NUCLEAR SCIENCE DATA SHEET

Physical Constants

Avogadro constant	N	6.022 136 7	(36)	$\times 10^{23}$	mol^{-1}
Boltzman constant	k	1.380 658	(12)	$\times 10^{-23}$	$J\ K^{-1}$
				$\times 10^{-16}$	$erg\ K^{-1}$
		8.617 385	(73)	$\times 10^{-5}$	$eV\ K^{-1}$
Gas constant	R = kN	8.314 510	(70)		$J\ mol^{-1}\ K^{-1}$
		82.056 8		$\times 10^{-6}$	$m^3\ atm\ mol^{-1}\ K^{-1}$
Gravitational constant	G	6.672 59	(85)	$\times 10^{-11}$	$m^3\ kg^{-2}\ sec^{-2}$
				$\times 10^{-15}$	$J\ cm\ g^{-2}$
				$\times 10^{-8}$	$erg\ cm\ g^{-2}$
		4.169		$\times 10^{11}$	$MeV\ fm\ g^{-2}$
Electron volt	eV	1.602 177 33	(49)	$\times 10^{-19}$	J
				$\times 10^{-12}$	erg
Elementary charge	e	1.602 177 33	(49)	$\times 10^{-19}$	C
		4.803 242		$\times 10^{-10}$	esu
	e^2	1.440 0			MeV fm
Faraday constant	F = Ne	9.648 530 9	(29)	$\times 10^{4}$	$C\ mol^{-1}$
Fine structure constant	$\alpha = e^2/(4\pi\varepsilon_0\ \hbar c)$	7.297 353 08	(33)	$\times 10^{-3}$	
		1/137.036 04	(11)		
Planck constant	h	6.626 075 5	(40)	$\times 10^{-34}$	J sec
				$\times 10^{-27}$	erg sec
		4.135 669 2	(12)	$\times 10^{-21}$	MeV sec
	hc	1.2398		$\times 10^{3}$	MeV fm
	ħ	1.054 572 66	(63)	$\times 10^{-34}$	J sec
		6.582 122 0	(20)	$\times 10^{-22}$	MeV sec
	ħc	3.161 529 3		$\times 10^{-24}$	J sec
		197.327 054			MeV fm
	hc/k	1.438 8			cm K
	$\hbar^2$	41.802			MeV u sec
Planck mass	$m_p = (\hbar c/G)^{1/2}$	2.176 71	(14)	$\times 10^{-8}$	kg
Planck length	$\lambda_\pi = \hbar/m_p c = (\hbar G/c^3)^{1/2}$	1.16 05	(10)	$\times 10^{-35}$	m
Planck time	$t_p = \lambda_p/c = (\hbar G/c^5)^{1/2}$	5.390 56	(34)	$\times 10^{-44}$	sec
Radiation density constant					
	$a = 8p^5k^4/15c^3h^3$	7.565		$\times 10^{-22}$	$J\ cm^{-3}\ K^{-4}$
Speed of light	c	2.997 924 58		$\times 10^{8}$	$m\ s^{-1}$
Stefan-Boltzmann constant	$\sigma = ac/4$	5.670 51	(19)	$\times 10^{-8}$	$W\ m^{-2}\ K^{-4}$
				$\times 10^{-12}$	$J\ cm^{-2}\ sec^{-1}\ K^{-4}$

π	3.141 592 65			Fermi	fm	10^{-15}	m
e	2.718 281 83			Barn	b	10^{-28}	m^2
J	10^7	erg		Angstrom		10^{-10}	m
	1/4.184	cal		1 mA	$6.28/n \times 10^{12}$		particles/sec
eV	1.602 177 33 (49)	$\times 10^{-19}$	J	year	3.156×10^7		sec

Rest Masses

		u		kg		MeV	
Atomic mass unit		1		$1.660\,540\,2\ (10) \times 10^{-27}$		$931.494\,32$	(28)
Electron		$5.485\,799\,03$	$(13) \times 10^{-4}$	$9.109\,389\,7\ (54) \times 10^{-31}$		$0.510\,999\,06$	(15)
Muon		$0.113\,428\,913$	(17)	$1.883\,532\,7\ (11) \times 10^{-28}$		$105.658\,389$	(34)
Pion	π^o	$0.144\,887\,1$	(42)	$2.405\,9 \times 10^{-28}$		$134.974\,5$	(16)
	π	$0.149\,830\,0$	(14)	$2.488\,1 \times 10^{-28}$		$139.565\,8$	(18)
Kaon	K	0.530 0		8.801×10^{-28}		493.7	
	K^o	0.534 3		8.872×10^{-28}		497.7	
Proton		$1.007\,276\,470$	(12)	$1.672\,623\,1\ (10) \times 10^{-27}$		$938.272\,31$	(28)
Neutron		$1.008\,664\,904$	(14)	$1.674\,928\,6\ (10) \times 10^{-27}$		$939.565\,63$	(28)

Relativistic Relations

Define: $\beta = v/c$ & $\gamma = (1 - \beta^2)^{-1/2}$

	Low v (Newtonian)	High v (Relativistic)
mass, m	m	γ m
mom, p	$\sim$ mv	γ mv
rest energy, E_o	mc^2	γmc^2
total energy, E ($E_o + T$)	$\sim mc^2$	
kinetic energy, T ($E - E_o$)	$\sim 1/2\ mv^2$	$\gamma mc^2 - mc^2 = mc^2(\gamma - 1)$

$(mc^2)^2 = (E/\gamma)^2 = E^2(1 - \beta^2) = E^2 - (v/c)^2E^2$
$= E^2 - \gamma^2m^2v^2c^2 = E^2 - (pc)^2$

$E^2 = (pc)^2 + (mc^2)^2$
$= (T + E_o)^2 = T^2 + 2TE_o + E_o^2$

Since:
$(pc)^2 = E^2 - (mc^2)^2 = T^2 + 2TE_o$
$= (mc^2)^2\beta^2/(1 - \beta^2)$
Then:
$T = (E_o^2 + (pc)^2)^{1/2} - E_o$
$pc = (T^2 + 2TE_o)^{1/2}$
$\beta^2 = (pc)^2/((pc)^2 + (mc^2)^2)$

Lorentz transformations

If t is given in units of length & p in units of E/c (x = lab; x' = moving frame)

$x = \gamma(x' + \beta t')$, $y = y'$, $z = z'$, $t = \gamma(\beta x' + t')$

$p_x = \gamma(p_x' + \beta E')$, $p_y = p_y'$, $p_z = p_z'$, $E = \gamma(\beta p_x' + E')$

Useful Equations

Law of cosines: $a^2 = b^2 + c^2 - 2bc \cos\alpha$

Quadratic equation: solutions of $ax^2+bx+c=0$ are $x=(-b\pm\sqrt{\Delta})/2/a$ if $\Delta=b^2-4ac\geq 0$

Cosmological Data

Cosmological Constants

	Mass	Mean Radius	Mean Distances	
Sun	1.989×10^{33} g	6.9598×10^{10} cm	Earth-sun 1 AU	1.495×10^{13} cm
Earth	5.977×10^{27} g	6.371×10^{8} cm	Earth-moon	3.84×10^{10} cm
Moon	7.36×10^{25} g	1.74×10^{8} cm		

Solar luminosity		3.9×10^{26} J s^{-1}		
Light year	ly	9.46×10^{17} cm	Parsec pc	3.26 ly