Fundamental Physical Constants — Atomic and Nuclear Constants

Quantity	Symbol	Value	Unit	Relative std. uncert. u_r
		General		
fine-structure constant $e^2/4\pi\epsilon_0\hbar c$	α	$7.297\,352\,5664(17) \times 10^{-3}$		2.3×10^{-10}
inverse fine-structure constant	α^{-1}	$137.035\,999\,139(31)$		2.3×10^{-10}
Rydberg constant $\alpha^2 m_e c/2h$	R_∞	$10\,973\,731.568\,508(65)$	m^{-1}	5.9×10^{-12}
	$R_\infty c$	$3.289\,841\,960\,355(19) \times 10^{15}$	Hz	5.9×10^{-12}
	$R_\infty hc$	$2.179\,872\,325(27) \times 10^{-18}$	J	1.2×10^{-8}
		$13.605\,693\,009(84)$	eV	6.1×10^{-9}
Bohr radius $\alpha/4\pi R_\infty = 4\pi\epsilon_0\hbar^2/m_e e^2$	a_0	$0.529\,177\,210\,67(12) \times 10^{-10}$	m	2.3×10^{-10}
Hartree energy $e^2/4\pi\epsilon_0 a_0 = 2R_\infty hc = \alpha^2 m_e c^2$	E_h	$4.359\,744\,650(54) \times 10^{-18}$	J	1.2×10^{-8}
		$27.211\,386\,02(17)$	eV	6.1×10^{-9}
quantum of circulation	$h/2m_e$	$3.636\,947\,5486(17) \times 10^{-4}$	$m^2\ s^{-1}$	4.5×10^{-10}
	h/m_e	$7.273\,895\,0972(33) \times 10^{-4}$	$m^2\ s^{-1}$	4.5×10^{-10}
		Electroweak		
Fermi coupling constant[1]	$G_F/(\hbar c)^3$	$1.166\,3787(6) \times 10^{-5}$	GeV^{-2}	5.1×10^{-7}
weak mixing angle[2] θ_W (on-shell scheme) $\sin^2\theta_W = s_W^2 \equiv 1 - (m_W/m_Z)^2$	$\sin^2\theta_W$	$0.2223(21)$		9.5×10^{-3}
		Electron, e^-		
electron mass	m_e	$9.109\,383\,56(11) \times 10^{-31}$	kg	1.2×10^{-8}
		$5.485\,799\,090\,70(16) \times 10^{-4}$	u	2.9×10^{-11}
energy equivalent	$m_e c^2$	$8.187\,105\,65(10) \times 10^{-14}$	J	1.2×10^{-8}
		$0.510\,998\,9461(31)$	MeV	6.2×10^{-9}
electron-muon mass ratio	m_e/m_μ	$4.836\,331\,70(11) \times 10^{-3}$		2.2×10^{-8}
electron-tau mass ratio	m_e/m_τ	$2.875\,92(26) \times 10^{-4}$		9.0×10^{-5}
electron-proton mass ratio	m_e/m_p	$5.446\,170\,213\,52(52) \times 10^{-4}$		9.5×10^{-11}
electron-neutron mass ratio	m_e/m_n	$5.438\,673\,4428(27) \times 10^{-4}$		4.9×10^{-10}
electron-deuteron mass ratio	m_e/m_d	$2.724\,437\,107\,484(96) \times 10^{-4}$		3.5×10^{-11}
electron-triton mass ratio	m_e/m_t	$1.819\,200\,062\,203(84) \times 10^{-4}$		4.6×10^{-11}
electron-helion mass ratio	m_e/m_h	$1.819\,543\,074\,854(88) \times 10^{-4}$		4.9×10^{-11}
electron to alpha particle mass ratio	m_e/m_α	$1.370\,933\,554\,798(45) \times 10^{-4}$		3.3×10^{-11}
electron charge to mass quotient	$-e/m_e$	$-1.758\,820\,024(11) \times 10^{11}$	$C\ kg^{-1}$	6.2×10^{-9}
electron molar mass $N_A m_e$	$M(e), M_e$	$5.485\,799\,090\,70(16) \times 10^{-7}$	$kg\ mol^{-1}$	2.9×10^{-11}
Compton wavelength $h/m_e c$	λ_C	$2.426\,310\,2367(11) \times 10^{-12}$	m	4.5×10^{-10}
$\lambda_C/2\pi = \alpha a_0 = \alpha^2/4\pi R_\infty$	$\lambda\!\!\!^{-}_C$	$386.159\,267\,64(18) \times 10^{-15}$	m	4.5×10^{-10}
classical electron radius $\alpha^2 a_0$	r_e	$2.817\,940\,3227(19) \times 10^{-15}$	m	6.8×10^{-10}
Thomson cross section $(8\pi/3)r_e^2$	σ_e	$0.665\,245\,871\,58(91) \times 10^{-28}$	m^2	1.4×10^{-9}
electron magnetic moment	μ_e	$-928.476\,4620(57) \times 10^{-26}$	$J\ T^{-1}$	6.2×10^{-9}
to Bohr magneton ratio	μ_e/μ_B	$-1.001\,159\,652\,180\,91(26)$		2.6×10^{-13}
to nuclear magneton ratio	μ_e/μ_N	$-1838.281\,972\,34(17)$		9.5×10^{-11}
electron magnetic moment anomaly $\lvert\mu_e\rvert/\mu_B - 1$	a_e	$1.159\,652\,180\,91(26) \times 10^{-3}$		2.3×10^{-10}
electron g-factor $-2(1 + a_e)$	g_e	$-2.002\,319\,304\,361\,82(52)$		2.6×10^{-13}
electron-muon magnetic moment ratio	μ_e/μ_μ	$206.766\,9880(46)$		2.2×10^{-8}
electron-proton magnetic moment ratio	μ_e/μ_p	$-658.210\,6866(20)$		3.0×10^{-9}
electron to shielded proton magnetic moment ratio (H_2O, sphere, 25 °C)	μ_e/μ'_p	$-658.227\,5971(72)$		1.1×10^{-8}
electron-neutron magnetic moment ratio	μ_e/μ_n	$960.920\,50(23)$		2.4×10^{-7}
electron-deuteron magnetic moment ratio	μ_e/μ_d	$-2143.923\,499(12)$		5.5×10^{-9}
electron to shielded helion magnetic				

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moment ratio (gas, sphere, 25 °C)	μ_e/μ'_h	864.058 257(10)		1.2×10^{-8}
electron gyromagnetic ratio $2\|\mu_e\|/\hbar$	γ_e	$1.760\,859\,644(11) \times 10^{11}$	$s^{-1}\ T^{-1}$	6.2×10^{-9}
	$\gamma_e/2\pi$	28 024.951 64(17)	MHz T^{-1}	6.2×10^{-9}
		Muon, μ^-		
muon mass	m_μ	$1.883\,531\,594(48) \times 10^{-28}$	kg	2.5×10^{-8}
		0.113 428 9257(25)	u	2.2×10^{-8}
energy equivalent	$m_\mu c^2$	$1.692\,833\,774(43) \times 10^{-11}$	J	2.5×10^{-8}
		105.658 3745(24)	MeV	2.3×10^{-8}
muon-electron mass ratio	m_μ/m_e	206.768 2826(46)		2.2×10^{-8}
muon-tau mass ratio	m_μ/m_τ	$5.946\,49(54) \times 10^{-2}$		9.0×10^{-5}
muon-proton mass ratio	m_μ/m_p	0.112 609 5262(25)		2.2×10^{-8}
muon-neutron mass ratio	m_μ/m_n	0.112 454 5167(25)		2.2×10^{-8}
muon molar mass $N_A m_\mu$	$M(\mu), M_\mu$	$0.113\,428\,9257(25) \times 10^{-3}$	kg mol^{-1}	2.2×10^{-8}
muon Compton wavelength $h/m_\mu c$	$\lambda_{C,\mu}$	$11.734\,441\,11(26) \times 10^{-15}$	m	2.2×10^{-8}
$\lambda_{C,\mu}/2\pi$	$\lambda\!\!\!^{-}_{C,\mu}$	$1.867\,594\,308(42) \times 10^{-15}$	m	2.2×10^{-8}
muon magnetic moment	μ_μ	$-4.490\,448\,26(10) \times 10^{-26}$	J T^{-1}	2.3×10^{-8}
to Bohr magneton ratio	μ_μ/μ_B	$-4.841\,970\,48(11) \times 10^{-3}$		2.2×10^{-8}
to nuclear magneton ratio	μ_μ/μ_N	−8.890 597 05(20)		2.2×10^{-8}
muon magnetic moment anomaly $\|\mu_\mu\|/(e\hbar/2m_\mu) - 1$	a_μ	$1.165\,920\,89(63) \times 10^{-3}$		5.4×10^{-7}
muon g-factor $-2(1 + a_\mu)$	g_μ	−2.002 331 8418(13)		6.3×10^{-10}
muon-proton magnetic moment ratio	μ_μ/μ_p	−3.183 345 142(71)		2.2×10^{-8}
		Tau, τ^-		
tau mass[3]	m_τ	$3.167\,47(29) \times 10^{-27}$	kg	9.0×10^{-5}
		1.907 49(17)	u	9.0×10^{-5}
energy equivalent	$m_\tau c^2$	$2.846\,78(26) \times 10^{-10}$	J	9.0×10^{-5}
		1776.82(16)	MeV	9.0×10^{-5}
tau-electron mass ratio	m_τ/m_e	3477.15(31)		9.0×10^{-5}
tau-muon mass ratio	m_τ/m_μ	16.8167(15)		9.0×10^{-5}
tau-proton mass ratio	m_τ/m_p	1.893 72(17)		9.0×10^{-5}
tau-neutron mass ratio	m_τ/m_n	1.891 11(17)		9.0×10^{-5}
tau molar mass $N_A m_\tau$	$M(\tau), M_\tau$	$1.907\,49(17) \times 10^{-3}$	kg mol^{-1}	9.0×10^{-5}
tau Compton wavelength $h/m_\tau c$	$\lambda_{C,\tau}$	$0.697\,787(63) \times 10^{-15}$	m	9.0×10^{-5}
$\lambda_{C,\tau}/2\pi$	$\lambda\!\!\!^{-}_{C,\tau}$	$0.111\,056(10) \times 10^{-15}$	m	9.0×10^{-5}
		Proton, p		
proton mass	m_p	$1.672\,621\,898(21) \times 10^{-27}$	kg	1.2×10^{-8}
		1.007 276 466 879(91)	u	9.0×10^{-11}
energy equivalent	$m_p c^2$	$1.503\,277\,593(18) \times 10^{-10}$	J	1.2×10^{-8}
		938.272 0813(58)	MeV	6.2×10^{-9}
proton-electron mass ratio	m_p/m_e	1836.152 673 89(17)		9.5×10^{-11}
proton-muon mass ratio	m_p/m_μ	8.880 243 38(20)		2.2×10^{-8}
proton-tau mass ratio	m_p/m_τ	0.528 063(48)		9.0×10^{-5}
proton-neutron mass ratio	m_p/m_n	0.998 623 478 44(51)		5.1×10^{-10}
proton charge to mass quotient	e/m_p	$9.578\,833\,226(59) \times 10^7$	C kg^{-1}	6.2×10^{-9}
proton molar mass $N_A m_p$	$M(p), M_p$	$1.007\,276\,466\,879(91) \times 10^{-3}$	kg mol^{-1}	9.0×10^{-11}
proton Compton wavelength $h/m_p c$	$\lambda_{C,p}$	$1.321\,409\,853\,96(61) \times 10^{-15}$	m	4.6×10^{-10}
$\lambda_{C,p}/2\pi$	$\lambda\!\!\!^{-}_{C,p}$	$0.210\,308\,910\,109(97) \times 10^{-15}$	m	4.6×10^{-10}
proton rms charge radius	r_p	$0.8751(61) \times 10^{-15}$	m	7.0×10^{-3}

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proton magnetic moment	μ_p	$1.410\,606\,7873(97) \times 10^{-26}$	J T^{-1}	6.9×10^{-9}
to Bohr magneton ratio	μ_p/μ_B	$1.521\,032\,2053(46) \times 10^{-3}$		3.0×10^{-9}
to nuclear magneton ratio	μ_p/μ_N	$2.792\,847\,3508(85)$		3.0×10^{-9}
proton g-factor $2\mu_p/\mu_N$	g_p	$5.585\,694\,702(17)$		3.0×10^{-9}
proton-neutron magnetic moment ratio	μ_p/μ_n	$-1.459\,898\,05(34)$		2.4×10^{-7}
shielded proton magnetic moment (H_2O, sphere, 25 °C)	μ'_p	$1.410\,570\,547(18) \times 10^{-26}$	J T^{-1}	1.3×10^{-8}
to Bohr magneton ratio	μ'_p/μ_B	$1.520\,993\,128(17) \times 10^{-3}$		1.1×10^{-8}
to nuclear magneton ratio	μ'_p/μ_N	$2.792\,775\,600(30)$		1.1×10^{-8}
proton magnetic shielding correction $1 - \mu'_p/\mu_p$ (H_2O, sphere, 25 °C)	σ'_p	$25.691(11) \times 10^{-6}$		4.4×10^{-4}
proton gyromagnetic ratio $2\mu_p/\hbar$	γ_p	$2.675\,221\,900(18) \times 10^{8}$	s^{-1} T^{-1}	6.9×10^{-9}
	$\gamma_p/2\pi$	$42.577\,478\,92(29)$	MHz T^{-1}	6.9×10^{-9}
shielded proton gyromagnetic ratio $2\mu'_p/\hbar$ (H_2O, sphere, 25 °C)	γ'_p	$2.675\,153\,171(33) \times 10^{8}$	s^{-1} T^{-1}	1.3×10^{-8}
	$\gamma'_p/2\pi$	$42.576\,385\,07(53)$	MHz T^{-1}	1.3×10^{-8}
		Neutron, n		
neutron mass	m_n	$1.674\,927\,471(21) \times 10^{-27}$	kg	1.2×10^{-8}
		$1.008\,664\,915\,88(49)$	u	4.9×10^{-10}
energy equivalent	$m_n c^2$	$1.505\,349\,739(19) \times 10^{-10}$	J	1.2×10^{-8}
		$939.565\,4133(58)$	MeV	6.2×10^{-9}
neutron-electron mass ratio	m_n/m_e	$1838.683\,661\,58(90)$		4.9×10^{-10}
neutron-muon mass ratio	m_n/m_μ	$8.892\,484\,08(20)$		2.2×10^{-8}
neutron-tau mass ratio	m_n/m_τ	$0.528\,790(48)$		9.0×10^{-5}
neutron-proton mass ratio	m_n/m_p	$1.001\,378\,418\,98(51)$		5.1×10^{-10}
neutron-proton mass difference	$m_n - m_p$	$2.305\,573\,77(85) \times 10^{-30}$	kg	3.7×10^{-7}
		$0.001\,388\,449\,00(51)$	u	3.7×10^{-7}
energy equivalent	$(m_n - m_p)c^2$	$2.072\,146\,37(76) \times 10^{-13}$	J	3.7×10^{-7}
		$1.293\,332\,05(48)$	MeV	3.7×10^{-7}
neutron molar mass $N_A m_n$	$M(n), M_n$	$1.008\,664\,915\,88(49) \times 10^{-3}$	kg mol^{-1}	4.9×10^{-10}
neutron Compton wavelength $h/m_n c$	$\lambda_{C,n}$	$1.319\,590\,904\,81(88) \times 10^{-15}$	m	6.7×10^{-10}
$\lambda_{C,n}/2\pi$	$\lambda\!\!\!^{-}_{C,n}$	$0.210\,019\,415\,36(14) \times 10^{-15}$	m	6.7×10^{-10}
neutron magnetic moment	μ_n	$-0.966\,236\,50(23) \times 10^{-26}$	J T^{-1}	2.4×10^{-7}
to Bohr magneton ratio	μ_n/μ_B	$-1.041\,875\,63(25) \times 10^{-3}$		2.4×10^{-7}
to nuclear magneton ratio	μ_n/μ_N	$-1.913\,042\,73(45)$		2.4×10^{-7}
neutron g-factor $2\mu_n/\mu_N$	g_n	$-3.826\,085\,45(90)$		2.4×10^{-7}
neutron-electron magnetic moment ratio	μ_n/μ_e	$1.040\,668\,82(25) \times 10^{-3}$		2.4×10^{-7}
neutron-proton magnetic moment ratio	μ_n/μ_p	$-0.684\,979\,34(16)$		2.4×10^{-7}
neutron to shielded proton magnetic moment ratio (H_2O, sphere, 25 °C)	μ_n/μ'_p	$-0.684\,996\,94(16)$		2.4×10^{-7}
neutron gyromagnetic ratio $2\lvert\mu_n\rvert/\hbar$	γ_n	$1.832\,471\,72(43) \times 10^{8}$	s^{-1} T^{-1}	2.4×10^{-7}
	$\gamma_n/2\pi$	$29.164\,6933(69)$	MHz T^{-1}	2.4×10^{-7}
		Deuteron, d		
deuteron mass	m_d	$3.343\,583\,719(41) \times 10^{-27}$	kg	1.2×10^{-8}
		$2.013\,553\,212\,745(40)$	u	2.0×10^{-11}
energy equivalent	$m_d c^2$	$3.005\,063\,183(37) \times 10^{-10}$	J	1.2×10^{-8}
		$1875.612\,928(12)$	MeV	6.2×10^{-9}
deuteron-electron mass ratio	m_d/m_e	$3670.482\,967\,85(13)$		3.5×10^{-11}

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deuteron-proton mass ratio	m_d/m_p	1.999 007 500 87(19)		9.3×10^{-11}
deuteron molar mass $N_A m_d$	$M(d), M_d$	$2.013\,553\,212\,745(40) \times 10^{-3}$	kg mol^{-1}	2.0×10^{-11}
deuteron rms charge radius	r_d	$2.1413(25) \times 10^{-15}$	m	1.2×10^{-3}
deuteron magnetic moment	μ_d	$0.433\,073\,5040(36) \times 10^{-26}$	J T^{-1}	8.3×10^{-9}
to Bohr magneton ratio	μ_d/μ_B	$0.466\,975\,4554(26) \times 10^{-3}$		5.5×10^{-9}
to nuclear magneton ratio	μ_d/μ_N	0.857 438 2311(48)		5.5×10^{-9}
deuteron g-factor μ_d/μ_N	g_d	0.857 438 2311(48)		5.5×10^{-9}
deuteron-electron magnetic moment ratio	μ_d/μ_e	$-4.664\,345\,535(26) \times 10^{-4}$		5.5×10^{-9}
deuteron-proton magnetic moment ratio	μ_d/μ_p	0.307 012 2077(15)		5.0×10^{-9}
deuteron-neutron magnetic moment ratio	μ_d/μ_n	−0.448 206 52(11)		2.4×10^{-7}
	Triton, t			
triton mass	m_t	$5.007\,356\,665(62) \times 10^{-27}$	kg	1.2×10^{-8}
		3.015 500 716 32(11)	u	3.6×10^{-11}
energy equivalent	$m_t c^2$	$4.500\,387\,735(55) \times 10^{-10}$	J	1.2×10^{-8}
		2808.921 112(17)	MeV	6.2×10^{-9}
triton-electron mass ratio	m_t/m_e	5496.921 535 88(26)		4.6×10^{-11}
triton-proton mass ratio	m_t/m_p	2.993 717 033 48(22)		7.5×10^{-11}
triton molar mass $N_A m_t$	$M(t), M_t$	$3.015\,500\,716\,32(11) \times 10^{-3}$	kg mol^{-1}	3.6×10^{-11}
triton magnetic moment	μ_t	$1.504\,609\,503(12) \times 10^{-26}$	J T^{-1}	7.8×10^{-9}
to Bohr magneton ratio	μ_t/μ_B	$1.622\,393\,6616(76) \times 10^{-3}$		4.7×10^{-9}
to nuclear magneton ratio	μ_t/μ_N	2.978 962 460(14)		4.7×10^{-9}
triton g-factor $2\mu_t/\mu_N$	g_t	5.957 924 920(28)		4.7×10^{-9}
	Helion, h			
helion mass	m_h	$5.006\,412\,700(62) \times 10^{-27}$	kg	1.2×10^{-8}
		3.014 932 246 73(12)	u	3.9×10^{-11}
energy equivalent	$m_h c^2$	$4.499\,539\,341(55) \times 10^{-10}$	J	1.2×10^{-8}
		2808.391 586(17)	MeV	6.2×10^{-9}
helion-electron mass ratio	m_h/m_e	5495.885 279 22(27)		4.9×10^{-11}
helion-proton mass ratio	m_h/m_p	2.993 152 670 46(29)		9.6×10^{-11}
helion molar mass $N_A m_h$	$M(h), M_h$	$3.014\,932\,246\,73(12) \times 10^{-3}$	kg mol^{-1}	3.9×10^{-11}
helion magnetic moment	μ_h	$-1.074\,617\,522(14) \times 10^{-26}$	J T^{-1}	1.3×10^{-8}
to Bohr magneton ratio	μ_h/μ_B	$-1.158\,740\,958(14) \times 10^{-3}$		1.2×10^{-8}
to nuclear magneton ratio	μ_h/μ_N	−2.127 625 308(25)		1.2×10^{-8}
helion g-factor $2\mu_h/\mu_N$	g_h	−4.255 250 616(50)		1.2×10^{-8}
shielded helion magnetic moment (gas, sphere, 25 °C)	μ'_h	$-1.074\,553\,080(14) \times 10^{-26}$	J T^{-1}	1.3×10^{-8}
to Bohr magneton ratio	μ'_h/μ_B	$-1.158\,671\,471(14) \times 10^{-3}$		1.2×10^{-8}
to nuclear magneton ratio	μ'_h/μ_N	−2.127 497 720(25)		1.2×10^{-8}
shielded helion to proton magnetic moment ratio (gas, sphere, 25 °C)	μ'_h/μ_p	−0.761 766 5603(92)		1.2×10^{-8}
shielded helion to shielded proton magnetic moment ratio (gas/H_2O, spheres, 25 °C)	μ'_h/μ'_p	−0.761 786 1313(33)		4.3×10^{-9}
shielded helion gyromagnetic ratio $2\lvert\mu'_h\rvert/\hbar$ (gas, sphere, 25 °C)	γ'_h	$2.037\,894\,585(27) \times 10^{8}$	s^{-1} T^{-1}	1.3×10^{-8}
	$\gamma'_h/2\pi$	32.434 099 66(43)	MHz T^{-1}	1.3×10^{-8}
	Alpha particle, α			
alpha particle mass	m_α	$6.644\,657\,230(82) \times 10^{-27}$	kg	1.2×10^{-8}
		4.001 506 179 127(63)	u	1.6×10^{-11}

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energy equivalent	$m_{\alpha}c^2$	$5.971\,920\,097(73) \times 10^{-10}$	J	1.2×10^{-8}
		$3727.379\,378(23)$	MeV	6.2×10^{-9}
alpha particle to electron mass ratio	$m_{\alpha}/m_{\mathrm{e}}$	$7294.299\,541\,36(24)$		3.3×10^{-11}
alpha particle to proton mass ratio	$m_{\alpha}/m_{\mathrm{p}}$	$3.972\,599\,689\,07(36)$		9.2×10^{-11}
alpha particle molar mass $N_{\mathrm{A}}m_{\alpha}$	$M(\alpha), M_{\alpha}$	$4.001\,506\,179\,127(63) \times 10^{-3}$	kg mol^{-1}	1.6×10^{-11}

[1] Value recommended by the Particle Data Group (Olive *et al.*, 2014).

[2] Based on the ratio of the masses of the W and Z bosons $m_{\mathrm{W}}/m_{\mathrm{Z}}$ recommended by the Particle Data Group (Olive *et al.*, 2014). The value for $\sin^2\theta_{\mathrm{W}}$ they recommend, which is based on a particular variant of the modified minimal subtraction ($\overline{\mathrm{MS}}$) scheme, is $\sin^2\hat{\theta}_{\mathrm{W}}(M_{\mathrm{Z}}) = 0.231\,26(5)$.

[3] This and all other values involving m_{τ} are based on the value of $m_{\tau}c^2$ in MeV recommended by the Particle Data Group (Olive *et al.*, 2014).