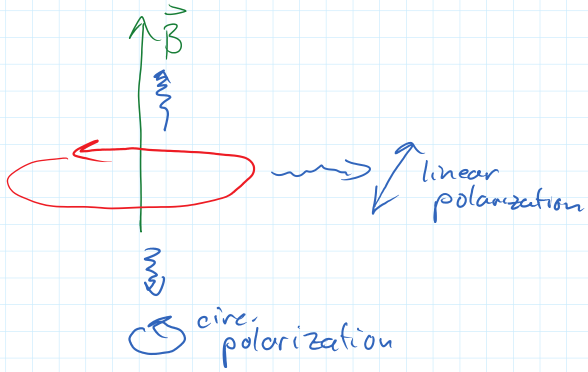
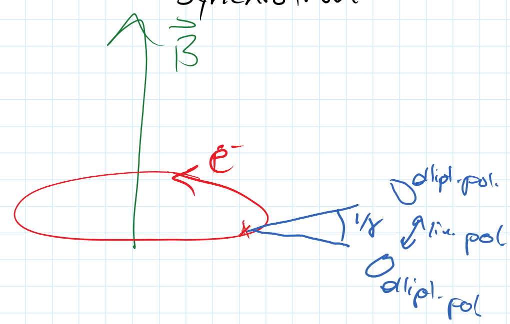
Because e^-'s motion is restricted by B-field, emission is coherent & likely to be polarized.

Unbeamed / Cyclotron



Synchrotron



In synchrotron, rad'n is strongly beamed in the forward moving direction, so all the polarizations are squeezed into the cone of width $\sim 1/\gamma$. In the center of the pulse, the pol. is linear w/ an orientation normal to the projected $\vec{B}$-field. Off center, there is some elliptical pol.

<u>But</u>, w/ an ensemble of e^- present, the circ. pol. will cancel b/c of the contributions from e^- on either side of the emission cone.

$\therefore$ predict a high degree of linear pol.

$\therefore$ pol. vector use observationally to measure B-field orientations

For uniform fields & power-law dist'n of e^- energies:

$$\text{Pol. fraction} = \frac{p+1}{p+7/3} \rightarrow 72\% \text{ for } p = 2.5$$

More typically, the field will have a turbulent/random

component which reduces fract ≃ few %.
But, detection of lin. pol. is strong evidence for synchrotron

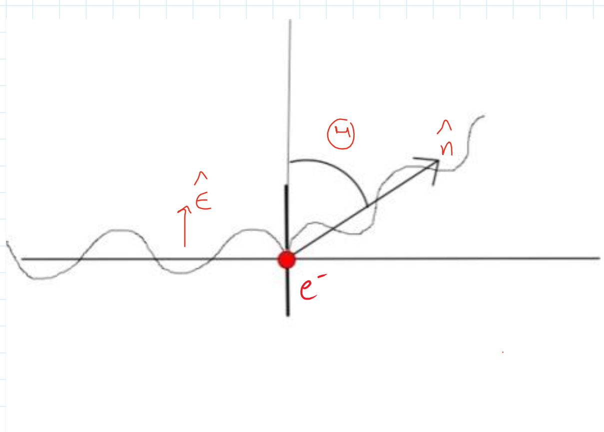
Synchrotron Self-Absorption

At low ν, synchrotron radiation can be absorbed by the very e^- that are emitting. Happens irrespective of e^- spectrum.
Can show that $\alpha_\nu \propto B^{(p+2/2)} \nu^{-(p+4)/2}$
When the gas is optically thick, $F_\nu \propto \frac{\alpha_\nu}{j_\nu} \propto \nu^{5/2} B^{-1/2}$ (indp. of p)

The turnover freq. is normally too small to be seen in astrophysics unless density is very high.

Thomson Scattering

Once emitted, radiation can be re-distributed & altered by interacting w/ charged particles. Consider the e^- scattering of an incident, linearly polarized E-M wave



If the charge oscillates w/ $v \ll c$ then $\frac{e}{c}\vec{v}\times\vec{B} \ll e\vec{E}$ since $|E| = |B|$ for an EM wave.

Then the e.o.m. of the

Charge is $m\ddot{\vec{r}} = e\hat{\epsilon} E_0 \sin\omega_0 t$ where e = charge

The dipole moment $\vec{d} = e\vec{r}$ so $\ddot{\vec{d}} = e\ddot{\vec{r}} = \frac{e^2}{m} E_0 \hat{\epsilon} \sin\omega_0 t$

Oscillating dipole, so power emitted/solid angle

$$\frac{dP}{d\Omega} = \frac{\ddot{\vec{d}}^{\,2} \sin^2\Theta}{4\pi c^3} = \frac{e^4 E_0^2}{4\pi c^3 m^2} \sin^2\omega_0 t \sin^2\Theta$$

Time average over a cycle $\langle \sin^2\omega t \rangle = \frac{1}{2}$

$$\rightarrow \left\langle \frac{dP}{d\Omega} \right\rangle = \frac{e^4 E_0^2}{4\pi c^3 m^2} \sin^2\Theta$$

w/ total time-averaged power $\langle P \rangle = \dfrac{e^4 E_0^2}{3 m^2 c^3}$

freq. indep.