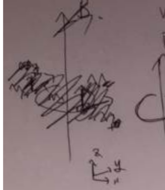


1. We define ~~electron velocity~~ parallel to magnetic flux component of electron velocity as $v_{\parallel}$

Vertical to 〃 as $v_{\perp}$

Then,

$$\frac{1}{2}m(v_{\parallel}^2 + v_{\perp}^2) = \frac{3}{2}kT$$

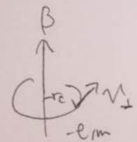
and, if the condition is thermal equilibrium

$$v_{\perp}^2 = v_x^2 + v_y^2, \quad v_{\parallel}^2 = v_z^2$$

$$v_x^2 = v_y^2 = v_z^2$$

$$\therefore v_{\perp}^2 = 2v_{\parallel}^2 = \frac{2kT}{m}$$

$$\therefore |v_{\perp}| = \sqrt{\frac{2kT}{m}}, \quad |v_{\parallel}| = \sqrt{\frac{kT}{m}}$$



Second, we think about circular motion

$$e v_{\perp} B = m v_{\perp} \omega_c$$

$$\therefore \omega_c = \frac{eB}{m}$$

$$T_c = \frac{2\pi}{\omega_c} = 2\pi \frac{m}{eB}$$

Due to $\tau \gg \frac{m}{Be} \sim T_c$,

we can suppose r_c (radius of circular motion) as one lap.

2

So,

$$m \cdot \frac{dv_{\perp}}{dt} = e \cdot \frac{1}{2\pi r_c} \cdot \frac{d\Phi}{dt}$$

$$= e \cdot \frac{1}{2\pi r_c} \cdot \pi r_c^2 \cdot \frac{dB}{dt}$$

$$\therefore \frac{dv_{\perp}}{dt} = \frac{e r_c}{2m} \cdot \frac{dB}{dt}$$

Now,

$$e v_{\perp} B = m \frac{v_{\perp}^2}{r_c}$$

$$\therefore eB = m \frac{v_{\perp}}{r_c}$$

$$\therefore \frac{e r_c}{m} = \frac{v_{\perp}}{B}$$

$$\therefore \frac{dv_{\perp}}{dt} = \frac{v_{\perp}}{2B} \cdot \frac{dB}{dt}$$

$$\therefore \frac{dv_{\perp}}{v_{\perp}} = \frac{1}{2} \cdot \frac{dB}{B}$$

$$\therefore \int \frac{dv_{\perp}}{v_{\perp}} = \frac{1}{2} \cdot \int \frac{dB}{B}$$

$$\therefore \ln v_{\perp} = \frac{1}{2} \ln B + C_1$$

$$\therefore v_{\perp}^2 = C_2 \cdot B$$

(C_1, C_2: Constant)

And, in this period, $v_{\parallel}$ is constant because no parallel force is worked.

(and, due to $t \gg \tau \gg T_c$, we don't need to think effect of collisions)

3

$T = T_0$

$$|v_{\perp,1}| = \sqrt{\frac{2kT_0}{m}}$$

$$|v_{\parallel,1}| = \sqrt{\frac{kT_0}{m}}$$

$B: B_0 \to 2B_0$

$v_{\parallel}$ is constant

$$\frac{v_{\perp,1}^2}{B_0} = \frac{v_{\perp,2}^2}{2B_0}$$

$$|v_{\perp,2}| = \sqrt{\frac{4kT_0}{m}}$$

$$|v_{\parallel,2}| = \sqrt{\frac{kT_0}{m}}$$

$T (\gg \tau)$ makes the condition thermal equilibrium state through many collisions.

$$\frac{1}{2}m(v_{\perp,3}^2 + v_{\parallel,3}^2) = \frac{1}{2}m(v_{\parallel,2}^2 + v_{\perp,2}^2)$$

$$= \frac{1}{2}m \cdot \left(\frac{5kT_0}{m}\right)$$

$$\therefore v_{\perp,3}^2 = 2v_{\parallel,3}^2 = \frac{10kT_0}{3m}$$

$$\therefore |v_{\perp,3}| = \sqrt{\frac{10kT_0}{3m}}, \quad |v_{\parallel,3}| = \sqrt{\frac{5kT_0}{3m}}$$

$B: 2B_0 \to B_0$

$v_{\parallel}$ is constant

$$\frac{v_{\perp,3}^2}{2B_0} = \frac{v_{\perp,4}^2}{B_0}$$

$$|v_{\perp,4}| = \sqrt{\frac{5kT_0}{3m}}$$

$$|v_{\parallel,4}| = \sqrt{\frac{5kT_0}{3m}}$$

4

As a result

$$\frac{3}{2}kT' = \frac{1}{2}m(v_{\perp,4}^2 + v_{\parallel,4}^2)$$

$$= \frac{1}{2}m\left(\frac{5kT_0}{3m} + \frac{5kT_0}{3m}\right)$$

$$= \frac{5}{3}kT_0$$

$$\therefore T' = \frac{10}{9}T_0$$