Lecture Notes 12/06/16

Review:

Boltzmann: n(E…E+ΔE) = $\frac{g(E)\Delta E}{e^{(E-\mu)/kT}}$

Normalize: $\int_0^\infty n(E)dE = N_{tot}$ to determine $\mu$

Fermi-Dirac: n(E…E+ΔE) = $\frac{g(E)\Delta E}{e^{(E-\mu)/kT}+1}$

For Spin{ ½, $\frac{3}{2}$, …}

Bose-Einstein: n(E…E+ΔE) = $\frac{g(E)\Delta E}{e^{(E-\mu)/kT}-1}$

For Spin{0,1,…}

<u>The Sun-Thermodynamics:</u>

-What will you find in the space immediately surrounding the Sun? …Photons!

Remembering that Photons are gauge Bosons with spin1 (z-projection +/-1 but 0 only for virtual photons) and P=$\frac{\hbar}{\lambda}$ E=$\frac{\hbar c}{\lambda} = h\nu$

**λ=wavelength**v=frequency**ħ=Planck's constant(h)/2π**

Now, we can use the Bose-Einstein equation to find the density of photons n(E…E+ΔE) in a Volume of space at a certain temperature(T).

Plugging in for the energy of a photon and accounting for the spin, we get:

$$n(E\ldots E+\Delta E) = \frac{(4\pi p^2 \Delta p * V)/h^3}{e^{(E-\mu)/kT}-1} * 2(\text{spins})$$

$$\Rightarrow \frac{8\pi * V d\lambda}{\lambda^2 \lambda^2} * \frac{1}{e^{(\frac{hc}{\lambda kT})}-1} = \frac{n(\lambda \ldots \lambda + \Delta\lambda)}{V}$$

$$\frac{\gamma Flux}{\text{area} * \text{time}} = \frac{2\pi c}{\lambda^4} * \frac{\Delta\lambda}{e^{(\frac{hc}{\lambda kT})}-1}$$

$$\frac{EnergyFlux}{area * time} = \frac{2\pi hc^2}{\lambda^5} * \frac{\Delta\lambda}{e^{(\frac{hc}{\lambda kT})}-1} \Rightarrow \text{Planck's Radiation Law}$$

$\frac{2\pi hc^2}{\lambda^5}\Delta\lambda$: Shows that small wavelengths would generate Huge energies and if that was the whole equation the Earth would have been incinerated by the Sun.

$\frac{1}{e^{(\frac{hc}{\lambda kT})}-1}$ : Planck's suppression factor to better describe actual observations.

The graph of the energy flux, Planck's Curve, can be seen on slide 2 of the whiteboard. The maximum =$\lambda_{max}$. We get $\frac{hc}{\lambda max} \approx 5kT$. This shows that color(wavelenght of light) is directly related to temperature. Seeing the sun as yellow (roughly 500nm) is directly related to its T(over 5000K). The TOTAL energy emitted by the sun per $m^2$ of its surface also reflects its temperature:
$I = \sigma T^4$ (see below)

The Sun is not a perfect black body radiator. As seen in the spectrum, on slide 2 of the whiteboard, there are black lines and lines of enhanced color. This is because the energy of certain wavelenghts are absorpted or emitted when interacting with certain atoms.

$E_{high} - E_{low} = \frac{hc}{\lambda}$ **either is absorpted(black lines on the spectrum or emmitted(enhanced lines on the spectrum)

*This is how Helium was discovered, its spectrum line was seen and had to correlate to a new atom.*

<u>Total Energy of the Sun</u>: Although a nasty intergal, $\int d\lambda \approx \sigma T^4$ ($\sigma$=constant)

The Sun's energy is roughly 60MeV/ $m^2$.

-Where does all this energy come from?

Bad answer=Coal

Clever answer=Gravity, the sun slowly contracting in upon itself

Actual answer= Nuclear fusion and gravity

Hydrogen(H) →protons(p+p)

When a proton Beta+ decays(because of the weak force), we have:

Proton + Neutron + Positron + Neutrino (P + N + (e+) + ve) → deuterium d (2H) + energy

D + D → He^3 + N He^3 + He^3→ He^4 + 2p

-The Sun is constantly (and thankfully) turning Hydrogen into Helium and the process emits huge amounts of energy, while its gravity continuosly draws it into itself.