FORMULARI DE FÍSICA QUÀNTICA

Formulari elaborat per Raimon Sunyer i Borrell. Distribució exclusiva a http://www.geocities.com/cyberfisica

$h = 6.62 \times 10^{-34}\ J \cdot s$
$\hbar = 1.05459 \times 10^{-34}\ J \cdot s$
$e = 1.60219 \times 10^{-19}\ C$
$k = 1.38066 \times 10^{-23}\ J\,K^{-1}$
$m_e = 9.10953 \times 10^{-31}\ kg = 5.48580 \times 10^{4}\ u.m.a.$
$M_p = 1.67265 \times 10^{-27}\ kg = 1.007276\ u.m.a.$
$R_H = 1.09678 \times 10^{7}\ m^{-1}$
$R(\infty) = \frac{me^4}{8\varepsilon_0^2 h^3 c} = 1.09737 \times 10^{7}\ m^{-1}$
$a_0 = \frac{4\pi\varepsilon_0\hbar^2}{m_e e^2} = 5.29177 \times 10^{-11}\ m$
$hc = 1.23985 \times 10^{-6}\ eV \times m = 12398.5\ eV$ Å
$c = 3 \times 10^{10}\ cm/s$ $\frac{e^2}{\hbar c} = \frac{1}{137}$
$\hbar c = 197\ MeV\ F = 1.97\ keV$ Å
$m_e c^2 = 0.511\ MeV \quad m_p c^2 = 938\ MeV \quad m_n c^2 = 939\ MeV$

$$R_\nu = I_\nu a_\nu \qquad a + r + t = 1$$

$$\rho(\nu, T) = \left(\frac{8\pi\nu^2}{c^3}\right) \frac{h\nu}{e^{\frac{h\nu}{k_B T}} - 1}$$

$$dE(\nu, T) = \rho(\nu, T)\ d\nu = \left(\frac{8\pi h}{c^3}\right) \frac{\nu^3\ d\nu}{e^{\frac{h\nu}{k_B T}} - 1}$$

$$R(T) = \sigma T^4\ \ [W\,m^{-2}] \qquad \sigma = 5.67 \times 10^{-8}\ \mathrm{W\ m^{-2}\ K^{-4}}$$

$$R(T) = \int_0^\infty R(\nu, T)\ d\nu \qquad R_T(\nu) = \frac{c}{4}\rho_T(\nu)$$

$$\lambda_{max} T = b = 2.898 \times 10^{-3}\ mK$$

$$E = h\nu - \Phi \quad \text{energia per arrencar un electró}$$

$$E_{\text{cin}} = h\nu - \Phi - eV \qquad V_f = \frac{h}{e}\nu - \frac{\Phi}{e}$$

$$\lambda' = \lambda + \frac{h}{mc}(1 - \cos\theta) \qquad K = \frac{E^2}{E + \frac{mc}{1-\cos\theta}}$$

$$\text{amb}\quad K \equiv \sqrt{c^2|p'|^2 + m^2c^4 - mc^2} \qquad E \equiv h\nu$$

$$\frac{1}{\tan\varphi} = -\left(1 + \frac{h\nu}{mc^2}\right) \tan\frac{\theta}{2}$$

$$N(\theta)\ d\theta = \left(\frac{1}{4\pi\varepsilon_0}\right)^2 \left(\frac{Ze^2}{2E}\right)^2 \frac{N_\perp \rho\, g\, 2\pi \sin\theta\, d\theta}{\sin^4\theta/2}$$

$$dn(\theta,\varphi) = N_\perp\, \sigma(\theta)\, d\Omega \qquad \sigma(\theta) = \left(\frac{qQ}{4E}\right)^2 \frac{1}{\sin^4\theta/2}$$

$$L = m_e v r = n\hbar \qquad \Delta E = h\nu = n\frac{hc}{\lambda}$$

$$r = \frac{4\pi\varepsilon_0\,\hbar^2 n^2}{Z m_e e^2} \qquad a_0 = \frac{4\pi\varepsilon_0\,\hbar^2}{m_e e^2} = 0.529\ \text{Å}$$

$$E_n = -\frac{m_e}{2\hbar^2}\left(\frac{Ze^2}{4\pi\varepsilon_0}\right)^2 \frac{1}{n^2}$$

$$E_1 = -I_p = -\frac{m}{2\hbar^2}\left(\frac{Ze^2}{4\pi\varepsilon_0}\right)^2 = hc\,R(\infty)\,Z^2 = -13.6\ eV$$

$$\nu_{ab} = \frac{m_e}{4\pi\hbar^3}\left(\frac{Ze^2}{4\pi\varepsilon_0}\right)^2 \left(\frac{1}{n_b^2} - \frac{1}{n_a^2}\right)$$

$$\mu = \frac{mM}{m+M} \qquad L = \mu v r = n\hbar$$

$$E_n = -\frac{\mu}{2\hbar^2}\left(\frac{Ze^2}{4\pi\varepsilon_0}\right)^2 \frac{1}{n^2} \qquad r = \frac{4\pi\varepsilon_0\,\hbar}{Z\mu e^2} n^2$$

$$E_{K\alpha} = h\nu_{K\alpha} = E_L - E_K = h(\nu_K - \nu_L)$$

$$\frac{1}{\lambda_\alpha} = R_H(Z-1)^2\left(1 - \frac{1}{2^2}\right)$$

$$\nu = \frac{E}{h} \qquad \lambda_{dB} = \frac{h}{p} \qquad L = n\frac{\lambda}{2}$$

$$\Delta x\ \Delta p \geq \frac{\hbar}{2} \qquad \Delta E\ \Delta t \geq \hbar \qquad \Delta\ell\ \Delta\phi \geq \frac{\hbar}{2}$$

Fotó

$$E = h\nu \qquad p = \frac{h\nu}{c}$$

Partícula

$$E = \sqrt{m^2c^4 + c^2|\vec{p}|^2} = mc^2 + T \qquad p = mv$$

$$i\hbar\frac{\partial}{\partial t}\psi(x,t) = -\frac{\hbar^2}{2\mu}\frac{\partial^2}{\partial x^2}\psi(x,t) + V(x)\ \psi(x,t)$$

$$H\phi(x) = E\phi(x) \qquad \frac{d^2}{dx^2}\phi(x) - \left[\frac{2m}{\hbar}\left(V(x) - E\right)\right]\phi(x) = 0$$

$$\int_{-\infty}^{\infty} |\psi(\mathbf{r},t)|\ d\mathbf{r} = 1 \qquad \sum\nolimits_n |a_n|^2 = 1$$

$$\psi(x,t) = \sum_{n=1}^{\infty} a_n \Phi_n(x) e^{-i\,E_n/\hbar} \qquad a_n = \int_{-\infty}^{\infty} \Phi_n^*\,\psi(x,0)\ dx$$

$$\langle E\rangle = \int_{-\infty}^{\infty} \psi^*(x,t)\ E\ \ \psi(x,t)\ dx \qquad \langle E\rangle = \sum\nolimits_n |a_n|^2\,E_n$$

$$\langle E^\ell\rangle = \int_{-\infty}^{\infty} \psi^*(x,t)\ E^\ell\ \ \psi(x,t)\ dx \qquad \langle E^\ell\rangle = \sum\nolimits_n |a_n|^2\,(E_n)^\ell$$

$$\langle f(E)\rangle = \sum\nolimits_n |a_n|^2 f(E_n)$$

Pou de Parets infinites (amplada L)

$$\phi_n(x) = \begin{cases} \sqrt{\frac{2}{L}}\sin\left(\frac{n\pi x}{L}\right) & \text{si } |x| \le L/2 \\ 0 & \text{si } |x| \ge L/2 \end{cases}$$

$$k = \left[\frac{2m(E-V_0)}{\hbar^2}\right]^{1/2} \qquad E_n - V_0 = \frac{\hbar^2\pi^2}{2mL^2}n^2$$

Pou quadrat (amplada $L = 2a$)

$$\alpha = \left[\tfrac{2m}{\hbar^2}(V_0 - |E|)\right]^{1/2} \quad k = \left[\tfrac{2m}{\hbar^2}|E|\right]^{1/2}$$

$$\tan\alpha\, a = \tfrac{k}{\alpha} \quad \tfrac{1}{\tan\alpha\, a} = -\tfrac{k}{\alpha}$$

$$(\underbrace{\alpha a}_{\xi})^2 + (\underbrace{ka}_{\eta})^2 = \theta_0^2 = \left(\frac{2mV_0a^2}{\hbar^2}\right)$$

$$\begin{array}{ll} \text{Parells} & \eta = \xi\tan\xi \\ \text{Senars} & \eta = -\xi\frac{1}{\tan\xi} \end{array}$$

$$\begin{array}{l} 0 \le \theta_0 \le \frac{\pi}{2} \Longrightarrow 1 \text{ solució} \\ \frac{\pi}{2} \le \theta_0 \le \pi \Longrightarrow 2 \text{ solucions} \\ \pi \le \theta_0 \le \frac{3\pi}{2} \Longrightarrow 3 \text{ solucions} \end{array}$$

$$\beta = \left[\tfrac{2m}{\hbar^2}(V_0 + E)\right]^{1/2}$$

$$R = \left[1 + \frac{4E(V_0+E)}{V_0^2\sin^2(\beta L)}\right]^{-1}$$

$$T = \left[1 + \frac{V_0^2\sin^2(\beta L)}{4E(V_0+E)}\right]^{-1}$$

Barrera de potencial (amplada a)

$$\alpha = \left[\frac{2m(V_0-E)}{\hbar^2}\right]^{1/2} \qquad k = \left[\frac{2mE}{\hbar^2}\right]^{1/2}$$

$$R = \frac{|B|^2}{|A|^2} = \left[1 + \frac{4E(V_0-E)}{V_0^2\sinh^2(\alpha a)}\right]^{-1}$$

$$T = \frac{|C|^2}{|A|^2} = \left[1 + \frac{V_0^2\sinh^2(\alpha a)}{4E(V_0-E)}\right]^{-1}$$

Funcions d'ona de l'oscil·lador harmònic

$$\left[-\frac{\hbar}{2m}\frac{d^2}{dx^2} + \frac{1}{2}m\omega^2x^2\right]\phi_n = E_n\phi_n(x)$$

$$\alpha \equiv \left(\frac{2m\omega}{\hbar}\right)^{1/2} \qquad \xi \equiv \alpha x \qquad E_n = \left(n + \frac{1}{2}\right)\hbar\omega$$

$$\phi_n(x) = \left(\frac{\sqrt{2\pi}}{\alpha}2^n n!\right)^{-1/2} e^{-\frac{1}{4}\xi^2} H_n\left(\frac{\xi}{\sqrt{2}}\right)$$

$$\langle x\rangle = \int_{-\infty}^{\infty}\phi_n^*(x)\, x\, \phi_n(x) = 0$$

$$\int_{-\infty}^{\infty}\phi_n^*(x)\phi_m(x) = \delta_{nm}$$

$n = 1, 2, 3, \ldots$
$l = 0, 1, 2, 3, \ldots, n-1$
$m = -l, -l+1, \ldots, 0, \ldots, l-1, l$

$$\Psi(\vec{r}) = \frac{R_{nl}(r)}{r}Y_{lm}(\theta,\varphi) \qquad T(t) = \exp\left(-i\frac{E_n}{\hbar}t\right)$$

$$\int_\Omega Y_{l'm'}^*(\theta,\varphi)Y_{lm}(\theta,\varphi) = \delta_{l'l}\delta_{m'm} \qquad \int_0^\infty |R_{nl}(r)|^2\, dr = 1$$

$$P = \int_{R_1}^{R_2} r^2\left|\frac{R_{nl}(r)}{r}\right|^2 dr \int_\Omega Y_{lm}^*(\theta,\varphi)Y_{lm}(\theta,\varphi)\, d\Omega$$

$$\int_{-\infty}^{\infty} e^{-ax^2}\, dx = \sqrt{\frac{\pi}{a}}$$

$$\int_{-\infty}^{\infty} e^{-ax^2+bx+c}\, dx = \sqrt{\frac{\pi}{a}}\exp\left(\frac{b^2}{4a} + c\right)$$

$$\int_0^\infty x^n e^{-ax}dx = \frac{\Gamma(n+1)}{a^{n+1}} \qquad \Gamma(n+1) = n!$$

$$\int_0^\infty \frac{x^3}{e^x - 1}dx = \frac{\pi^4}{15}$$

$$\int_{-\infty}^{\infty} x^2\, e^{-ax^2} = \frac{\sqrt{\pi}}{2a^{3/2}}$$

Frank Hertz

$$\lambda = \frac{hc}{eU_R}$$

$$\Delta E = \sqrt{\langle E^2\rangle - \langle E\rangle^2}$$

$$p = -i\hbar\nabla$$

$$T = \frac{p^2}{2m} = -\frac{\hbar^2}{2m}\nabla^2$$

$$E = H = -\frac{\hbar^2}{2m}\nabla^2 + V(\vec{r}, t)$$