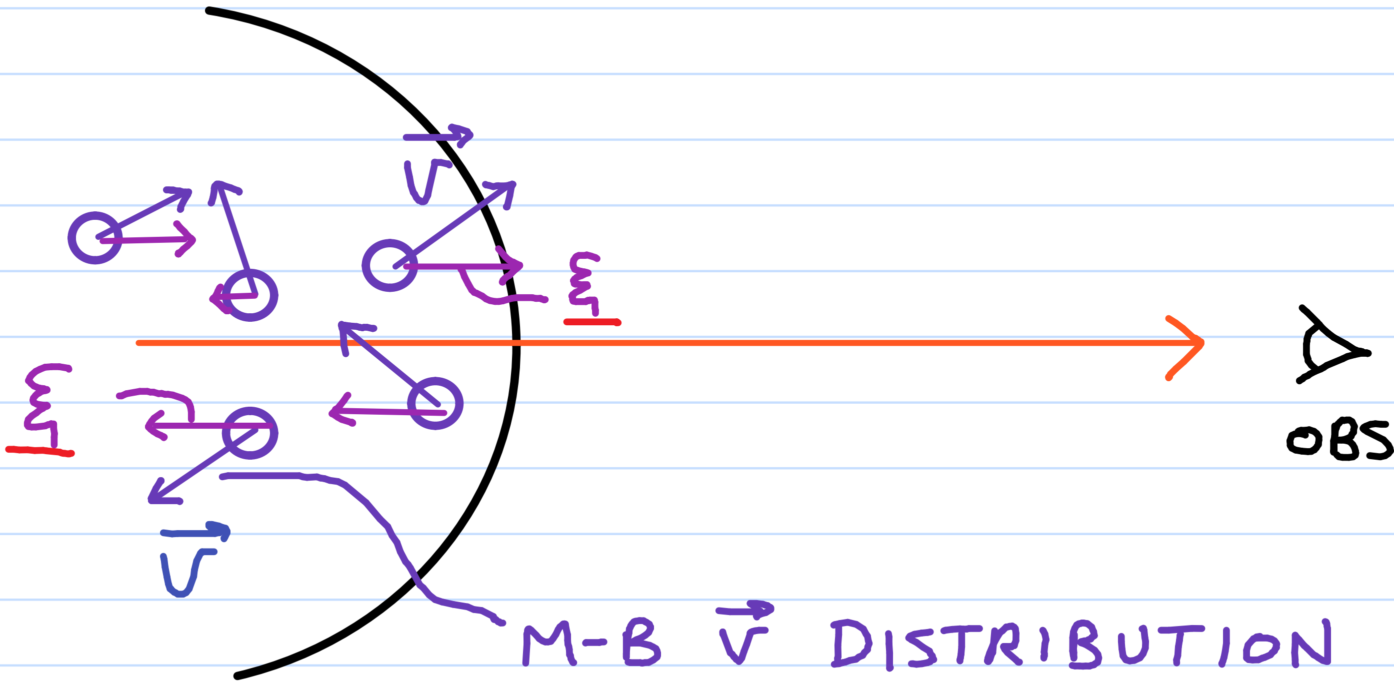
THERMAL LINE BROADENING:



ENSEMBLE OF ABSORBERS
BROADENS LINE

→ ASCRIBE EFFECT TO A
REPRESENTATIVE ATOM

NO NET ϕ_ν SHIFT: $\Delta\nu_0 = 0$



IN ATOM'S REST FRAME ($'$):

- RADIATION & COLLISIONAL DAMPING ONLY:

$$\phi^{*}_{\nu'}(\nu'-\nu_0') = \frac{\gamma/4\pi^2}{(\nu'-\nu_0')^2 + (\gamma/4\pi)^2}$$

$$\rightarrow \gamma = \gamma^R + \gamma^C$$

IN STAR'S REST FRAME :

$$\frac{\Delta\nu}{\nu'} \equiv \frac{\nu - \nu'}{\nu'} = \frac{\xi}{c}$$

$\rightarrow \therefore \xi > 0 \Rightarrow \Delta\nu > 0$

$\rightarrow$ NO NET ϕ_ν SHIFT : $\nu_0' = \nu_0$

$\rightarrow$ FWHM $= \frac{\gamma}{2\pi}$ SMALL $\therefore \nu' \approx \nu_0'$

$$\therefore \frac{\xi}{c} = \frac{\nu - \nu'}{\nu_0}$$

$\therefore$ TRANSFORMATION : $\nu' \approx \nu - \nu_0 \frac{\xi}{c}$

$\therefore$ FOR SINGLE ATOM:

$$\phi^*_{\nu'}(\nu' - \nu_0') = \phi^*_\nu\left(\left(\nu - \frac{\xi \nu_0}{c}\right) - \nu_0\right)$$

∴ FOR ENSEMBLE IN STAR'S FRAME:

$$\phi_\nu(\nu-\nu_0) = \int_{\xi=-\infty}^{\infty} \underbrace{\phi_\nu^*\left(\left(\nu - \frac{\xi\nu_0}{c}\right) - \nu_0\right)}_{\text{LORENTZIAN}} \underbrace{\frac{n_\xi(\xi)}{N}}_{\text{1D M-B DIST}} \, d\xi$$

$$\frac{n_\xi(\xi)\, d\xi}{N} = \frac{1}{\xi_0\sqrt{\pi}} e^{-\xi^2/\xi_0^2} \, d\xi$$

- AREA-NORMALIZED GAUSSIAN

$$- \xi_0 \equiv \bar{\xi} = \sqrt{\frac{2kT_{KIN}}{m}}$$

$$\therefore \text{FWHM} = 2\xi_0\sqrt{\ln 1/2}$$

DOPPLER WIDTH, $\Delta\nu_D \equiv \frac{\xi_0 \nu_0}{c}$

$$= \frac{\nu_0}{c}\sqrt{\frac{2kT_{KIN}}{m}}$$

$$\therefore \phi_\nu(\nu-\nu_0) \equiv \phi_\nu(\Delta\nu) =$$

$$\frac{1}{\sqrt{\pi}\,\Delta\nu_D}\int_{\nu'=0}^{\infty} \frac{(\gamma/4\pi^2)\, e^{-(\Delta\nu/\Delta\nu_D)^2}}{(\nu'-\nu_0)^2 + (\gamma/4\pi)^2}\, d\nu'$$

- VOIGT fn

$$\therefore \phi_\nu(\nu-\nu_0) =$$

$$\frac{1}{\sqrt{\pi}\,\Delta\nu_D} e^{-(\Delta\nu/\Delta\nu_D)^2} * \frac{\gamma/4\pi^2}{(\nu'-\nu_0)^2 + (\gamma/4\pi)^2}$$

- VOIGT fn

VOIGT fn, USEFUL FORM:

$$\phi_\nu(v) = \frac{H(a,v)}{\sqrt{\pi}\,\Delta\nu_D}$$

$$\rightarrow H(a,v) \equiv \frac{a}{\pi}\int_{y=-\infty}^{\infty} \frac{e^{-y^2}}{(v-y)^2 + a^2}\,dy$$

$$\rightarrow a \equiv \frac{\gamma}{4\pi\,\Delta\nu_D}$$

$\therefore\ \gamma^R + \gamma^C \gg \xi_0$

$\rightarrow$ LARGE a

OR $\gamma^R + \gamma^C \ll \xi_0$

$\rightarrow$ SMALL a

$$\rightarrow v \equiv \frac{\Delta\nu}{\Delta\nu_D}$$

$-\ v < 1 \Rightarrow$ IN CORE

$v \gg 1 \Rightarrow$ IN WING

$$\left(y \equiv \xi/\xi_0\right)$$

CONTRIBUTION OF MICROTURBULENCE:

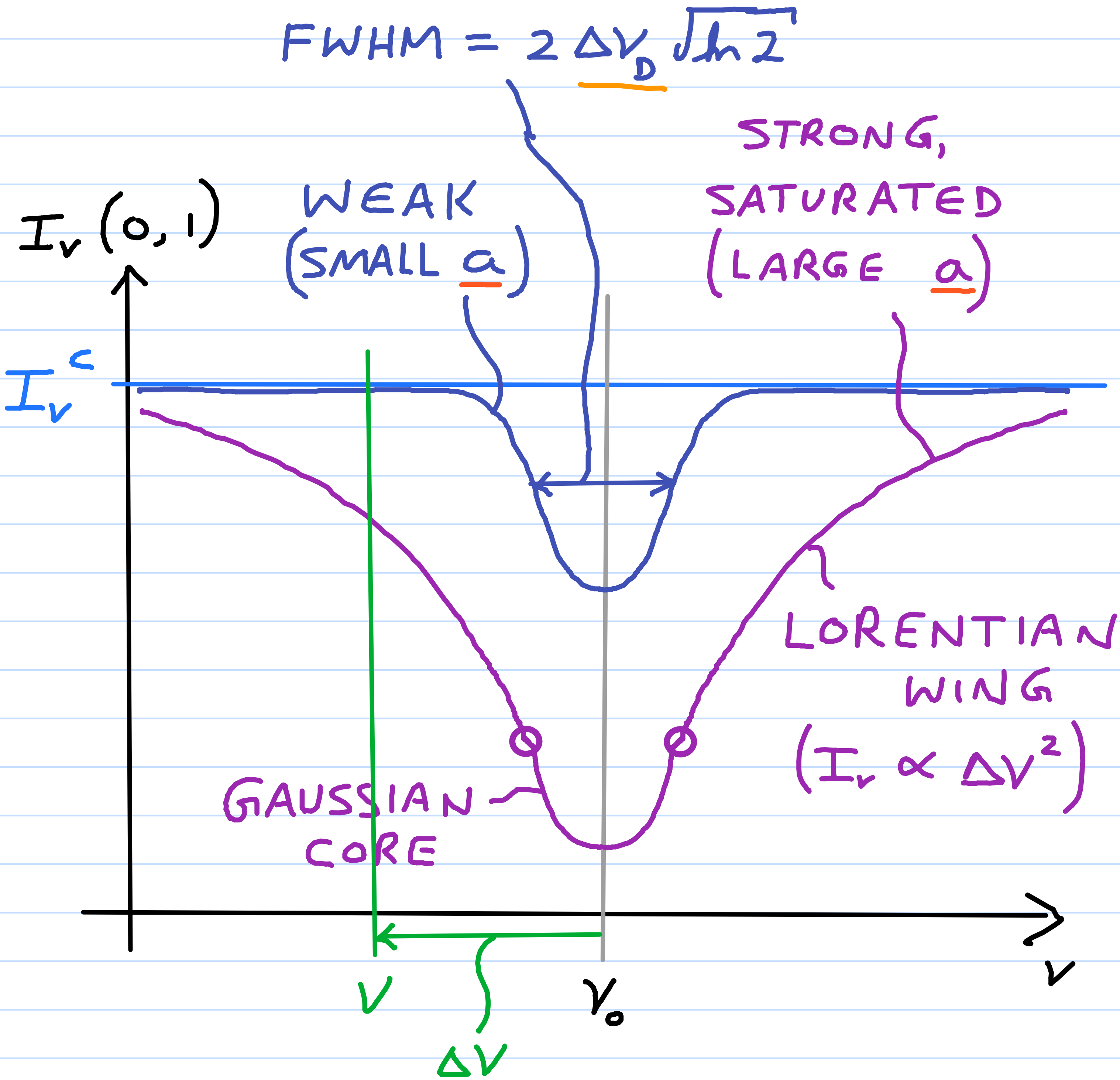
$$\Delta\nu_D = \left(\frac{\xi_0 + \xi_T}{c}\right)\nu_0$$

RECALL:

- ξ_T = MICROTURB. v DISPERSION
  - AN INPUT PARAMETER

NORMALLY: $\xi_T \gtrsim \xi_0$

VOIGT LINE PROFILES:



WEAK LINE: $\alpha_\nu^l / \alpha_\nu^c$ SMALL

STRONG LINE: $\alpha_\nu^l / \alpha_\nu^c$ LARGE