Physical Constants

speed of light, c	$= 3 \cdot 10^{10} \frac{cm}{s}$	e^- charge, e	$= 5 \cdot 10^{-10} esu$
e^- mass, m_e	$= 10^{-27} g$	Planck const., $\hbar$	$= 10^{-27} erg \cdot s$
Boltzmann const., k	$= 1.4 \cdot 10^{-16} \frac{erg}{K}$	grav. const., G	$= 7 \cdot 10^{-8} \frac{erg \cdot cm}{g^2}$
Avogadro's Number, N_0	$= 6 \cdot 10^{23} \frac{1}{mol}$	ideal gas const., R	$= 2 \frac{cal}{mol \cdot K}$
vaccuum permeability, μ_0	$= 4\pi \cdot 10^{-7} \frac{N}{amp^2}$	vaccuum permittivity, ϵ_0	$= 9 \cdot 10^{-12} \frac{C^2}{N \cdot m^2}$
vaccuum resistivity	$= \sqrt{\frac{\mu_0}{\epsilon_0}} = 377 ohms$	$1 ohm^{-1}$	$= 9 \cdot 10^{11} \frac{cm}{s}$
Stefan-Boltzmann const., σ	$= 6 \cdot 10^{-5} \frac{erg}{s \cdot cm^2 \cdot k^4}$		
classical e^- radius, r_e	$= \frac{e^2}{m_e c^2} = 3 \cdot 10^{-13} cm$	Compton wavelength, λ_c	$= \frac{\hbar}{m_e c} = 4 \cdot 10^{-11} cm$
Bohr radius, a_0	$= \frac{\hbar^2}{m_e e^2} = 5 \cdot 10^{-9} cm$	Rydberg energy, Ryd	$= \frac{Xe^2}{2a_0} = 13.6 Z^2\ eV$
fine structure const., α	$= \frac{e^2}{\hbar c} = \frac{1}{137}$	Bohr magneton, μ_B	$= \frac{e\hbar}{2m_{e,p}c} \frac{erg}{gauss}$
e^- rest mass, $m_e c^2$	$= 0.5 MeV$	Einstein $A\|_{Ly\alpha}$	$= 5 \cdot 10^8 \frac{1}{s}$
visible photon energy	$= 2eV$	kT_{room}	$= 0.025 eV$
black body luminosity	$= 6 \cdot 10^{-12} \frac{W}{K^4 cm^2}$	1 W at 5550Å	= 680 lumens
$m_{nucleon}$	$= 2000 m_e$	m_{kaon}	$= 1000 m_e$
m_{pion}	$= 270 m_e$	m_{muon}	$= 200 m_e$
radius of atomic nucleus	$= A^{\frac{1}{3}} \cdot 10^{-13} cm$	1 eV	$= 1.6 \cdot 10^{-12} erg$
		Thomson Cross., σ_T	$= \frac{8}{3}\pi r_e^2 = 7 \cdot 10^{-25} cm^2$
scale height of atmosphere	$= 8km$	atm. pressure, P_{atm}	$= 10^6 \frac{dynes}{cm^2} = 15 psi$
ρ_{air}	$= 10^{-3} \frac{g}{cm^3}$	n_{air} at STP	$= 3 \cdot 10^{19} \frac{1}{cm^3}$
sound speed at STP, c_s	$\sim v_{molec} = 4 \cdot 10^4 \frac{cm}{s}$	λ_{mfp} at STP	$= 7 \cdot 10^{-6} cm$
specific heat (solid or liquid)	$= 0.5 \frac{cal}{cm^3 K}$	expansion (solid/liquid)	$\leq 2 \cdot 10^{-5} \frac{1}{K}$
heat conduction (insulator)	$= 10^{-2} \frac{cal}{s \cdot cm \cdot K}$	heat conduction (metal)	$= 1 \left(\frac{\rho_{Cu}}{\rho_{metal}}\right) \frac{cal}{s \cdot cm \cdot K}$
combustion heat (food/fuel)	$= 7 \frac{kcal}{g}$	vaporization heat	$= 10^4 \frac{cal}{mol}$
elastic modulii (solids)	$= 10^{11} \to 10^{12} \frac{dynes}{cm^2}$	tensile strength (solids)	$= 10^8 \to 10^{10} \frac{dyne}{cm^2}$
surface tension H_2O, γ	$= 50 \frac{dyne}{cm} = \frac{erg}{cm^2}$	diffusion rate of H_2O	$= 10^{-5} \frac{cm^2}{s}$
diffusion rate in air	$= 0.2 \frac{cm^2}{s}$	viscosity of $H_2 0$, $\mu = \rho\nu$	$= 10^{-2}$
viscosity of air, μ_{air}	$= 2 \cdot 10^{-4} \frac{dyne \cdot s}{cm^2}$	1 cal	$= 4W \cdot s = 4 \cdot 10^7 erg$
resistivity of Cu at usual T	$= 2 \cdot 10^{-6}$	resistivity of pure H_2O	$= 2 \cdot 10^7$
resistivity of sea water	$= 25 ohm \cdot cm$	grav. acceleration, g	$= 10^3 \frac{cm}{s^2}$
1 Newton	$= 10^5 dynes$	1 lb	$= 4.4N$
1 Debye	$= 10^{-18} cgs$		
1 parsec	$= 3 \cdot 10^{18} cm$	1 mag	$= -4dB$
absolute magnitude M_{abs}	$= M_{app}$ at 10 pc	apparent mag. of sun	$= 5$
earth magnetic field at pole	$= 0.5 gauss$	mass of earth, M_e	$= 6 \cdot 10^{27} g$
radius of earth R_e	$= 6 \cdot 10^8 cm$	mass of sun $M_\odot$	$= 2 \cdot 10^{33} g$
radius of sun, $R_\odot$	$= 8 \cdot 10^{10} cm$	luminosity of sun, $L_\odot$	$= 4 \cdot 10^{33} \frac{erg}{s}$
flux from sun at earth	$= 1 \frac{kW}{m^2}$	starlight energy density	$= 10^{-12} \frac{erg}{cm^3}$
distance to moon	$= 4 \cdot 10^{10} cm$	distance to sun	$= 1AU = 1.5 \cdot 10^{13} cm$
distance to galactic center	$= 7kpc$	mass of galaxy	$= 10^{11} M_\odot$
radius of galaxy cluster	$= 2Mpc$	radius of universe	$= 3000 Mpc$
critical density, ρ_{cr}	$= \frac{3H_0^2}{8\pi G} = 2h^2 \cdot 10^{-29} \frac{g}{cm^3}$	Hubble const., $H_0 = 100h$	$= 72 \frac{km}{s\ Mpc} = \frac{1}{10^{10} yrs}$
baryon density Ω_B	$= \frac{\rho_B}{\rho_{cr}} = .02$	radiation density Ω_R	$= 10^{-3}$
dark energy density Ω_Λ	$= .7$	magnetic field of galaxy	$= 5\mu G$

Radiation Equations

Maxwell's Equations	$\vec{\nabla} \times \vec{E} = -\frac{1}{c}\frac{\partial B}{\partial t}$ $\vec{\nabla} \times \vec{B} = \frac{1}{c}\frac{\partial E}{\partial t} + \frac{4\pi}{c} J$ $\vec{\nabla} \cdot \vec{E} = 4\pi\rho$ $\vec{\nabla} \cdot \vec{B} = 0$
Planck Function Wein Tail $(h\nu \gg kT)$ Rayleigh-Jeans Tail $(h\nu \ll kT)$	$B_\nu = \frac{2h\nu^3}{c^2}\frac{1}{\left(e^{\frac{h\nu}{kT}} - 1\right)}$ $B_\nu \approx \frac{2h\nu^3}{c^2} e^{-\frac{h\nu}{kT}}$ $B_\nu \approx \frac{2kT}{\lambda^2}$
Power Radiated by Accelerated Charge	$P = \frac{2}{3}\frac{(e\ddot{x})^2}{c^3}$
Einstein A (d = electric dipole moment)	$A_{21} \sim \frac{2d^2\omega_0^3}{3\hbar c^3}$
Einstein A of 21cm (using $\mu_e = \frac{eh}{m_e c} \sim \alpha d$ for d)	$A_{21}\big\|_{21cm} \sim \alpha^2 \left(\frac{1216\mathring{A}}{21cm}\right)^3 \sim 3 \cdot 10^{-15}\frac{1}{s}$
Electronic Cross-Section at Line Center	$\sigma \sim \frac{B_{12}\phi(\nu)h\nu}{4\pi} \sim \frac{\lambda^2}{8\pi}\frac{A_{21}}{\Delta\nu}$
Einstein Relations $\left(\bar{J} \equiv \int_0^\infty J_\nu \phi(\nu) d\nu\right)$	$n_1 B_{12}\bar{J} = n_2 A_{21} + n_2 B_{21}\bar{J}$
Emissivity	$j_\nu = \frac{1}{4\pi} n_2 A_{21} h\nu\phi(\nu)$
Absorption	$\alpha_\nu = \frac{h\nu}{4\pi}\phi(\nu)(n_1 B_{12} - n_2 B_{21}) = n\sigma$
Opacity	$\kappa_\nu = \frac{\alpha_\nu}{\rho}$
Fundamental Equation of Radiative Transfer	$\frac{dI_\nu}{ds} = j_\nu - \alpha_\nu I_\nu$
Integrated Intensity $\left(S_\nu \equiv \frac{j_\nu}{\alpha_\nu}\right)$, $(\tau = n\sigma s = N\sigma)$	$I_\nu(\tau_\nu) = I_\nu(0)e^{-\tau_\nu} + e^{-\tau_\nu}\int S_\nu(\tau'_\nu)e^{-\tau'_\nu}d\tau'_\nu$
Energy State Populations in Thermal Equilibrium	$\frac{n_2}{n_2} = \frac{g_2}{g_1} e^{-\frac{h\nu_0}{kT}}$
Fine Structure Transition Energies	$\Delta E \sim Z^4\alpha^2 \cdot Ryd$
Hyperfine Transition Energies	$\Delta E \sim \Delta E_{fine}\frac{m_e}{m_p}$
Maxwellian Velocity Distribution	$f(v) = 4\pi\left(\frac{m_r}{2\pi kT}\right)^{\frac{3}{2}} v^2 e^{-\frac{mv^2}{2kT}}$
Excitation Rate $(q_{12}$ = collisional rate coefficient)	$R_{ex} = n_A n_B \sigma_{12}\int f(v_{rel})v_{rel}dv$ $= n_A n_B \langle\sigma_{12}v\rangle = n_A n_B q_{12}$
Mie Theory (m = complex index of refraction)	$\sigma_{abs} = \pi a^2 Q_{abs} = \pi a^2\left[-4\left(\frac{2\pi a}{\lambda}\right) Im\left(\frac{m^2-1}{m^2+2}\right)\right]$ $\sigma_{scat} = \pi a^2 Q_{scat} = \pi a^2\left[\frac{8}{3}\left(\frac{2\pi a}{\lambda}\right)^4 Re\left(\left[\frac{m^2-1}{m^2+2}\right]^2\right)\right]$
Collisional Cross-Section (Ω of order 1, 0 below energy threshold)	$\sigma_{12} = \frac{\pi\hbar^2}{m_e^2 v^2}\left(\frac{\Omega(1,2)}{g_1}\right)$
Milne Relation	$\frac{\sigma_{fb}(v)}{\sigma_{bf}(\nu)} = \frac{g_0}{g_+}\left(\frac{h\nu}{m_e c v}\right)^2$
Saha Equation (ionization/recombination equilibrium)	$\frac{n_+ n_e}{n_0} = \left(\frac{2\pi m_e kT}{h^2}\right)^{\frac{3}{2}}\frac{2g_+}{g_0}e^{-\frac{\chi}{kT}}$

Bremsstrahlung (Free-Free Emission)	$j_{\nu,ff} = \frac{16}{3\sqrt{2\pi}} \frac{Z^2 e^6}{m_e^{\frac{3}{2}} c^3 (kT)^{\frac{1}{2}}} n_e n_{ions} e^{-\frac{h\nu}{kT}}$
Inverse Bremsstrahlung	$\alpha_{\nu,ff} \equiv \frac{j_{\nu,ff}}{B_\nu}$
Cyclotron Frequency	$\omega_{cyc} = \frac{eB}{m_e c}$
Synchrotron Frequency	$\omega_{sync} = \frac{3}{2}\gamma^2 \omega_{cyc} \sin\alpha$
Synchrotron Power ($\sigma_T = \frac{8\pi}{3} r_0^2$, $\frac{e^2}{r_0} = m_e c^2$)	$P = 2\sigma_T c U_B \sin^2\alpha\gamma^2$
Synchrotron Spectrum ($p \sim -2.5$)	$\frac{dP}{d\omega} \propto B^{\frac{1-p}{2}} \omega^{\frac{1+p}{2}}$
Synchrotron Self-Absorption	$I_\nu(\nu_{crit}) = B_\nu(T \sim \frac{\gamma m_e c^2}{k}, \nu_{crit})$
Compton Scattering (e^- gaining energy from photons) $\left(\lambda_c \equiv \frac{h}{m_e c}\right)$	$\Delta\lambda = \lambda_c(1 - \cos\theta)$
Inverse Compton Scattering (electrons losing energy to photons)	$P_{lost} = \sigma_T c U_{ph} \gamma^2$
Zeeman Splitting	$\Delta E \sim \mu_{Bohr} B$
Dispersion relation $\left(\omega_p^2 \equiv \frac{4\pi n e^2}{m_e}\right)$, $(\eta \equiv \frac{ck}{\omega})$	$\eta^2 = 1 + \frac{\omega_p^2}{\omega^2}$
Dispersion Measure ($DM = \int n_e ds$)	$\frac{dt}{d\omega} = \frac{4\pi e^2}{m_e c \omega^3} DM$
Faraday Rotation ($RM = \int n_e B_\parallel ds$)	$\Delta\theta = \frac{2\pi e^3}{c^2 m_e^2 \omega^2} RM$
Emission Measure	$EM = \int n_e^2 ds$