Fundamental Physical Constants — Atomic and Nuclear Constants

Quantity	Symbol	Value	Unit	Relative std. uncert. $u_{\rm r}$
		General		
fine-structure constant $e^2/4\pi\epsilon_0\hbar c$	α	$7.297\,352\,568(24)\times10^{-3}$		3.3×10^{-9}
inverse fine-structure constant	α^{-1}	$137.035\,999\,11(46)$		3.3×10^{-9}
Rydberg constant $\alpha^2 m_{\rm e}c/2h$	R_∞	$10\,973\,731.568\,525(73)$	$\rm m^{-1}$	6.6×10^{-12}
	$R_\infty c$	$3.289\,841\,960\,360(22)\times10^{15}$	Hz	6.6×10^{-12}
	$R_\infty hc$	$2.179\,872\,09(37)\times10^{-18}$	J	1.7×10^{-7}
$R_\infty hc$ in eV		$13.605\,6923(12)$	eV	8.5×10^{-8}
Bohr radius $\alpha/4\pi R_\infty = 4\pi\epsilon_0\hbar^2/m_{\rm e}e^2$	a_0	$0.529\,177\,2108(18)\times10^{-10}$	m	3.3×10^{-9}
Hartree energy $e^2/4\pi\epsilon_0 a_0 = 2R_\infty hc = \alpha^2 m_{\rm e}c^2$	$E_{\rm h}$	$4.359\,744\,17(75)\times10^{-18}$	J	1.7×10^{-7}
in eV		$27.211\,3845(23)$	eV	8.5×10^{-8}
quantum of circulation	$h/2m_{\rm e}$	$3.636\,947\,550(24)\times10^{-4}$	$\rm m^2\,s^{-1}$	6.7×10^{-9}
	$h/m_{\rm e}$	$7.273\,895\,101(48)\times10^{-4}$	$\rm m^2\,s^{-1}$	6.7×10^{-9}
		Electroweak		
Fermi coupling constant[1]	$G_{\rm F}/(\hbar c)^3$	$1.166\,39(1)\times10^{-5}$	$\rm GeV^{-2}$	8.6×10^{-6}
weak mixing angle[2] $\theta_{\rm W}$ (on-shell scheme) $\sin^2\theta_{\rm W} = s^2_{\rm W} \equiv 1-(m_{\rm W}/m_{\rm Z})^2$	$\sin^2\theta_{\rm W}$	$0.222\,15(76)$		3.4×10^{-3}
		Electron, $\rm e^-$		
electron mass	$m_{\rm e}$	$9.109\,3826(16)\times10^{-31}$	kg	1.7×10^{-7}
in u, $m_{\rm e} = A_{\rm r}({\rm e})$ u (electron relative atomic mass times u)		$5.485\,799\,0945(24)\times10^{-4}$	u	4.4×10^{-10}
energy equivalent	$m_{\rm e}c^2$	$8.187\,1047(14)\times10^{-14}$	J	1.7×10^{-7}
in MeV		$0.510\,998\,918(44)$	MeV	8.6×10^{-8}
electron-muon mass ratio	$m_{\rm e}/m_\mu$	$4.836\,331\,67(13)\times10^{-3}$		2.6×10^{-8}
electron-tau mass ratio	$m_{\rm e}/m_\tau$	$2.875\,64(47)\times10^{-4}$		1.6×10^{-4}
electron-proton mass ratio	$m_{\rm e}/m_{\rm p}$	$5.446\,170\,2173(25)\times10^{-4}$		4.6×10^{-10}
electron-neutron mass ratio	$m_{\rm e}/m_{\rm n}$	$5.438\,673\,4481(38)\times10^{-4}$		7.0×10^{-10}
electron-deuteron mass ratio	$m_{\rm e}/m_{\rm d}$	$2.724\,437\,1095(13)\times10^{-4}$		4.8×10^{-10}
electron to alpha particle mass ratio	$m_{\rm e}/m_\alpha$	$1.370\,933\,555\,75(61)\times10^{-4}$		4.4×10^{-10}
electron charge to mass quotient	$-e/m_{\rm e}$	$-1.758\,820\,12(15)\times10^{11}$	$\rm C\,kg^{-1}$	8.6×10^{-8}
electron molar mass $N_{\rm A}m_{\rm e}$	$M({\rm e}), M_{\rm e}$	$5.485\,799\,0945(24)\times10^{-7}$	$\rm kg\,mol^{-1}$	4.4×10^{-10}
Compton wavelength $h/m_{\rm e}c$	$\lambda_{\rm C}$	$2.426\,310\,238(16)\times10^{-12}$	m	6.7×10^{-9}
$\lambda_{\rm C}/2\pi = \alpha a_0 = \alpha^2/4\pi R_\infty$	$ƛ_{\rm C}$	$386.159\,2678(26)\times10^{-15}$	m	6.7×10^{-9}
classical electron radius $\alpha^2 a_0$	$r_{\rm e}$	$2.817\,940\,325(28)\times10^{-15}$	m	1.0×10^{-8}
Thomson cross section $(8\pi/3)r_{\rm e}^2$	$\sigma_{\rm e}$	$0.665\,245\,873(13)\times10^{-28}$	$\rm m^2$	2.0×10^{-8}
electron magnetic moment	$\mu_{\rm e}$	$-928.476\,412(80)\times10^{-26}$	$\rm J\,T^{-1}$	8.6×10^{-8}
to Bohr magneton ratio	$\mu_{\rm e}/\mu_{\rm B}$	$-1.001\,159\,652\,1859(38)$		3.8×10^{-12}
to nuclear magneton ratio	$\mu_{\rm e}/\mu_{\rm N}$	$-1838.281\,971\,07(85)$		4.6×10^{-10}
electron magnetic moment anomaly $\lvert\mu_{\rm e}\rvert/\mu_{\rm B}-1$	$a_{\rm e}$	$1.159\,652\,1859(38)\times10^{-3}$		3.2×10^{-9}

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Quantity	Symbol	Value	Unit	Relative std. uncert. u_r
electron g-factor $-2(1+a_e)$	g_e	$-2.002\,319\,304\,3718(75)$		3.8×10^{-12}
electron-muon magnetic moment ratio	μ_e/μ_μ	$206.766\,9894(54)$		2.6×10^{-8}
electron-proton magnetic moment ratio	μ_e/μ_p	$-658.210\,6862(66)$		1.0×10^{-8}
electron to shielded proton magnetic moment ratio (H_2O, sphere, 25 °C)	μ_e/μ'_p	$-658.227\,5956(71)$		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	$-2143.923\,493(23)$		1.1×10^{-8}
electron to shielded helion[3] magnetic moment ratio (gas, sphere, 25 °C)	μ_e/μ'_h	$864.058\,255(10)$		1.2×10^{-8}
electron gyromagnetic ratio $2\|\mu_e\|/\hbar$	γ_e	$1.760\,859\,74(15) \times 10^{11}$	$s^{-1}\ T^{-1}$	8.6×10^{-8}
	$\gamma_e/2\pi$	$28\,024.9532(24)$	MHz T^{-1}	8.6×10^{-8}
		Muon, μ^-		
muon mass	m_μ	$1.883\,531\,40(33) \times 10^{-28}$	kg	1.7×10^{-7}
in u, $m_\mu = A_r(\mu)$ u (muon relative atomic mass times u)		$0.113\,428\,9264(30)$	u	2.6×10^{-8}
energy equivalent	$m_\mu c^2$	$1.692\,833\,60(29) \times 10^{-11}$	J	1.7×10^{-7}
in MeV		$105.658\,3692(94)$	MeV	8.9×10^{-8}
muon-electron mass ratio	m_μ/m_e	$206.768\,2838(54)$		2.6×10^{-8}
muon-tau mass ratio	m_μ/m_τ	$5.945\,92(97) \times 10^{-2}$		1.6×10^{-4}
muon-proton mass ratio	m_μ/m_p	$0.112\,609\,5269(29)$		2.6×10^{-8}
muon-neutron mass ratio	m_μ/m_n	$0.112\,454\,5175(29)$		2.6×10^{-8}
muon molar mass $N_A m_\mu$	$M(\mu), M_\mu$	$0.113\,428\,9264(30) \times 10^{-3}$	kg mol^{-1}	2.6×10^{-8}
muon Compton wavelength $h/m_\mu c$	$\lambda_{C,\mu}$	$11.734\,441\,05(30) \times 10^{-15}$	m	2.5×10^{-8}
$\lambda_{C,\mu}/2\pi$	$\bar{\lambda}_{C,\mu}$	$1.867\,594\,298(47) \times 10^{-15}$	m	2.5×10^{-8}
muon magnetic moment	μ_μ	$-4.490\,447\,99(40) \times 10^{-26}$	J T^{-1}	8.9×10^{-8}
to Bohr magneton ratio	μ_μ/μ_B	$-4.841\,970\,45(13) \times 10^{-3}$		2.6×10^{-8}
to nuclear magneton ratio	μ_μ/μ_N	$-8.890\,596\,98(23)$		2.6×10^{-8}
muon magnetic moment anomaly $\|\mu_\mu\|/(e\hbar/2m_\mu) - 1$	a_μ	$1.165\,919\,81(62) \times 10^{-3}$		5.3×10^{-7}
muon g-factor $-2(1+a_\mu)$	g_μ	$-2.002\,331\,8396(12)$		6.2×10^{-10}
muon-proton magnetic moment ratio	μ_μ/μ_p	$-3.183\,345\,118(89)$		2.8×10^{-8}
		Tau, τ^-		
tau mass[4]	m_τ	$3.167\,77(52) \times 10^{-27}$	kg	1.6×10^{-4}
in u, $m_\tau = A_r(\tau)$ u (tau				

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Fundamental Physical Constants — Atomic and Nuclear Constants

Quantity	Symbol	Value	Unit	Relative std. uncert. u_r
relative atomic mass times u)		$1.907\,68(31)$	u	1.6×10^{-4}
energy equivalent	$m_\tau c^2$	$2.847\,05(46) \times 10^{-10}$	J	1.6×10^{-4}
in MeV		$1776.99(29)$	MeV	1.6×10^{-4}
tau-electron mass ratio	m_τ/m_e	$3477.48(57)$		1.6×10^{-4}
tau-muon mass ratio	m_τ/m_μ	$16.8183(27)$		1.6×10^{-4}
tau-proton mass ratio	m_τ/m_p	$1.893\,90(31)$		1.6×10^{-4}
tau-neutron mass ratio	m_τ/m_n	$1.891\,29(31)$		1.6×10^{-4}
tau molar mass $N_A m_\tau$	$M(\tau), M_\tau$	$1.907\,68(31) \times 10^{-3}$	kg mol^{-1}	1.6×10^{-4}
tau Compton wavelength $h/m_\tau c$	$\lambda_{C,\tau}$	$0.697\,72(11) \times 10^{-15}$	m	1.6×10^{-4}
$\lambda_{C,\tau}/2\pi$	$\lambda\!\!\!^{-}_{C,\tau}$	$0.111\,046(18) \times 10^{-15}$	m	1.6×10^{-4}
		Proton, p		
proton mass	m_p	$1.672\,621\,71(29) \times 10^{-27}$	kg	1.7×10^{-7}
in u, $m_p = A_r(p)$ u (proton relative atomic mass times u)		$1.007\,276\,466\,88(13)$	u	1.3×10^{-10}
energy equivalent	$m_p c^2$	$1.503\,277\,43(26) \times 10^{-10}$	J	1.7×10^{-7}
in MeV		$938.272\,029(80)$	MeV	8.6×10^{-8}
proton-electron mass ratio	m_p/m_e	$1836.152\,672\,61(85)$		4.6×10^{-10}
proton-muon mass ratio	m_p/m_μ	$8.880\,243\,33(23)$		2.6×10^{-8}
proton-tau mass ratio	m_p/m_τ	$0.528\,012(86)$		1.6×10^{-4}
proton-neutron mass ratio	m_p/m_n	$0.998\,623\,478\,72(58)$		5.8×10^{-10}
proton charge to mass quotient	e/m_p	$9.578\,833\,76(82) \times 10^{7}$	C kg^{-1}	8.6×10^{-8}
proton molar mass $N_A m_p$	$M(p), M_p$	$1.007\,276\,466\,88(13) \times 10^{-3}$	kg mol^{-1}	1.3×10^{-10}
proton Compton wavelength $h/m_p c$	$\lambda_{C,p}$	$1.321\,409\,8555(88) \times 10^{-15}$	m	6.7×10^{-9}
$\lambda_{C,p}/2\pi$	$\lambda\!\!\!^{-}_{C,p}$	$0.210\,308\,9104(14) \times 10^{-15}$	m	6.7×10^{-9}
proton rms charge radius	R_p	$0.8750(68) \times 10^{-15}$	m	7.8×10^{-3}
proton magnetic moment	μ_p	$1.410\,606\,71(12) \times 10^{-26}$	J T^{-1}	8.7×10^{-8}
to Bohr magneton ratio	μ_p/μ_B	$1.521\,032\,206(15) \times 10^{-3}$		1.0×10^{-8}
to nuclear magneton ratio	μ_p/μ_N	$2.792\,847\,351(28)$		1.0×10^{-8}
proton g-factor $2\mu_p/\mu_N$	g_p	$5.585\,694\,701(56)$		1.0×10^{-8}
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	$1.410\,570\,47(12) \times 10^{-26}$	J T^{-1}	8.7×10^{-8}
to Bohr magneton ratio	μ'_p/μ_B	$1.520\,993\,132(16) \times 10^{-3}$		1.1×10^{-8}
to nuclear magneton ratio	μ'_p/μ_N	$2.792\,775\,604(30)$		1.1×10^{-8}
proton magnetic shielding correction $1 - \mu'_p/\mu_p$ (H_2O, sphere, 25 °C)	σ'_p	$25.689(15) \times 10^{-6}$		5.7×10^{-4}
proton gyromagnetic ratio $2\mu_p/\hbar$	γ_p	$2.675\,222\,05(23) \times 10^{8}$	s^{-1} T^{-1}	8.6×10^{-8}
	$\gamma_p/2\pi$	$42.577\,4813(37)$	MHz T^{-1}	8.6×10^{-8}
shielded proton gyromagnetic				

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Quantity	Symbol	Value	Unit	Relative std. uncert. u_r
ratio $2\mu'_p/\hbar$ (H_2O, sphere, 25 °C)	γ'_p	$2.675\,153\,33(23) \times 10^{8}$	s^{-1} T^{-1}	8.6×10^{-8}
	$\gamma'_p/2\pi$	$42.576\,3875(37)$	MHz T^{-1}	8.6×10^{-8}
		Neutron, n		
neutron mass	m_n	$1.674\,927\,28(29) \times 10^{-27}$	kg	1.7×10^{-7}
in u, $m_n = A_r(n)$ u (neutron relative atomic mass times u)		$1.008\,664\,915\,60(55)$	u	5.5×10^{-10}
energy equivalent	$m_n c^2$	$1.505\,349\,57(26) \times 10^{-10}$	J	1.7×10^{-7}
in MeV		$939.565\,360(81)$	MeV	8.6×10^{-8}
neutron-electron mass ratio	m_n/m_e	$1838.683\,6598(13)$		7.0×10^{-10}
neutron-muon mass ratio	m_n/m_μ	$8.892\,484\,02(23)$		2.6×10^{-8}
neutron-tau mass ratio	m_n/m_τ	$0.528\,740(86)$		1.6×10^{-4}
neutron-proton mass ratio	m_n/m_p	$1.001\,378\,418\,70(58)$		5.8×10^{-10}
neutron molar mass $N_A m_n$	$M(n), M_n$	$1.008\,664\,915\,60(55) \times 10^{-3}$	kg mol^{-1}	5.5×10^{-10}
neutron Compton wavelength $h/m_n c$	$\lambda_{C,n}$	$1.319\,590\,9067(88) \times 10^{-15}$	m	6.7×10^{-9}
$\lambda_{C,n}/2\pi$	$\bar{\lambda}_{C,n}$	$0.210\,019\,4157(14) \times 10^{-15}$	m	6.7×10^{-9}
neutron magnetic moment	μ_n	$-0.966\,236\,45(24) \times 10^{-26}$	J T^{-1}	2.5×10^{-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	$-3.826\,085\,46(90)$		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	$1.832\,471\,83(46) \times 10^{8}$	s^{-1} T^{-1}	2.5×10^{-7}
	$\gamma_n/2\pi$	$29.164\,6950(73)$	MHz T^{-1}	2.5×10^{-7}
		Deuteron, d		
deuteron mass	m_d	$3.343\,583\,35(57) \times 10^{-27}$	kg	1.7×10^{-7}
in u, $m_d = A_r(d)$ u (deuteron relative atomic mass times u)		$2.013\,553\,212\,70(35)$	u	1.7×10^{-10}
energy equivalent	$m_d c^2$	$3.005\,062\,85(51) \times 10^{-10}$	J	1.7×10^{-7}
in MeV		$1875.612\,82(16)$	MeV	8.6×10^{-8}
deuteron-electron mass ratio	m_d/m_e	$3670.482\,9652(18)$		4.8×10^{-10}
deuteron-proton mass ratio	m_d/m_p	$1.999\,007\,500\,82(41)$		2.0×10^{-10}
deuteron molar mass $N_A m_d$	$M(d), M_d$	$2.013\,553\,212\,70(35) \times 10^{-3}$	kg mol^{-1}	1.7×10^{-10}
deuteron rms charge radius	R_d	$2.1394(28) \times 10^{-15}$	m	1.3×10^{-3}
deuteron magnetic moment	μ_d	$0.433\,073\,482(38) \times 10^{-26}$	J T^{-1}	8.7×10^{-8}
to Bohr magneton ratio	μ_d/μ_B	$0.466\,975\,4567(50) \times 10^{-3}$		1.1×10^{-8}

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to nuclear magneton ratio	μ_d/μ_N	$0.857\,438\,2329(92)$		1.1×10^{-8}
deuteron-electron magnetic moment ratio	μ_d/μ_e	$-4.664\,345\,548(50)\times10^{-4}$		1.1×10^{-8}
deuteron-proton magnetic moment ratio	μ_d/μ_p	$0.307\,012\,2084(45)$		1.5×10^{-8}
deuteron-neutron magnetic moment ratio	μ_d/μ_n	$-0.448\,206\,52(11)$		2.4×10^{-7}
		Helion, h		
helion mass[3]	m_h	$5.006\,412\,14(86)\times10^{-27}$	kg	1.7×10^{-7}
in u, $m_h = A_r(h)$ u (helion relative atomic mass times u)		$3.014\,932\,2434(58)$	u	1.9×10^{-9}
energy equivalent	m_hc^2	$4.499\,538\,84(77)\times10^{-10}$	J	1.7×10^{-7}
in MeV		$2808.391\,42(24)$	MeV	8.6×10^{-8}
helion-electron mass ratio	m_h/m_e	$5495.885\,269(11)$		2.0×10^{-9}
helion-proton mass ratio	m_h/m_p	$2.993\,152\,6671(58)$		1.9×10^{-9}
helion molar mass $N_A m_h$	$M(h), M_h$	$3.014\,932\,2434(58)\times10^{-3}$	kg mol^{-1}	1.9×10^{-9}
shielded helion magnetic moment (gas, sphere, 25 °C)	μ'_h	$-1.074\,553\,024(93)\times10^{-26}$	J T^{-1}	8.7×10^{-8}
to Bohr magneton ratio	μ'_h/μ_B	$-1.158\,671\,474(14)\times10^{-3}$		1.2×10^{-8}
to nuclear magneton ratio	μ'_h/μ_N	$-2.127\,497\,723(25)$		1.2×10^{-8}
shielded helion to proton magnetic moment ratio (gas, sphere, 25 °C)	μ'_h/μ_p	$-0.761\,766\,562(12)$		1.5×10^{-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	$2.037\,894\,70(18)\times10^{8}$	s^{-1} T^{-1}	8.7×10^{-8}
	$\gamma'_h/2\pi$	$32.434\,1015(28)$	MHz T^{-1}	8.7×10^{-8}
		Alpha particle, α		
alpha particle mass	m_α	$6.644\,6565(11)\times10^{-27}$	kg	1.7×10^{-7}
in u, $m_\alpha = A_r(\alpha)$ u (alpha particle relative atomic mass times u)		$4.001\,506\,179\,149(56)$	u	1.4×10^{-11}
energy equivalent	$m_\alpha c^2$	$5.971\,9194(10)\times10^{-10}$	J	1.7×10^{-7}
in MeV		$3727.379\,17(32)$	MeV	8.6×10^{-8}
alpha particle to electron mass ratio	m_α/m_e	$7294.299\,5363(32)$		4.4×10^{-10}
alpha particle to proton mass ratio	m_α/m_p	$3.972\,599\,689\,07(52)$		1.3×10^{-10}
alpha particle molar mass $N_A m_\alpha$	$M(\alpha), M_\alpha$	$4.001\,506\,179\,149(56)\times10^{-3}$	kg mol^{-1}	1.4×10^{-11}

[1] Value recommended by the Particle Data Group (Hagiwara, *et al.*, 2002).

[2] Based on the ratio of the masses of the W and Z bosons m_W/m_Z recommended by the Particle Data Group (Hagiwara, *et al.*, 2002). The value for $\sin^2\theta_W$ they recommend, which is based on a particular variant of the modified minimal subtraction $(\overline{\text{MS}})$ scheme, is $\sin^2\hat{\theta}_W(M_Z) = 0.231\,24(24)$.

Source: Peter J. Mohr and Barry N. Taylor, CODATA Recommended Values of the Fundamental Physical Constants: 2002, to be published in an archival journal in 2004.

[3] The helion, symbol h, is the nucleus of the ^{3}He atom.

[4] 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, (Hagiwara, *et al.*, 2002), but with a standard uncertainty of 0.29 MeV rather than the quoted uncertainty of -0.26 MeV, $+0.29$ MeV.