$v \ll 0.1c \quad t' = t \quad u = v_{S'} - v_S \quad x' = x - ut \quad v'_x = v_x - u \quad a'_x = a_x \quad y' = y \quad v'_y = v_y \quad a'_y = a_y$

$\gamma = \frac{1}{\sqrt{1-(\frac{u}{c})^2}}[>1] \quad t' = \gamma(t - \frac{ux}{c^2}) \quad x' = \gamma(x - ut) \quad y' = y \quad v'_y = \frac{v_y\sqrt{1-(u/c)^2}}{1 - \frac{v_x u}{c^2}} \quad v'_x = \frac{v_x - u}{1 - \frac{v_x u}{c^2}}$

$\theta' = \tan^{-1}\frac{V'_y}{V'_x} \quad t_o = \gamma t_p \quad r = \frac{1}{t} \quad L = \frac{L_p}{\gamma} \quad \theta = \tan^{-1}\frac{L_y}{L_x} \quad \beta = \frac{v}{c} \quad \lambda_o = \lambda_s\sqrt{\frac{1 \pm \beta}{1 \mp \beta}} \quad f_o = f_s\sqrt{\frac{1 \mp \beta}{1 \pm \beta}}$

$m = m_0\gamma \quad E_t = \gamma m_0 c^2 = m_0 c^2 + K.E = \sqrt{\rho^2 c^2 + E_0^2} \quad E_0 = m_0 c^2 \quad K.E = (\gamma - 1)E_0$

$\rho = \gamma m_0 v = \frac{1}{c}\sqrt{E_t^2 - E_0^2} \quad \rho^2 c^2 = E_t^2 - E_0^2 \quad F = \gamma^3 m_0 a \quad v = \frac{pc^2}{E_t} = c\sqrt{1 - (1/\gamma^2)}$

$c = \lambda f \quad E = hf = \frac{hc}{\lambda} = W + K.E = W + eV \quad W = hf_c = \frac{hc}{\lambda_c} \quad K.E_{max} = \frac{1}{2}mv_{max}^2 = eV_S$

$\frac{n}{t} = \frac{IA}{hf} = \frac{P}{E} \quad i = \frac{n}{t}\cdot e = \frac{Q}{t} \quad I = \frac{P}{A} \quad E_n = nhf \quad E_i > W \quad f_i > f_c \quad \lambda_i < \lambda_c$

$P = \sigma A T^4 \quad \sigma = 5.6 \times 10^{-8} \quad \lambda_{max} T = 2.898 \times 10^{-3} mK \quad {}^\circ K = 273 + {}^\circ C$

$\lambda_{min} = \frac{hc}{eV} = \frac{1.26 \times 10^{-6}}{V}[V \cdot m] \quad E_{x\text{-ray}} = eV = \frac{hc}{\lambda_{min}} \quad | \quad E_{ph} = 2m_e c^2 + K.E_- + K.E_+$

$E = \rho c = eV \quad \rho_{ph} = \frac{E_{ph}}{c} = \frac{h}{\lambda} \quad \rho_e = mv \quad K.E_e = \frac{1}{2}mv^2 = E_{ph} - E'_{ph} \quad E_{ph} + m_e c^2 = E'_{ph} + E_e$

$\lambda_c = \frac{h}{mc} = 2.426 \times 10^{-12} \quad \lambda' - \lambda = \lambda_c(1 - \cos\theta)$

$x : \rho_i = \rho_s\cos\theta + \rho_e\cos\phi \quad y : \rho_s\sin\theta = \rho_e\sin\phi \quad \tan\phi = \frac{\sin\theta}{\lambda_f/\lambda_i - \cos\theta} = \frac{\rho'\sin\theta}{\rho - \rho'\cos\theta}$

$\lambda_{brog} = \frac{h}{\rho_{ph}} = \frac{h}{mv} = \frac{h}{\sqrt{2mK.E}} \quad hf = 2\gamma mc^2 \quad \Delta x\Delta P \geqslant \frac{\hbar}{2} \quad \Delta E\Delta t \geqslant \frac{\hbar}{2} \quad \Delta\rho = m\Delta v \quad \Delta E = h\Delta f$

$F_c = \frac{mv^2}{r} = F_e = \frac{1}{4\pi\epsilon_0}\frac{e}{r^2} \quad v = \frac{e}{\sqrt{4\pi\epsilon_0 mr}} \quad K.E = \frac{1}{2}mv^2 \quad K.E_n = \frac{e^2}{8\pi\epsilon_0 r_n} \quad P.E = \frac{-e^2}{4\pi\epsilon_0 r_n}$

$E = \frac{-e^2}{8\pi\epsilon_0 r_n} \quad r_n = a_0 n^2 = \frac{n^2 h^2 \epsilon_0}{\pi m e^2} \quad L = n\hbar = \rho r \quad f_n = \frac{v}{2\pi r} = \frac{e}{2\pi\sqrt{4\pi\epsilon_0 m r^3}} = \frac{-E_1}{h}(\frac{2}{n^3})$

$E_n = \frac{-13.6}{n^2}[eV] \quad E_{ph} = hf = E_i - E_f = -13.6(\frac{1}{n_f^2} - \frac{1}{n_i^2}) \quad \frac{1}{\lambda} = R_\infty(\frac{1}{n_f^2} - \frac{1}{n_i^2}) \quad v_n = \frac{1.28 \times 10^6}{n}$

$N = f\Delta t \quad f = \frac{-E_1}{h}(\frac{1}{n_f^2} - \frac{1}{n_i^2}) \quad f_L = \frac{-E_1}{h}(\frac{2\rho}{n^3}) \quad E = K.E + P.E \quad n\lambda = 2\pi r_n$

$K.E = \frac{\rho^2}{2m} \quad \mu = -(\frac{e}{2m})L \quad P.E_m = -\mu B\cos\theta \quad U_m = m_l(\frac{e\hbar}{2m})B$

$L_z = m_l\hbar = L\cos\theta \quad \cos\theta = \frac{m_l}{\sqrt{l(l+1)}} \quad S_z = \pm\frac{1}{2}\hbar \quad \mu_s = \frac{-e}{m}S \quad \mu_{sz} = \pm\frac{e\hbar}{2m} = \pm\mu_B \quad l = n - 1$

$n = 1, 2, 3, 4\ldots \quad l = 0, 1, \ldots, n-1 \quad -l \leqslant m_l \leqslant l \quad m_s = \pm 0.5 \quad L = \sqrt{l(l+1)}\hbar \quad S = 0.5\sqrt{3}\hbar$

$J = L + S \quad N_{max} = 2n^2 \quad L_{max} = 2(2l+1) \quad \Delta l = \pm 1 \quad \Delta m_l = 0, \pm 1$

$f_1 = f_0 - \mu_B\frac{B}{h} \quad f_2 = f_0 \quad f_3 = f_0 + \mu_B\frac{B}{h} \quad \Delta\lambda = \frac{eB\lambda^2}{4\pi mc} \quad \Delta f = \frac{eB}{4\pi m}$

$1s^2 \quad 2s^2 \quad 2p^6 \quad 3s^2 \quad 3p^6 \quad 4s^2 \quad 3d^{10} \quad 4p^6 \quad 5s^2 \quad 4d^{10} \quad 5p^6 \quad 6s^2 \quad 4f^{14} \quad 5d^{10} \quad 6p^6 \quad 7s^2 \quad 6d^{10} \quad 5f^{14}$

$c = 3 \times 10^8$ m/s   Mach $= 343$ m/s 1.6×10^{-19} J $= 1$ eV $e = 1.6 \times 10^{-19}$ C $h = 6.626 \times 10^{-34}$ J · s

$m_e = 9.11 \times 10^{-31}$ kg $m_p = 1.67 \times 10^{-27}$ kg   MeV/$c^2 = 1.79 \times 10^{-30}$ kg   MeV/c $= 5.36 \times 10^{-22}$ kg · m/s

$m_e c^2 = 0.511$ MeV $m_p c^2 = 938$ MeV $m_n c^2 = 939$ MeV $\mu_B = 9.274 \times 10^{-24}$J/T $= 5.788 \times 10^{-5}$eV/T

$\frac{h}{m_e c} = 0.024 \times 10^{-10}$ m $\hbar = 1.054 \times 10^{-34}$ J · s $a_0 = 0.529 \times 10^{-10}$ m $R = 1.097 \times 10^7$ m^{-1}

1 L.Y $\approx 9.46 \times 10^{15}$ m   μm : 10^{-6} nm : 10^{-9} pm : 10^{-12} fm : 10^{-15} Å $= 10^{-10}$ m