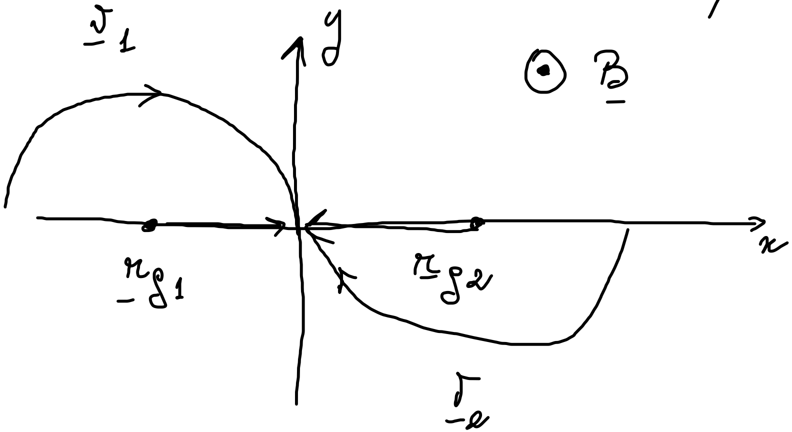
$D \sim r_L^2 \nu$

ii $\quad \cancel{D_{ii} \sim r_{Li}^2 \nu_{ii}}$

Fully ionized same part. collisions do not lead to transport of particles



$$\begin{cases} v_x = v_\perp \cos(\omega_L t - \phi) \\ v_y = -v_\perp \sin(\omega t - \phi) \end{cases}$$

$$\begin{cases} x = x_{gc} + r_L \sin(\omega_L t - \phi) \\ y = y_{gc} + r_L \cos(\omega_L t - \phi) \end{cases}$$

Collision occurs at $\begin{cases} x = 0 \\ y = 0 \end{cases}$ $\Rightarrow$ $\begin{matrix} 0 = x_{gc} + r_L \sin(\omega_L t - \phi) \\ 0 = y_{gc} + r_L \cos(\omega_L t - \phi) \end{matrix}$

$$\Rightarrow \begin{cases} x_{gc} = -r_L \sin(\omega_L t - \phi) \\ y_{gc} = -r_L \cos(\omega_L t - \phi) \end{cases}$$

$$\underline{r}_{g\,1,2} = -r_L \sin(\omega_L t - \phi)\,\hat{\underline{i}} - r_L \cos(\omega_L t - \phi)\,\hat{\underline{j}}$$

$$= \frac{1}{\omega_L} v_y \hat{\underline{i}} - \frac{1}{\omega_L} v_x \hat{\underline{j}} = \frac{\underline{v}_{1,2} \times \hat{\underline{e}}_z}{\omega_L}$$

$$r_L / v_\perp = \frac{m v_{\cancel{\perp}}}{qB} \frac{1}{\cancel{v_\perp}} = \omega_L^{-1}$$

$$\underline{v} = v_x \hat{\underline{i}} + v_y \hat{\underline{j}} \qquad \underline{v} \times \hat{\underline{k}} = (v_x \hat{\underline{i}} + v_y \hat{\underline{j}}) \times \hat{\underline{k}} =$$

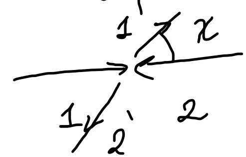
$$= -v_x \hat{\underline{j}} + v_y \hat{\underline{i}} \qquad \underline{v}_{rel} = \underline{v}_1 - \underline{v}_2$$

$$\underline{r}_{g\,1,2} = \frac{\underline{v}_{1,2} \times \hat{\underline{k}}}{\omega_L} \qquad \underline{v}_{cm} = \frac{m_1 \underline{v}_1 + m_2 \underline{v}_2}{m_1 + m_2} \underset{m_1 = m_2}{=} \frac{\underline{v}_1 + \underline{v}_2}{2}$$

$$\underline{v}_2 = \underline{V}_{cm} - \underline{v}_{rel}/2$$

$$\underline{v}_1 = \underline{V}_{cm} + \underline{v}_{rel}/2$$

c.m. frame



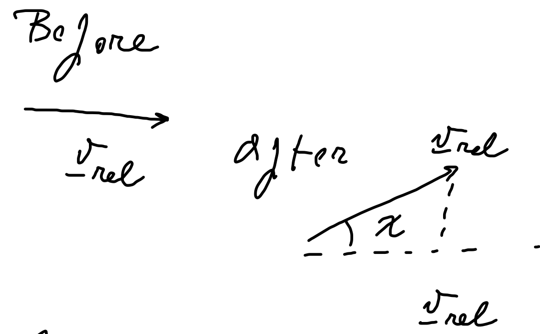
In c.m. frame $\underline{V}_{cm}$ is unchanged

$\underline{v}_{rel}$ experiences a rotation by an angle χ

$E = \frac{1}{2} M V_{cm}^2 + \frac{1}{2}\mu v_{rel}^2 \underset{\text{c.m. frame}}{=} \frac{1}{2}\mu v_{rel}^2$ $\quad E$ is conserved $\Rightarrow |\underline{v}_{rel}|$ is conserved

': quantities after a collision

$$\underline{v}_{rel}' = \underline{v}_{rel}\cos\chi + \hat{\underline{k}}\times\underline{v}_{rel}\sin\chi$$



We can now evaluate

$$\underline{v}_1' = \underline{V}_{cm} + \frac{\underline{v}_{rel}'}{2} = \underline{V}_{cm} + \frac{1}{2}\left(\underline{v}_{rel}\cos\chi + \hat{\underline{k}}\times\underline{v}_{rel}\sin\chi\right)$$

$$\underline{v}_2' = \underline{V}_{cm} - \frac{\underline{v}_{rel}'}{2} = \underline{V}_{cm} - \frac{1}{2}\left(\underline{v}_{rel}\cos\chi + \hat{\underline{k}}\times\underline{v}_{rel}\sin\chi\right)$$

$$\underline{\rho}_1' = \frac{\underline{v}_1'\times\hat{\underline{k}}}{\omega_L} = \frac{1}{\omega_L}\left(\underline{V}_{cm}\times\hat{\underline{k}} + \frac{1}{2}\left(\underline{v}_{rel}\cos\chi + \hat{\underline{k}}\times\underline{v}_{rel}\sin\chi\right)\times\hat{\underline{k}}\right)$$

$$\underline{r}'_{g2} = \frac{\underline{v}'_2 \times \hat{\underline{k}}}{\omega_L} = \frac{1}{\omega_L}\left(\underline{V}_{cm} \times \hat{\underline{k}} - \frac{1}{2}\left(\underline{v}_{rel}\cos\chi + \hat{\underline{k}} \times \underline{v}_{rel}\sin\chi\right) \times \hat{\underline{k}}\right)$$

$$\underline{r}_{cm} = \frac{m_1 \underline{r}_{g1} + m_2 \underline{r}_{g2}}{m_1 + m_2} \underset{m_1 = m_2}{=} \frac{\underline{r}_{g1} + \underline{r}_{g2}}{2} = \frac{(\underline{v}_1 + \underline{v}_2) \times \hat{\underline{k}}}{2\omega_L} = \frac{\underline{V}_{cm} \times \hat{\underline{k}}}{\omega_L}$$

$$\underline{r}'_{cm} = \frac{\underline{r}'_{g1} + \underline{r}'_{g2}}{2} = \frac{1}{\omega_L}\left(\underline{V}_{cm} \times \hat{\underline{k}}\right)$$

$$\boxed{\underline{r}_{cm} = \underline{r}'_{cm}}$$

$D_{\text{identical part.}} = 0$

Collisions between ions and electrons

$$\underline{V}_{cm} = \frac{m_i \underline{v}_i + m_e \underline{v}_e}{m_i + m_e} \qquad \underline{v}_{rel} = \underline{v}_e - \underline{v}_i$$

$$\underline{v}_i = \underline{V}_{cm} - \frac{m_e}{m_i + m_e} \underline{v}_{rel} \qquad \underline{v}_e = \underline{V}_{cm} + \frac{m_i}{m_i + m_e} \underline{v}_{rel}$$

$$\underline{r}_{cm} = \frac{m_e \underline{r}_{\rho e} + m_i \underline{r}_{\rho i}}{m_e + m_i} [\ldots] \qquad \Delta \underline{r}_{\rho cm} = -\frac{1}{\omega_{cr}} \left[(\underline{v}_{rel} \times \underline{\hat{e}}_z)(\cos \underline{\underline{\chi}} - 1) + \underline{v}_{rel} \sin \underline{\underline{\chi}} \right]$$

$$\omega_{cr} = \frac{qB}{\mu} \qquad \mu = \frac{m_i m_e}{m_i + m_e}$$