Useful equations

Friedmann equation (here $c = 1$):

$$H^2 = \left(\frac{\dot{a}}{a}\right)^2 = \frac{8\pi G_N}{3}(\rho_m+\rho_r+\rho_\Lambda)-\frac{k}{a^2} = H_0^2\Big[\Omega_M(1+z)^3+\Omega_R(1+z)^4+\Omega_K(1+z)^2+\Omega_\Lambda\Big],$$

with $\rho_\Lambda = \frac{\Lambda}{8\pi G_N}$, $\Omega_M = \rho_m(t_0)/\rho_c^0$, etc, also $\rho_k = -\frac{3k}{8\pi G_N a^2}$, $\Omega_K = \rho_k(t_0)/\rho_c^0$.

The critical density at the present time $t = t_0$ is

$\rho_c^0 = (3H_0^2)/(8\pi G_N) = 1.05h^2 \cdot 10^{-5}$ GeV cm^{-3}.

Fluid equation:
$\dot{\rho} + 3\frac{\dot{a}}{a}\left(\rho + \frac{p}{c^2}\right) = 0$

Equation of state:
$p/c^2 = w \cdot \rho$
Acceleration equation:
$\frac{\ddot{a}}{a} = -\frac{4\pi G_N}{3}\left(\rho + 3\frac{p}{c^2}\right)$

For a sum of different components ρ_i in the universe, $p_i/c^2 = w_i\rho_i$
$\frac{\ddot{a}}{a} = -\frac{4\pi G_N}{3}\sum_i\left(\rho_i + 3\frac{p_i}{c^2}\right) = -\frac{4\pi G_N}{3}\sum_i \rho_i(1+3w_i)$

"Deceleration parameter":

$q_0 = -\frac{\ddot{a}(t_0)}{a(t_0)}\frac{1}{H_0^2}$

Coulomb potential:

$V(r) = \frac{Q_1Q_2}{4\pi\epsilon_0 r} = \frac{Z_1Z_2\alpha\hbar c}{r}$,

where $Q_i = Z_ie$, $\alpha = \frac{1}{137}$ is the fine-structure constant and

$\hbar c = 1.973 \cdot 10^{-7}$ eV·m

Constants (W, Z masses and Hubble h are 2017 values)

Name	Symbol	value
Newton's constant	G_N	$6.672 \cdot 10^{-11}$ $\mathrm{m^3 kg^{-1} s^{-2}}$
Speed of light	c	$2.998 \cdot 10^{8}$ m $\mathrm{s^{-1}}$
		or $3.076 \cdot 10^{-7}$ Mpc $\mathrm{year^{-1}}$
Planck's constant	$\hbar = h/2\pi$	$1.055 \cdot 10^{-34}$ $\mathrm{m^2}$ kg $\mathrm{s^{-1}}$
Boltzmann's constant	k_B	$1.381 \cdot 10^{-23}$ J/K
		or $8.619 \cdot 10^{-5}$ eV/K
Radiation constant	$\alpha_{rad} = \pi^2 k_B^4 / 15\hbar^3 c^3$	$7.565 \cdot 10^{-16}$ J $\mathrm{m^{-3}}$ $\mathrm{K^{-4}}$
Stefan-Boltzmann constant	$\sigma_{SB} = \pi^2 k_B^4 / 60\hbar^3 c^2$	$5.670 \cdot 10^{-8}$ W $\mathrm{m^{-2}}$ $\mathrm{K^{-4}}$
Electron rest mass energy	$m_e c^2$	0.511 MeV
Proton rest mass energy	$m_p c^2$	938.3 MeV
Neutron rest mass energy	$m_n c^2$	939.6 MeV
W boson rest mass energy	$m_W c^2$	80.4 GeV
Z boson rest mass energy	$m_Z c^2$	91.2 GeV
Planck energy	$M_{Pl} c^2$	$1.2 \cdot 10^{19}$ GeV
Thomson cross section	σ_e	$6.652 \cdot 10^{-29}$ $\mathrm{m^2}$
Neutron half-life (free neutron)	$t_{\frac{1}{2}}$	611 s
Hubble constant	H_0	$100 \cdot h$ km $\mathrm{s^{-1}}$ $\mathrm{Mpc^{-1}}$
	h	0.70 ± 0.03
Critical density	ρ_c^0	$1.05h^2 \cdot 10^{-5}$ GeV $\mathrm{cm^{-3}}$

Conversion factors

1 pc = 3.261 light-years = $3.086 \cdot 10^{16}$ m
1 AU = $1.5 \cdot 10^{11}$ m
1 year = $3.156 \cdot 10^{7}$ s
1 eV = $1.602 \cdot 10^{-19}$ J
1 $\mathrm{M_\odot}$ = $1.989 \cdot 10^{30}$ kg

PARTICLE DATA

(Mass in MeV/c^2; Lifetime in Seconds; Charge in Units of Proton Charge.)

QUARKS (Spin $\frac{1}{2}$)

	Flavor	Charge	Mass (speculative)		
			Bare	Effective	
				In baryons	In mesons
First generation	d	$-\frac{1}{3}$	7.5	363	310
	u	$+\frac{2}{3}$	4.2		
Second generation	s	$-\frac{1}{3}$	150	538	483
	c	$+\frac{2}{3}$	1100	1500	
Third generation	b	$-\frac{1}{3}$	4200	4700	
	t	$+\frac{2}{3}$	>23,000		

LEPTONS (Spin $\frac{1}{2}$)

	Lepton	Charge	Mass	Lifetime	Principal decays
First generation	e	-1	0.511003	∞	—
	ν_e	0	~ 0	∞	—
Second generation	μ	-1	105.659	2.197×10^{-6}	$e\nu_\mu\bar{\nu}_e$
	ν_μ	0	~ 0	∞	—
Third generation	τ	-1	1784	3.3×10^{-13}	$\mu\nu_\tau\bar{\nu}_\mu$, $e\nu_\tau\bar{\nu}_e$, $\rho\nu_\tau$
	ν_τ	0	~ 0	∞	—

MEDIATORS (Spin 1)

Mediator	Charge	Mass	Lifetime	Force
gluon	0	0	∞	strong
photon (γ)	0	0	∞	electromagnetic
$W^\pm$	±1	80.4	3×10^{-25}	(charged) weak
Z^0	0	91.2	3×10^{-25}	(neutral) weak

electroweak

BARYONS (Spin $\frac{1}{2}$)

Baryon	Quark content	Charge	Mass	Lifetime	Principal decays
N p	uud	+1	938.280	∞	—
N n	udd	0	939.573	900	$pe\bar{\nu}_e$
Λ	uds	0	1115.6	2.63×10^{-10}	$p\pi^-$, $n\pi^0$
Σ^+	uus	+1	1189.4	0.80×10^{-10}	$p\pi^0$, $n\pi^+$
Σ^0	uds	0	1192.5	6×10^{-20}	$\Lambda\gamma$
Σ^-	dds	−1	1197.3	1.48×10^{-10}	$n\pi^-$
Ξ^0	uss	0	1314.9	2.90×10^{-10}	$\Lambda\pi^0$
Ξ^-	dss	−1	1321.2	1.64×10^{-10}	$\Lambda\pi^-$
Λ_c^+	udc	+1	2281	2×10^{-13}	not established

BARYONS (Spin $\frac{3}{2}$)

Baryon	Quark content	Charge	Mass	Lifetime	Principal decays
Δ	uuu, uud, udd, ddd	+2, +1, 0, −1	1232	0.6×10^{-23}	$N\pi$
Σ^*	uus, uds, dds	+1, 0, −1	1385	2×10^{-23}	$\Lambda\pi$, $\Sigma\pi$
Ξ^*	uss, dss	0, −1	1533	7×10^{-23}	$\Xi\pi$
Ω^-	sss	−1	1672	0.82×10^{-10}	ΛK^-, $\Xi^0\pi^-$, $\Xi^-\pi^0$

PSEUDOSCALAR MESONS (Spin 0)

Meson	Quark content	Charge	Mass	Lifetime	Principal decays
$\pi^\pm$	$u\bar{d}$, $d\bar{u}$	+1, −1	139.569	2.60×10^{-8}	$\mu\nu_\mu$
π^0	$(u\bar{u}-d\bar{d})/\sqrt{2}$	0	134.964	8.7×10^{-17}	$\gamma\gamma$
$K^\pm$	$u\bar{s}$, $s\bar{u}$	+1, −1	493.67	1.24×10^{-8}	$\mu\nu_\mu$, $\pi^+\pi^0$, $\pi^+\pi^-\pi^\pm$
K^0, $\bar{K}^0$	$d\bar{s}$, $s\bar{d}$	0, 0	497.72	K_S^0 0.892×10^{-10}; K_L^0 5.18×10^{-8}	$\pi^+\pi^-$, $\pi^0\pi^0$; $\pi e\nu_e$, $\pi\mu\nu_\mu$, $\pi\pi\pi$
η	$(u\bar{u}+d\bar{d}-2s\bar{s})/\sqrt{6}$	0	548.8	7×10^{-19}	$\gamma\gamma$, $\pi^0\pi^0\pi^0$, $\pi^+\pi^-\pi^0$
η'	$(u\bar{u}+d\bar{d}+s\bar{s})/\sqrt{3}$	0	957.6	3×10^{-21}	$\eta\pi\pi$, $\rho^0\gamma$
$D^\pm$	$c\bar{d}$, $d\bar{c}$	+1, −1	1869	9×10^{-13}	$K\pi\pi$
D^0, $\bar{D}^0$	$c\bar{u}$, $u\bar{c}$	0, 0	1865	4×10^{-13}	$K\pi\pi$
$F^\pm$ (now $D_s^\pm$)	$c\bar{s}$, $s\bar{c}$	+1, −1	1971	3×10^{-13}	not established
$B^\pm$	$u\bar{b}$, $b\bar{u}$	+1, −1	5271	14×10^{-13}	$D+?$
B^0, $\bar{B}^0$	$d\bar{b}$, $b\bar{d}$	0, 0	5275		
η_c	$c\bar{c}$	0	2981	6×10^{-23}	$KK\pi$, $\eta\pi\pi$, $\eta'\pi\pi$

VECTOR MESONS (Spin 1)

Meson	Quark content	Charge	Mass	Lifetime	Principal decays
ρ	$u\bar{d}$, $d\bar{u}$, $(u\bar{u}-d\bar{d})/\sqrt{2}$	+1, −1, 0	770	0.4×10^{-23}	$\pi\pi$
K^*	$u\bar{s}$, $s\bar{u}$, $d\bar{s}$, $s\bar{d}$	+1, −1, 0, 0	892	1×10^{-23}	$K\pi$
ω	$(u\bar{u}+d\bar{d})/\sqrt{2}$	0	783	7×10^{-23}	$\pi^+\pi^-\pi^0$, $\pi^0\gamma$
ϕ	$s\bar{s}$	0	1020	20×10^{-23}	K^+K^-, $K^0\bar{K}^0$
J/ψ	$c\bar{c}$	0	3097	1×10^{-20}	e^+e^-, $\mu^+\mu^-$, 3π, 7π
D^*	$c\bar{d}$, $d\bar{c}$, $c\bar{u}$, $u\bar{c}$	+1, −1, 0, 0	2010	$>1\times10^{-22}$	$D\pi$, $D\gamma$
Υ	$b\bar{b}$	0	9460	2×10^{-20}	$\tau^+\tau^-$, $\mu^+\mu^-$, e^+e^-