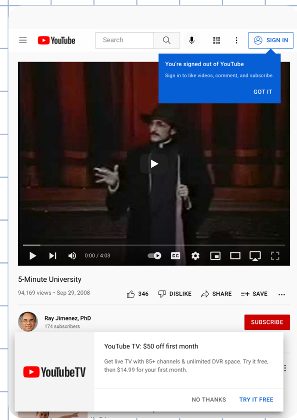
Final Exam

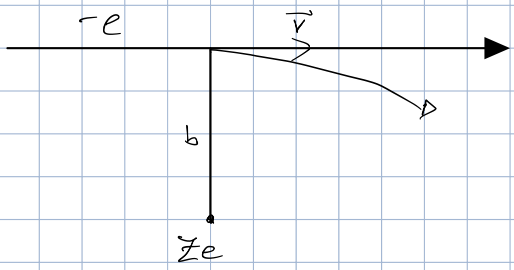
Tuesday Dec. 7th

10-11am

1 sheet of notes (2 sides)



Bremsstrahlung



maxwellian velocity distribution for electrons in thermal emission

integrate to get emission

multiply by Planck $\longrightarrow$ absorption

need to take Fourier Transform of E in e^- frame, what about relativistically?

will look like ion is zipping past

so: fourier transform!

25 minutes in, only drew 1 picture
pls write down this stuff on board
pls @Fausto

26 mins. in, finally something!

e density, ion density, fudge

$$\frac{dW}{d\omega\, dt\, dV} = \frac{16\pi e^6 Z^2}{3\sqrt{3}\, c^3 m^2 v}\, n_e\, n_i \cdot g(v,\omega)$$

Thermal Big Boi B emission

Average single speed expression over a distribution

Thermal distribution

velocity

$$dProb \propto \exp\left[-\frac{E}{kT}\right] d^3\vec{v} = \exp\left[\left(-\frac{mv^2}{2}/kT\right)\right] d^3\vec{v}$$

$$= \exp\left[-\frac{mv^2}{2kT}\right] d^3\vec{v}$$

b/c isotropic distribution: $d^3\vec{v} = 4\pi v^2 dv$

$$dProb \propto 4\pi\, v^2 \exp\left[-\frac{mv^2}{2kT}\right] dv$$

dProb = probability particle has velocity in velocity range $d^3\vec{v}$

min KE needed for $E = h\nu = \frac{1}{2}mv^2$ (frequency)

$\longrightarrow \frac{2h\nu}{m} = v^2$

lower limit of integration $\quad v_{min} = \left(\frac{2h\nu}{m}\right)^{1/2}$

$$\frac{dW(T,\omega)}{dV\, dt\, d\omega} = \frac{\int_{v_{min}}^{\infty} \frac{dW}{d\omega\, dt\, dV}\, v^2 \exp\left[-\frac{mv^2}{2kT}\right] dv}{\int_0^{\infty} v^2 \exp\left[-\frac{mv^2}{2kT}\right] dv}$$

avg of fudge factor

$$= \frac{32}{3}\,\frac{\pi e^6}{mc^3}\left(\frac{2\pi}{3km}\right)^{1/2} T^{-1/2} Z^2 n_e n_i\, e^{\left(-\frac{h\nu}{kT}\right)}\, \bar{g}$$

Thermal Big Boi B Absorption

thermal radiation $\quad j_\nu = \alpha_\nu \underbrace{B_\nu(T)}_{\text{Planck spectrum}}$

spontaneous emission

$$4\pi j_\nu = \frac{dW}{dt\, dV\, d\nu}$$

$$\alpha_\nu = \frac{4e^6}{3mhc}\cdot\left(\frac{2\pi}{3km}\right)^{1/2}\cdot T^{-1/2}\cdot Z^2\, n_e n_i\, \nu^{-3}\left(1 - e^{-\frac{h\nu}{kT}}\right)\bar{g}$$

$h\nu \gg kT$

neglect exponential

$\alpha_\nu \sim \nu^{-3}$

$h\nu \ll kT$ Rayleigh Jeans

$$\alpha_\nu = \frac{4e^6}{3mkc}\left(\frac{2\pi}{3km}\right)^{1/2} T^{-3/2} Z^2\, n_e n_i\, \nu^{-2}\, \bar{g}$$

absorb more in low frequency

$$\frac{dI_\nu}{ds} = -\alpha_\nu I_\nu + j_\nu$$

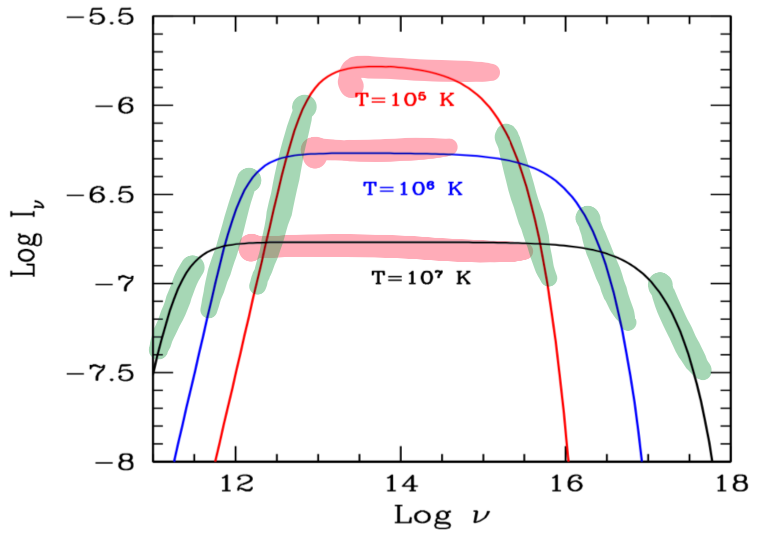


Figure 2.1: The bremsstrahlung intensity from a source of radius $R = 10^{15}$ cm, density $n_e = n_p = 10^{10}$ cm^{-3} and varying temperature. The Gaunt factor is set to unity for simplicity. At smaller temperatures the thin part of I_ν is larger ($\propto T^{-1/2}$), even if the frequency integrated I is smaller ($\propto T^{1/2}$).

Not assuming Blackbody

flat - optically thin

steep - optically thick

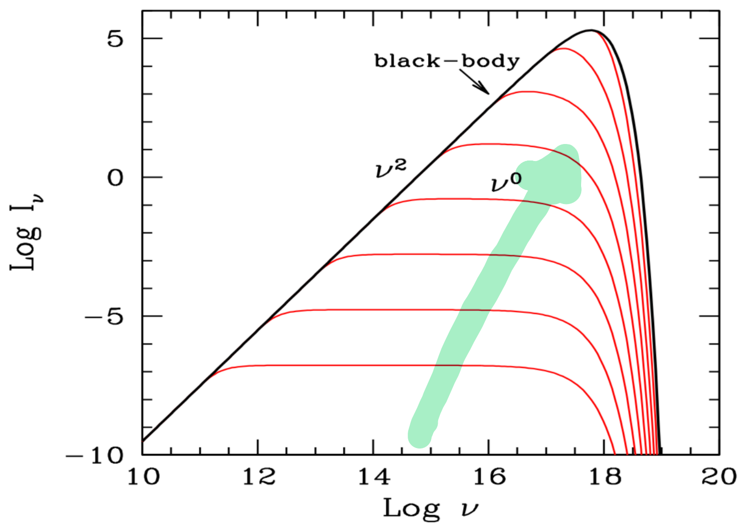


Figure 2.2: The bremsstrahlung intensity from a source of radius $R = 10^{15}$ cm, temperature $T = 10^7$ K. The Gaunt factor is set to unity for simplicity. The density $n_e = n_p$ varies from 10^{10} cm^{-3} (bottom curve) to 10^{18} cm^{-3} (top curve), increasing by a factor 10 for each curve. Note the self–absorbed part ($\propto \nu^2$), the flat and the exponential parts. As the density increases, the optical depth also increases, and the spectrum approaches the black–body one.

increasing density

gets optically thicker & thicker

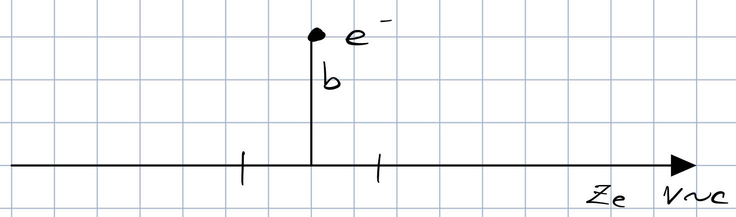
10:30 → analysis, rewatch

Blackbody depends only on T, not density

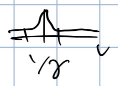
infinitely thin surface

Relativistic electron passing a stationary (K frame) ion

in electron frame (K' frame) now moves relativistically past electron



looks like a pulse to e^-



same as Thompson scattering

need to account for $\vec{F} \neq m_0 \vec{a}$, need 4 vectors :(

need Compton to do Thompson

still gonna do it b/c fuck it