2. ASTROPHYSICAL CONSTANTS AND PARAMETERS

Table 2.1. Revised 2001 by D.E. Groom (LBNL) and December 2005 by M.A. Dobbs (LBNL). The figures in parentheses after some values give the one-standard deviation uncertainties in the last digit(s). Physical constants are from Ref. 1. While every effort has been made to obtain the most accurate current values of the listed quantities, the table does not represent a critical review or adjustment of the constants, and is not intended as a primary reference. The values and uncertainties for the cosmological parameters depend on the exact datasets, priors, and basis parameters used in the fit. Many of the parameters reported in this table are derived parameters or have non-Gaussian likelihoods. Their error bars may be highly correlated with other parameters and care must be taken when extrapolating to higher significance levels. In most cases we report the best fit running spectral index model parameters from the WMAPext plus 2dFGRS and Lyman α forest dataset, as reported in Ref. 2. Refer to Ref. 3 and the original papers for more information.

Quantity	Symbol, equation	Value	Reference, footnote
speed of light	c	299 792 458 m s^{-1}	defined[4]
Newtonian gravitational constant	G_N	$6.6742(10) \times 10^{-11}$ $m^3 kg^{-1}$ s^{-2}	[1, 5]
astronomical unit (mean $\oplus$–$\odot$ distance)	au	149 597 870 660(20) m	[6, 7]
tropical year (equinox to equinox) (2005.0)	yr	31 556 925.2 s	[6]
sidereal year (fixed star to fixed star) (2005.0)		31 558 149.8 s	[6]
mean sidereal day (2005.0)		$23^h\,56^m\,04^s.090\,53$	[6]
Jansky	Jy	10^{-26} W m^{-2} Hz^{-1}	
Planck mass	$\sqrt{\hbar c/G_N}$	$1.22090(9) \times 10^{19}$ GeV/c^2 $= 2.17645(16) \times 10^{-8}$ kg	[1]
Planck length	$\sqrt{\hbar G_N/c^3}$	$1.61624(12) \times 10^{-35}$ m	[1]
Hubble length	c/H_0	$\sim 1.2 \times 10^{26}$ m	[8]
parsec (1 AU/1 arc sec)	pc	$3.085\,677\,580\,7(4) \times 10^{16}$ m = 3.262...ly	[9]
light year (deprecated unit)	ly	0.306 6... pc = 0.946 1... $\times 10^{16}$ m	
Schwarzschild radius of the Sun	$2G_N M_\odot/c^2$	2.953 250 08 km	[10]
Solar mass	$M_\odot$	$1.988\,44(30) \times 10^{30}$ kg	[11]
Solar equatorial radius	$R_\odot$	6.961×10^8 m	[6]
Solar luminosity	$L_\odot$	$(3.846 \pm 0.008) \times 10^{26}$ W	[12]
Schwarzschild radius of the Earth	$2G_N M_\oplus/c^2$	8.870 056 22 mm	[13]
Earth mass	$M_\oplus$	$5.972\,3(9) \times 10^{24}$ kg	[14]
Earth mean equatorial radius	$R_\oplus$	$6.378\,140 \times 10^6$ m	[6]
luminosity conversion	L	$3.02 \times 10^{28} \times 10^{-0.4\ M_{\rm bol}}$ W ($M_{\rm bol}$ = absolute bolometric magnitude = bolometric magnitude at 10 pc	[15]
flux conversion	$\mathscr{F}$	$2.52 \times 10^{-8} \times 10^{-0.4\ m_{\rm bol}}$ W m^{-2} ($m_{\rm bol}$ = apparent bolometric magnitude)	from above
$v_\odot$ around center of Galaxy	$\Theta_\circ$	220(20) km s^{-1}	[16]
Solar distance from Galactic center	$R_\circ$	8.0(5) kpc	[17]
local disk density	$\rho_{\rm disk}$	3–12 $\times 10^{-24}$ g cm^{-3} $\approx$ 2–7 GeV/c^2 cm^{-3}	[18]
local halo density	$\rho_{\rm halo}$	2–13 $\times 10^{-25}$ g cm^{-3} $\approx$ 0.1–0.7 GeV/$c^2 cm^{-3}$	[19]
present day Hubble expansion rate	H_0	100 h km s^{-1} Mpc^{-1} $= h \times (9.778\,13\ {\rm Gyr})^{-1}$	[20]
present day normalized Hubble expansion rate	h	$0.71^{+0.04}_{-0.03}$	[2]
critical density of the Universe	$\rho_c = 3H_0^2/8\pi G_N$	$2.775\,366\,27 \times 10^{11}\, h^2\ M_\odot {\rm Mpc}^{-3}$ $= 1.878\,37(28) \times 10^{-29}\, h^2$ g cm^{-3} $= 1.053\,69(16) \times 10^{-5}\, h^2$ (GeV/c^2) cm^{-3}	derived
pressureless matter density of the Universe	$\Omega_m \equiv \rho_m/\rho_c$	$0.135^{+0.008}_{0.009}/h^2 = 0.27 \pm 0.04$	[2]
baryon density of the Universe	$\Omega_b \equiv \rho_b/\rho_c$	$0.0224 \pm 0.0009/h^2 = 0.044 \pm 0.004$	[2]
dark matter density of the Universe	$\Omega_{dm} \equiv \Omega_m - \Omega_b$	$0.113^{+0.008}_{-0.009}/h^2 = 0.22 \pm 0.04$	[21]
radiation density of the Universe	$\Omega_\gamma = \rho_\gamma/\rho_c$	$(2.471 \pm 0.004) \times 10^{-5}/h^2 = (4.9 \pm 0.5) \times 10^{-5}$	[22]
neutrino density of the Universe	Ω_ν	$< (0.0076/h^2 = 0.015)$, 95% C.L.	[2]
dark energy density	Ω_Λ	0.73 ± 0.04	[2]
total energy density	$\Omega_{\rm tot} = \Omega_m + \ldots + \Omega_\Lambda$	1.02 ± 0.02	[2]
number density of baryons	n_b	$(2.5 \pm 0.1) \times 10^{-7}/{\rm cm}^3$	[2]
number density of CMB photons	n_γ	$(410.4 \pm 0.5)/{\rm cm}^{-3}$	[23]
baryon-to-photon ratio	$\eta = n_b/n_\gamma$	$(6.1 \pm 0.2) \times 10^{-10}$	derived
scale factor for cosmological constant	$c^2/3H_0^2$	$2.853 \times 10^{51}\, h^{-2}$ m^2	
dark energy equation of state	w	< -0.78 at 95% C.L.	[2, 24]
fluctuation amplitude at $8h^{-1}$ Mpc scale	σ_8	0.84 ± 0.04	[2]
scalar spectral index at $k_0 = 0.05$ Mpc^{-1}	n_s	0.93 ± 0.03	[2]

Quantity	Symbol, equation	Value	Reference, footnote
running spectral index slope at $k_0 = 0.05$ Mpc^{-1}	$dn_s/d\,ln\,k$	$-0.031^{+0.023}_{-0.025}$	[2]
tensor to scalar field perturbations ratio at $k_0 = 0.002$ Mpc^{-1}	$r = T/S$	< 0.53 at 95% C.L.	[25, 26]
reionization optical depth	τ	0.17 ± 0.04	[2]
age of the Universe	t_0	13.7 ± 0.2 Gyr	[2]
present day CBR temperature	T_0	2.725 ± 0.001 K	[27]
Solar velocity with respect to CBR		368 ± 2 km/s towards $(\ell, b) = (263.85° \pm 0.10°, 48.25° \pm 0.04°)$	[28, 29]
local group velocity with respect to CBR	$v_{\rm LG}$	$627 \pm 22\,{\rm km\,s^{-1}}$ towards $(\ell, b) = (276° \pm 3°, 30° \pm 3°)$	[28]
entropy density/Boltzmann constant	s/k	$2\,889.2\ (T/2.725)^3$ cm^{-3}	[15]

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10. Product of $2/c^2$ and the heliocentric gravitational constant [6]. The given 9-place accuracy seems consistent with uncertainties in defining the earth's orbital parameters.
11. Obtained from the heliocentric gravitational constant [6] and G_N [1]. The error is the 150 ppm standard deviation of G_N.
12. 1996 mean total solar irradiance (TSI) = 1367.5 ± 2.7 [30]; the solar luminosity is $4\pi \times (1\ {\rm AU})^2$ times this quantity. This value increased by 0.036% between the minima of solar cycles 21 and 22. It was modulated with an amplitude of 0.039% during solar cycle 21 [31].

    Sackmann *et al.* [32] use TSI = 1370 ± 2 W m^{-2}, but conclude that the solar luminosity ($L_\odot = 3.853 \times 10^{26}$ J s^{-1}) has an uncertainty of 1.5%. Their value comes from three 1977–83 papers, and they comment that the error is based on scatter among the reported values, which is substantially in excess of that expected from the individual quoted errors.

    The conclusion of the 1971 review by Thekaekara and Drummond [33] ($1353 \pm 1\%$ W m^{-2}) is often quoted [34]. The conversion to luminosity is not given in the Thekaekara and Drummond paper, and we cannot exactly reproduce the solar luminosity given in Ref. 34.

    Finally, a value based on the 1954 spectral curve due to Johnson [35] ($1395 \pm 1\%$ W m^{-2}, or $L_\odot = 3.92 \times 10^{26}$ J s^{-1}) has been used widely, and may be the basis for the higher value of the solar luminosity and the corresponding lower value of the solar absolute bolometric magnitude (4.72) still common in the literature [15].
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