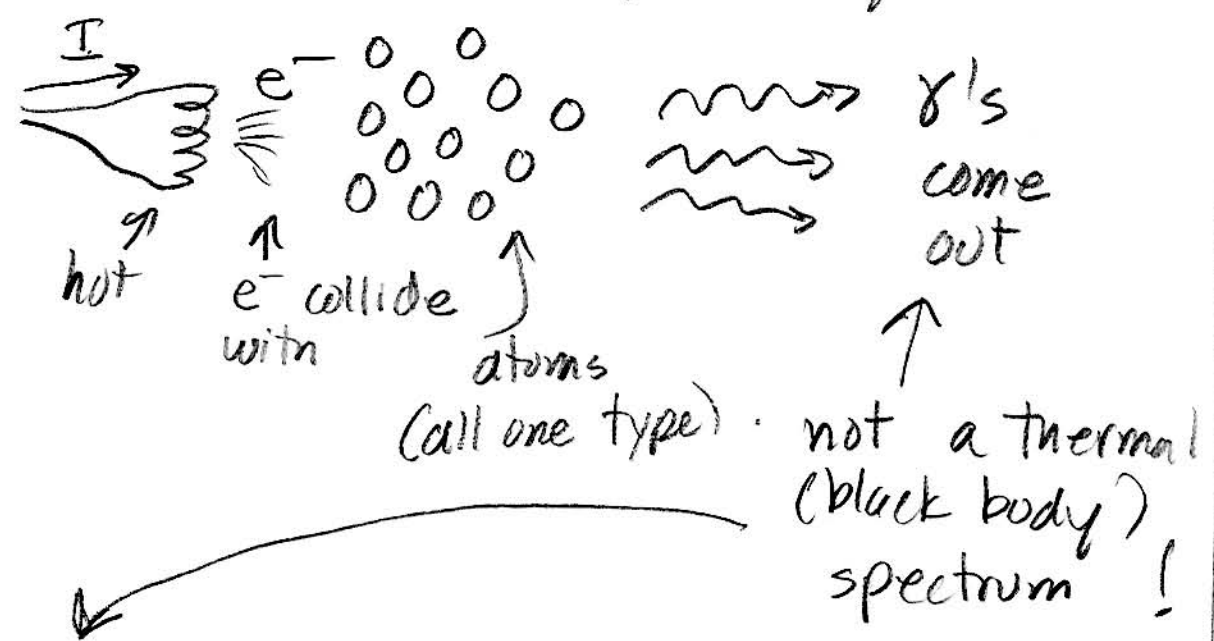


# Energy Levels

Blackbody Radiation → smooth  
 maximizes entropy  
 $kT$  can cause excitations...

There are ways to add energy to systems in less entropic ways...



lines of certain wavelengths emitted (line spectra) ... Example.

## Ritz Combination Principal Figure...

often... when  $E_1$  present --

(note,  $E_1 = h\nu_1 = \hbar\omega_1 = \frac{hc}{\lambda_1} = hc\tilde{\nu}_1$   
 where  $\tilde{\nu} = \frac{1}{\lambda_1}$ )

and  $E_2$  present,

$E_1 + E_2$  also present.

## Interpretation

Atoms ... all microscopic objects really, are in "quasi-stationary" states ...

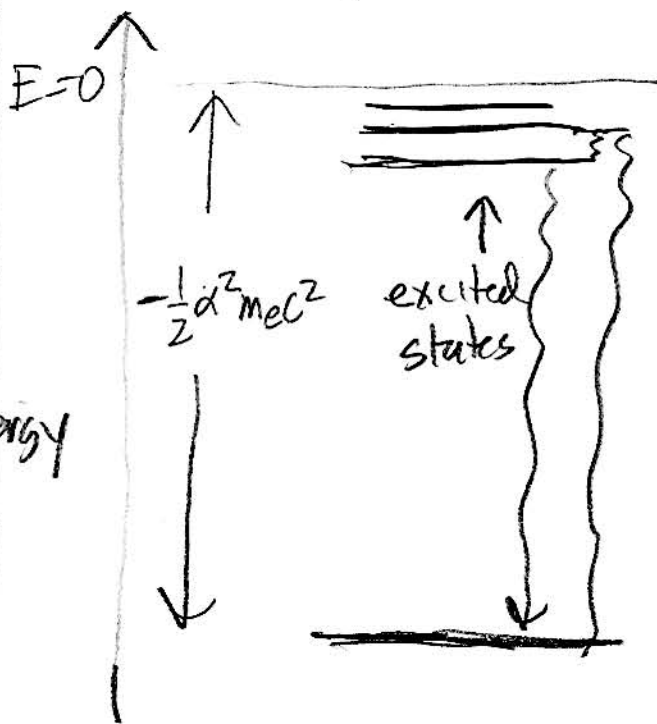
Hydrogen,

For example ...

Energy Levels

E-Ritz.

⊙ Ground State



Excited (Bohr Picture).

$$m_e \frac{v_n^2}{a_n} = \frac{e^2}{a_n^2}$$

$$m_e v_n a_n = n \hbar$$

$$v_n = \frac{n \hbar}{m_e a_n}$$

$$\frac{m_e n^2 \hbar^2}{m_e^2 a_n^3} = \frac{e^2}{a_n^2}$$

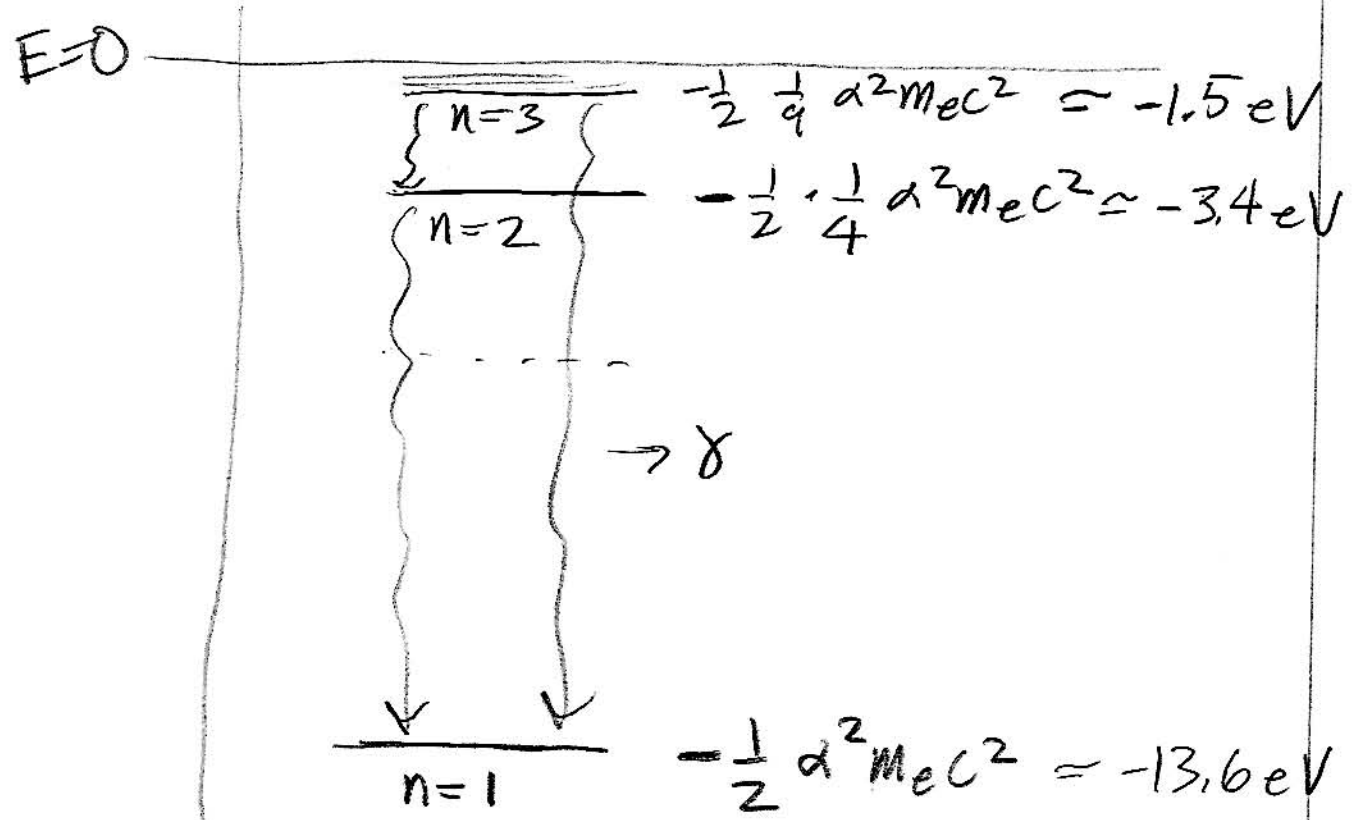
$$a_n^2 = n^2 \cdot \frac{\hbar^2}{m_e e^2} = n^2 \left( \frac{\hbar c}{e^2} \right) \frac{\hbar}{m_e c}$$

$$a_n^2 = n^2 \frac{1}{\alpha} \lambda_e = n^2 a_0$$

$$V_n = \frac{n\hbar}{m_e a_n} = \frac{n\hbar}{m_e n^2 \cdot \frac{1}{\alpha} \frac{\hbar}{m_e c}} = \frac{\alpha}{n} \cdot c$$

$$E_n = \frac{1}{2} m_e V_n^2 - \frac{e^2}{a_n} = \frac{1}{2} m_e \frac{\alpha^2}{n^2} - \frac{e^2}{n^2 \cdot \frac{1}{\alpha} \frac{\hbar}{m_e c}}$$

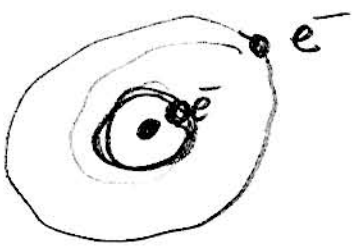
$$E_n = -\frac{1}{2} \alpha^2 \frac{1}{n^2} m_e c^2$$



actually correct, but details are wrong! More later.

Descriptive Energy Levels ( $\gamma$  emission)

Energy



Electronic  
(outer shell)

$\sim$  eV/s



Vibrational

$\sim$  10's  $\cdot 10^{-3}$  eV



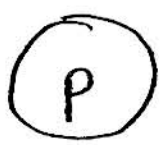
Rotational

$\sim$   $10^{-3}$  eV



Nuclei

: way different  
scale, energy but still,  
levels.



$\uparrow$  what does force  
look like?