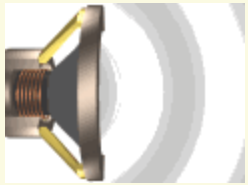
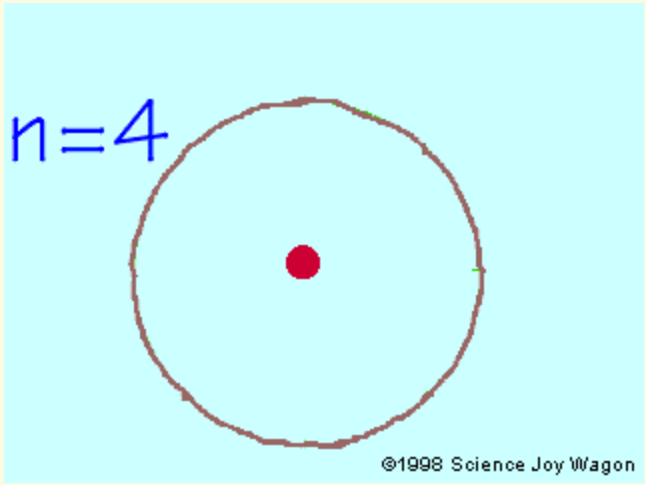
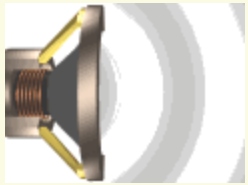


Aula 20: Ondas de Matéria

1. Espectros ópticos
2. Estados estacionários
3. Níveis de energia
4. Emissão da luz
5. Ondas de Broglie



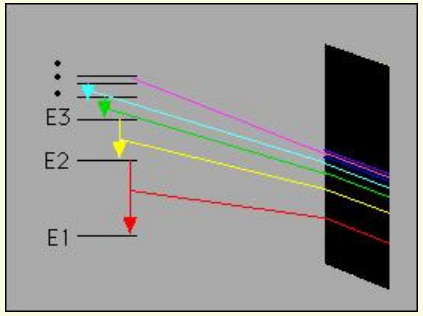
Simulação: espectro óptico do hidrogénio

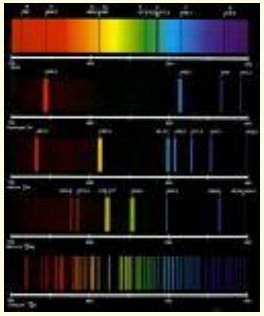


1. Espectros ópticos

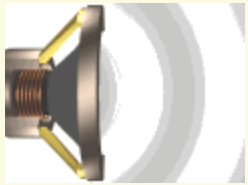
$$\frac{1}{\lambda} = R\left(\frac{1}{n^2} - \frac{1}{m^2}\right) \quad , \qquad m > n \geq 1$$

Ritz: $\nu_{mn} = T_n - T_m$

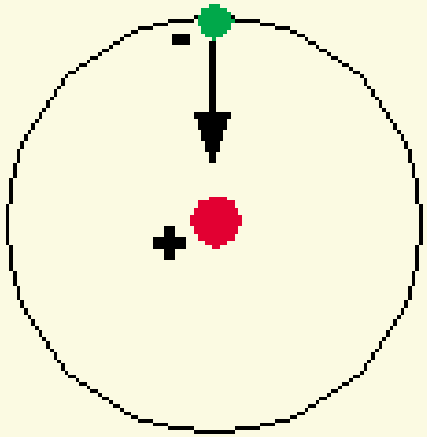




Ondas estacionárias no átomo: animação

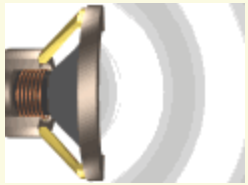


2. Estados estacionários

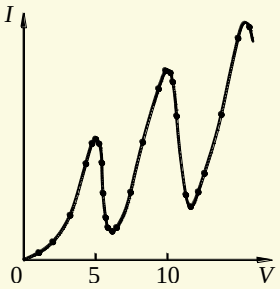


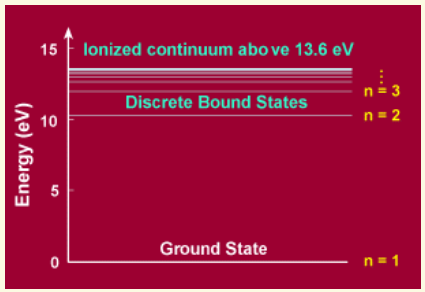
$$m_e v r = n\hbar$$

Simulação: órbitas estacionárias do electrão atómico



3. Níveis de energia

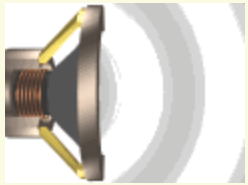




Experiência de Franck-Hertz

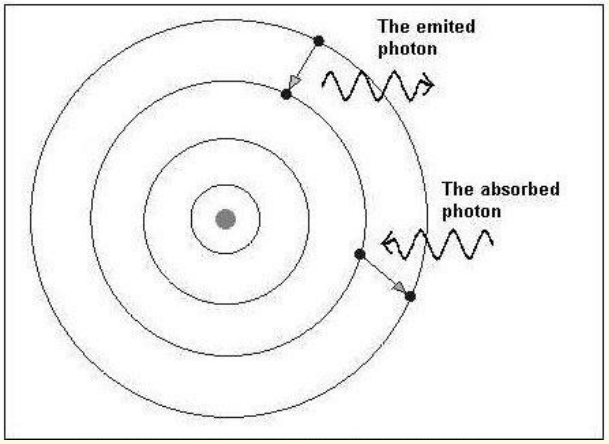
$$E_n = \frac{m_e v^2}{2} - \frac{Ze_0^2}{r_n} = -\frac{Z^2}{n^2}\frac{e_0^2}{2a_0} = -13.6\frac{Z^2}{n^2}$$

Simulação: absorção/emissão da luz

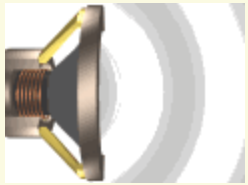


4. Emissão/absorção da luz

$$h\nu_{mn} = E_m - E_n$$



Ondas associadas: animação



5. Ondas de Broglie

$$v_g = \frac{\partial \omega}{\partial k} = \frac{\partial (E/\hbar)}{\partial (p/\hbar)} = \frac{\partial E}{\partial p}$$

$$\begin{aligned} v_g &= \frac{\partial E}{\partial p} = \frac{\partial}{\partial p}\left(\sqrt{p^2c^2 + m_0^2c^4}\right) \\ &= \frac{pc^2}{\sqrt{p^2c^2 + m_0^2c^4}} \\ &= \frac{\gamma m_0 v c^2}{\sqrt{\gamma^2 m_0^2 v^2 c^2 + m_0^2 c^4}} = \frac{\gamma v c}{\sqrt{\gamma^2 v^2 + c^2}} \\ &= \frac{vc}{\sqrt{v^2 + (c/\gamma)^2}} = \frac{vc}{\sqrt{v^2 + \left(\sqrt{c^2 - v^2}\right)^2}} \\ &= v. \end{aligned}$$

$$\lambda = \frac{h}{p} = \frac{h}{mv}$$