disk-halo interface v. dynamic

<u>But</u> some galaxies (e.g NGC 5746) not enough activity (SNe) to account for their x-ray halos

W10L3

Loads of ICG – intracluster gas

$M_{tot_{ICG}} = 18 \times M_{tot}$ (∀★ in ∀ gals in the cluster)

(!!!)

$M_{tot.}$ (light+DM) > gas mass

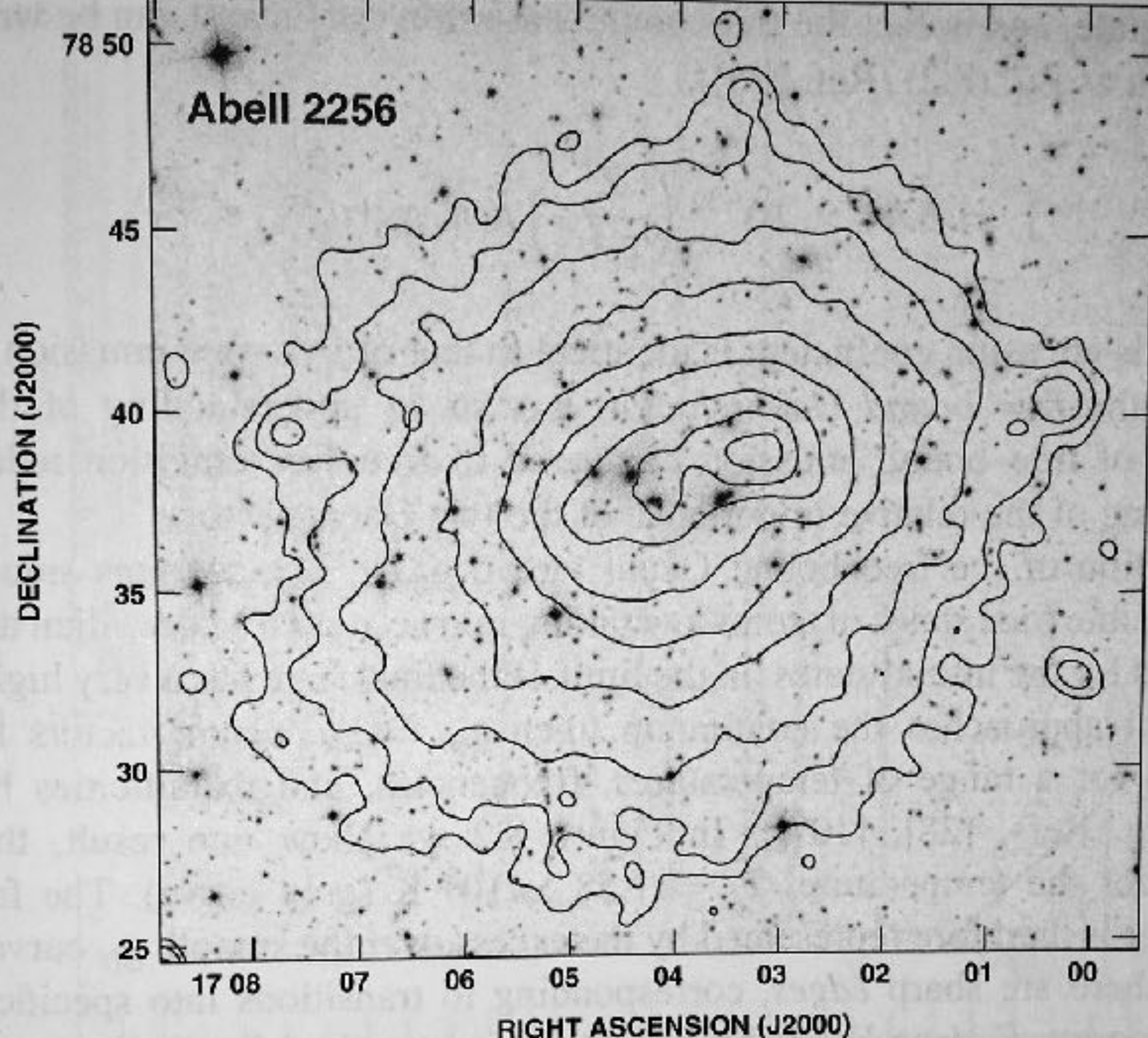


Figure 8.8. The cluster of galaxies, Abell 2256 (redshift, $z = 0.0581$), is shown in the optical (negative grescale) and in X-rays in the observing band, 0.1–2.4 keV (contours). The gas is emitting at $kT_e = 7.5$ keV and the X-ray luminosity is $L_{0.1\rightarrow 2.4} = 3.6 \times 10^{44}$ erg s^{-1} (Ref. [56]), of which 78 per cent is due to thermal Bremsstrahlung (Ref. [22]). The cluster radius is $R = 2.0$ Mpc (Ref. [141]). The total mass of the cluster, including all light and dark matter, is $M = 1.2 \times 10^{15}\ M_\odot$ (Ref. [130]). All values have been adjusted to $H_0 = 71$ km s^{-1} Mpc^{-1}. The optical image is in R band (Reproduced courtesy of the Palomar Observatory-STS$_c$ I Digital Sky Survey, Cal Tech). X-ray data were obtained from the Position Sensitive Proportional Counter (PSPC) of the Röntgen Satellite (ROSAT)

8.3 Free-bound emission (Recombination)

- contamination of X-ray Bremsstrahlung
- ionization equilibrium

  $\text{rate}_i = \text{rate}_{\text{recomb}}$ in HII regions

Here: recombination $\equiv$ emission mechanism

e^- (free) $\longrightarrow$ $\oplus$ (e^-, $b < b_{min}$) captured by nucleus $\Longrightarrow$ $e^- - \oplus$ bound

$\Longrightarrow$ free-bound can only happen in ionized gases

so, free-free (B) & free-bound in same gas also same: emission coefficient

$$j_\nu = 5.44 \cdot 10^{-39} \left(\frac{Z^2}{T_e^{1/2}}\right) n_i n_e \underbrace{g_{fb}}_{\text{free-bound gaunt factor}} (\nu, T_e)\, e^{-\frac{h\nu}{kT_e}}$$

So - to understand

relationship b/w f-f & f-b, study Gaunt-factors.

grey curve is

$g_{ff} + g_{fb}$ for a given T

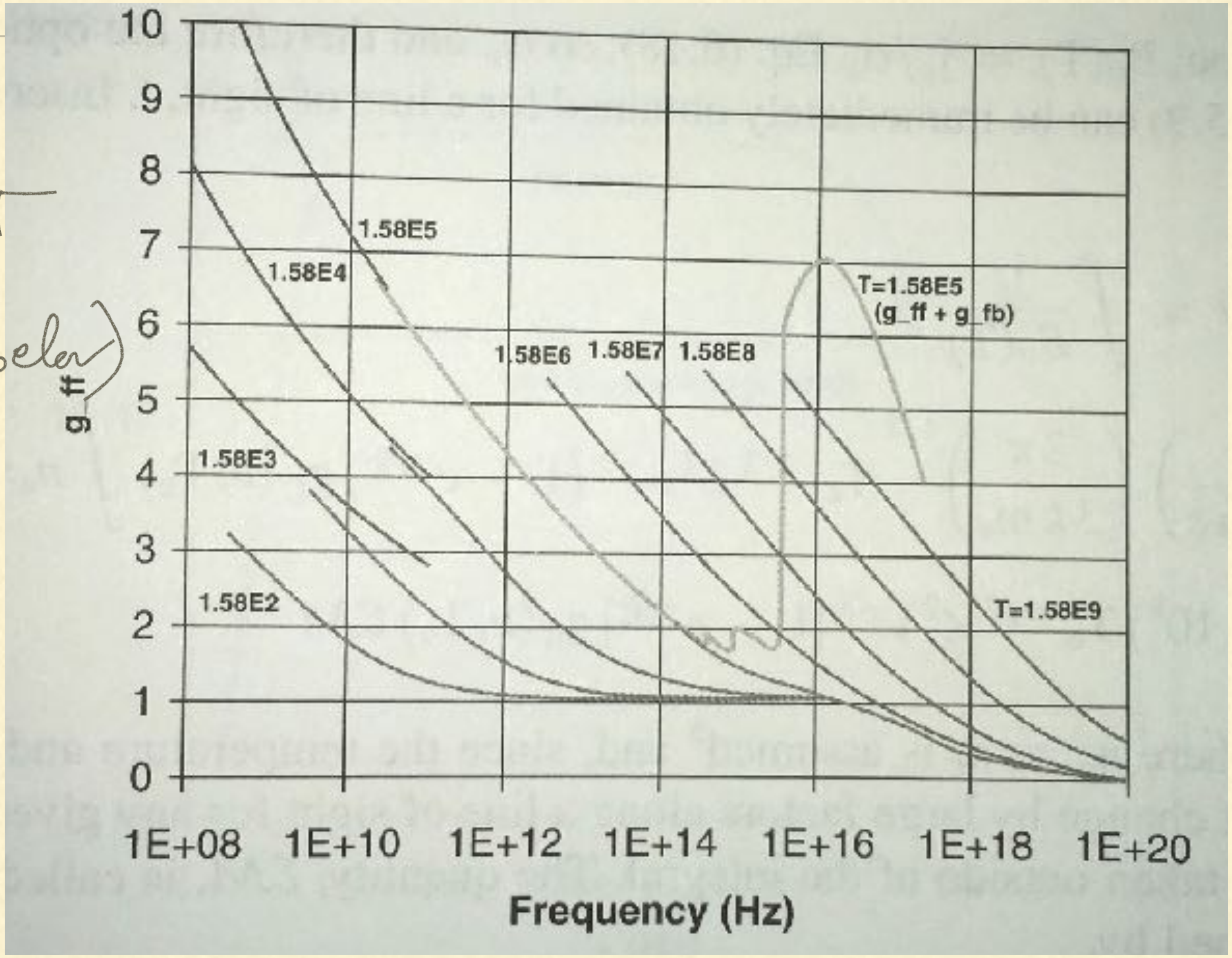
(g_{fb} is excess over curve below)

when ν is low,

$h\nu << k_B T_e$

$g = g_{ff} \Rightarrow$ negligible contribution

$\Rightarrow$ in HII regions and PNe only Bremsstrahlung



For much higher $\nu \Rightarrow e^-$ higher vel $\Rightarrow$ less likely to be captured.

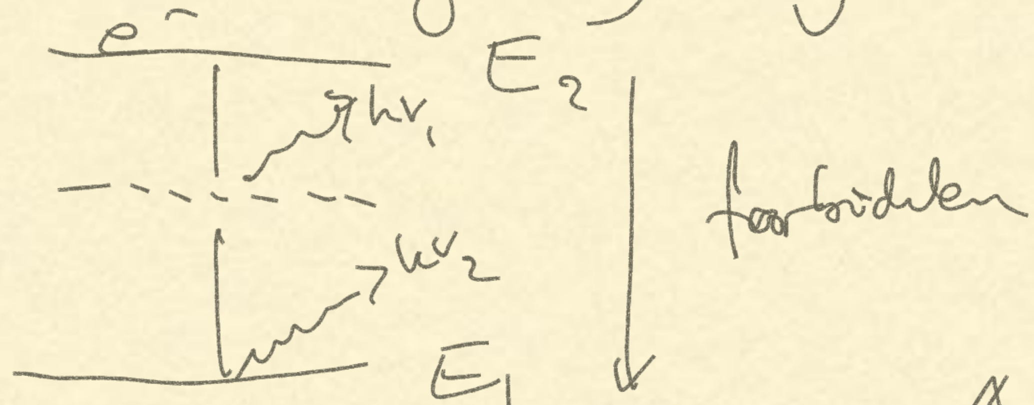
8.4 Two-photon emission

also contributes to continuum emission

bound-bound

e^- can't de-excite b/c transition highly forbidden

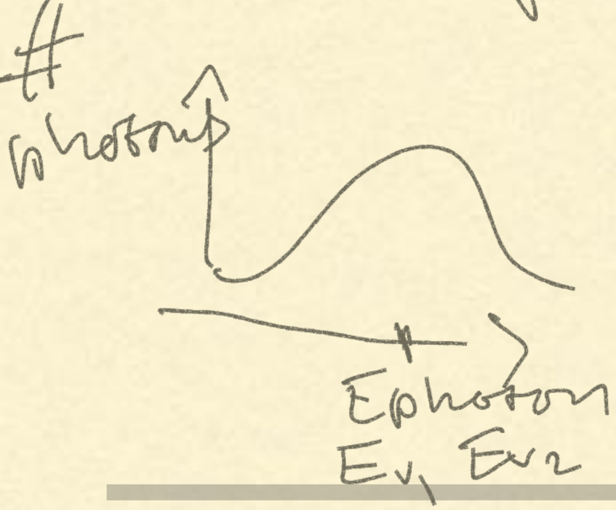
some do anyway by taking a break on the way



The E of the intermediate level varies

$$\Delta E = E_2 - E_1 = h\nu_1 + h\nu_2$$

Same for ν $\quad \nu_1 + \nu_2 = \nu_{Ly\alpha}$



higher probability that both photons will have same energy, same ν

highly ν-dependent, how big contribution to continuum it is depends on ν

Continuum emission

- Thermal : Free-free (Bremsstrahlung)
  - free-bound (recombination)
  - 2-photon
- Non-thermal : cyclotron emission
  synchrotron "
  inverse Compton " (scattering)

Synchrotron is the same as cyclotron, only difference is that v_e are relativistic

$$v_e \to c$$

relativistic e^- — e^- component of CR

See 3.6

$\uparrow B$ strong enough to affect dynamics of particles

cyclotron $v_e \ll c$

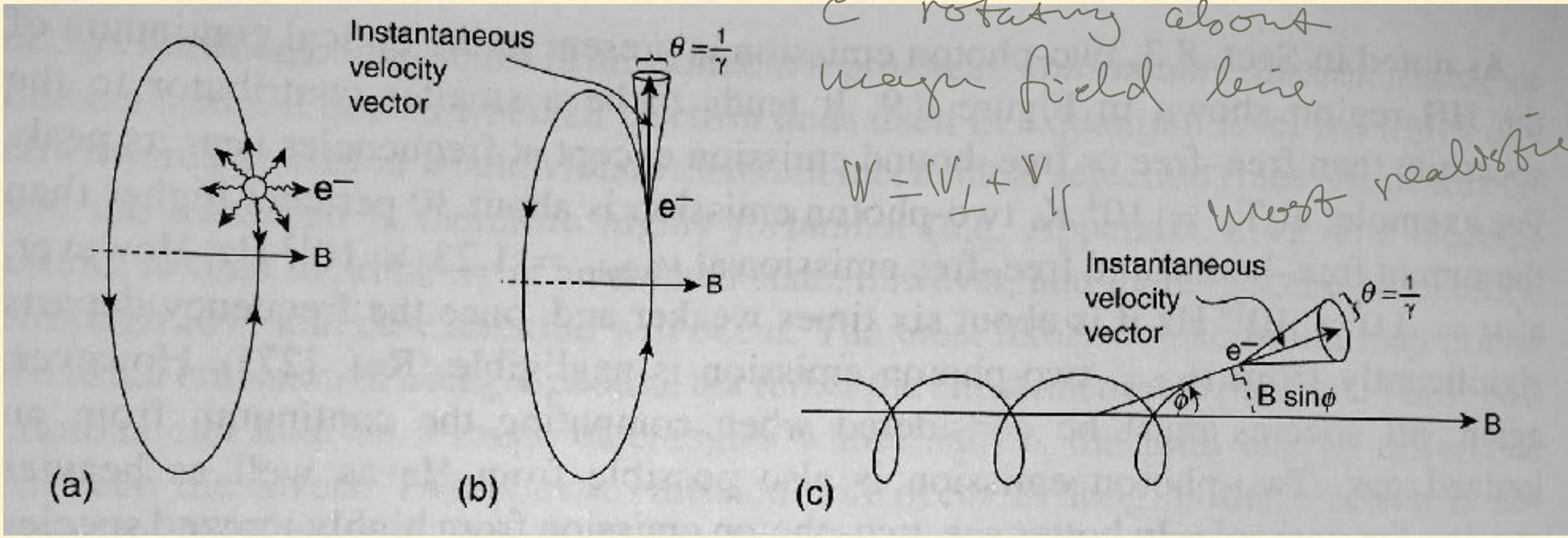
Synchrotron $v_e \to c$

Non-thermal emission so not Maxwell-Boltzmann velocity distribution $\Rightarrow$ no T eq eq.

e⁻ rotating about magn field line

$\mathbb{V} = \mathbb{V}_\perp + \mathbb{V}_\parallel$

most realistic



8.10

a) non-rel e⁻

$\mathbb{V} \perp \mathbb{B}$

$\mathbb{F}$ acting on the e⁻ $\perp$ to both $\mathbb{V}$ & $\mathbb{B}$

⇒ e⁻ circles around field line

⇒ cyclotron rad in every direction

b) Same as a but emission beamed forward into a cone of θ angular radius $= \frac{1}{\gamma}$ γ = Lorentz factor $\frac{1}{\sqrt{1-\frac{v^2}{c^2}}}$

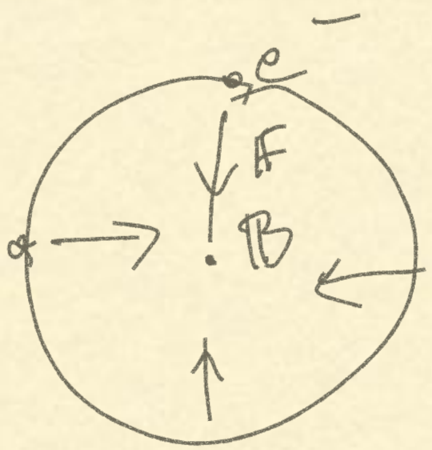
c) add some parallel component to $\mathbb{V}$

⇒ spiral

ϕ = pitch angle = angle b/w $\mathbb{V}$ & $\mathbb{B}$

emitted radiation has frequency of gyration of e^- around $\mathbb{B}$

ν_0 gyrofrequency



v is same

$\mathbb{V}$ direction changes

$\Rightarrow$ acceleration,

$\Rightarrow$ radiation

$$\mathbb{F}_e = \frac{e}{c}\left(\mathbb{V} \times \mathbb{B}\right)$$

(table I 1)

$$F_e = \frac{ev}{c} B \sin\phi = \frac{ev}{c} B_\perp$$

pitch angle

if $\mathbb{V} \perp \mathbb{B} \Rightarrow \sin\phi = 1$ $\mathbb{F}$ max

e^- circling

if parallel $\Rightarrow \sin\phi = 0 \Rightarrow$ no force, no radiation

if any other direction $\Rightarrow$ spiral motion

circular, or circular + linear polarization
depending on position of observer.