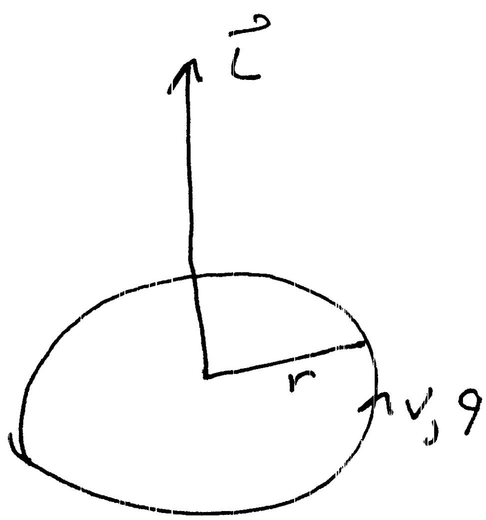
Spin

Consider a particle orbiting a fixed center with angular momentum L, mass m, and charge q.

The motion of charge is a current, so the system has a magnetic moment $\vec{\mu}$.



The magnetic moment is from UPII

$$\mu = NIA = I\pi r^2$$

$$I = \frac{q}{\text{period}} = \frac{q}{T}$$

$$v = \frac{2\pi r}{T} \quad \Rightarrow \quad T = \frac{2\pi r}{v}$$

$$I = \frac{qv}{2\pi r}$$

and

$$\mu = I \pi r^2 = \frac{qvr}{2}$$

The angular momentum is by definition

$$\vec{L} = \vec{r} \times \vec{p} = m \vec{r} \times \vec{v}$$

For a circular orbit,

$$|\vec{L}| = mrv$$

$$v = \frac{|\vec{L}|}{mr}$$

So

$$\mu = \frac{q}{2m} |\vec{L}|$$

or

$$\vec{\mu} = \frac{q}{2m} \vec{L}$$

The ratio of magnetic moment to angular momentum is called the gyromagnetic ratio γ.

$$\gamma = \frac{q}{2m} \quad \text{classical.}$$

Elementary particles have intrinsic angular momentum called spin, and therefore have an intrinsic magnetic moment.

For the electron, the gyromagnetic ratio is

$$\gamma_e = -\frac{e}{m}$$

twice the classical value.

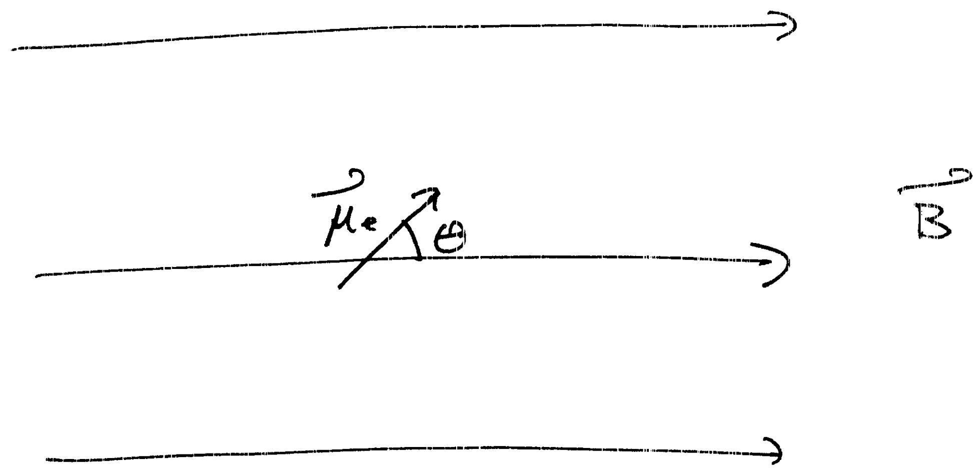
Therefore the magnetic moment of the electron can be calculated as

$$\vec{\mu}_e = \gamma_e \vec{S}$$

where $\vec{S}$ is the spin $\vec{S} = (S_x, S_y, S_z)$

We can consider two experiments with the magnetic moment of the electron.

(1) Place the electron (or any particle with moment) in a uniform magnetic field



Classically, the moment will oscillate about the field direction. The potential energy of the moment is

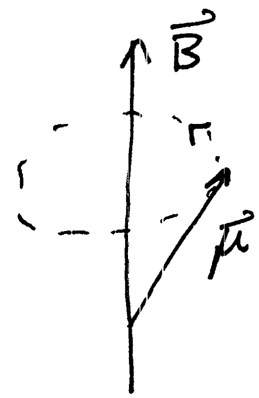
$$U = -\vec{\mu}\cdot\vec{B} = -|\vec{\mu}||\vec{B}|\cos\theta$$

⇒ However, our moment results from angular momentum which most be conserved.

The magnetic field exerts a torque

$$\vec{\tau} = \vec{\mu} \times \vec{B}$$

that causes the moment to precess about the field direction.



This precession occurs with a frequency

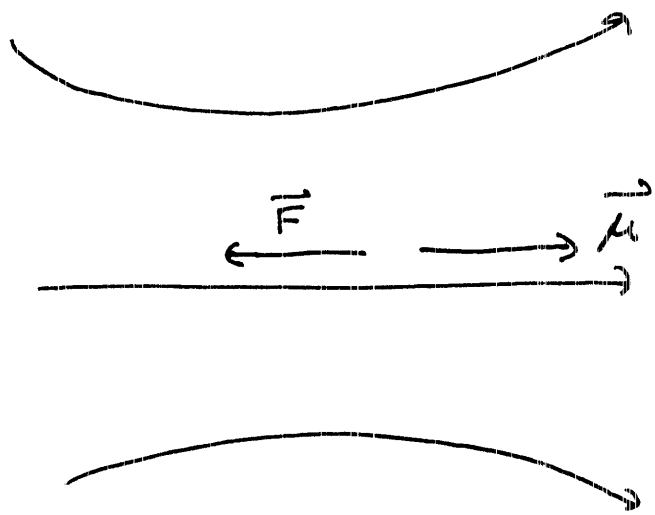
$$\omega = \gamma B$$

called the Larmor Frequency.

⟹ Note, the potential energy does not change; no losses in QM.

⟹ This is the same physics as a symmetric top under the force of gravity. While gravity exerts a torque that would tend to make the top fall over, to conserve angular momentum it precesses.

(2) We could place the magnetic moment in a non-uniform field



The moment aligns with the field and feels a force toward stronger field.

$$\vec{F} = \nabla(\mu \cdot \vec{B}) = -\nabla U$$

Fundamental Physical Constants — Universal constants

Quantity	Symbol	Value	Unit	Relative std. uncert. u_r
speed of light in vacuum	c, c_0	299 792 458	m s^{-1}	(exact)
magnetic constant	μ_0	$4\pi \times 10^{-7}$	N A^{-2}	
		$= 12.566\,370\,614... \times 10^{-7}$	N A^{-2}	(exact)
electric constant $1/\mu_0 c^2$	ϵ_0	$8.854\,187\,817... \times 10^{-12}$	F m^{-1}	(exact)
characteristic impedance of vacuum $\sqrt{\mu_0/\epsilon_0} = \mu_0 c$	Z_0	376.730 313 461...	Ω	(exact)
Newtonian constant of gravitation	G	$6.674\,28(67) \times 10^{-11}$	m^3 kg^{-1} s^{-2}	1.0×10^{-4}
	$G/\hbar c$	$6.708\,81(67) \times 10^{-39}$	$(\mathrm{GeV}/c^2)^{-2}$	1.0×10^{-4}
Planck constant	h	$6.626\,068\,96(33) \times 10^{-34}$	J s	5.0×10^{-8}
in eV s		$4.135\,667\,33(10) \times 10^{-15}$	eV s	2.5×10^{-8}
$h/2\pi$	$\hbar$	$1.054\,571\,628(53) \times 10^{-34}$	J s	5.0×10^{-8}
in eV s		$6.582\,118\,99(16) \times 10^{-16}$	eV s	2.5×10^{-8}
$\hbar c$ in MeV fm		197.326 9631(49)	MeV fm	2.5×10^{-8}
Planck mass $(\hbar c/G)^{1/2}$	m_P	$2.176\,44(11) \times 10^{-8}$	kg	5.0×10^{-5}
energy equivalent in GeV	$m_P c^2$	$1.220\,892(61) \times 10^{19}$	GeV	5.0×10^{-5}
Planck temperature $(\hbar c^5/G)^{1/2}/k$	T_P	$1.416\,785(71) \times 10^{32}$	K	5.0×10^{-5}
Planck length $\hbar/m_P c = (\hbar G/c^3)^{1/2}$	l_P	$1.616\,252(81) \times 10^{-35}$	m	5.0×10^{-5}
Planck time $l_P/c = (\hbar G/c^5)^{1/2}$	t_P	$5.391\,24(27) \times 10^{-44}$	s	5.0×10^{-5}

Fundamental Physical Constants — Electromagnetic constants

Quantity	Symbol	Value	Unit	Relative std. uncert. u_r
elementary charge	e	$1.602\,176\,487(40) \times 10^{-19}$	C	2.5×10^{-8}
	e/h	$2.417\,989\,454(60) \times 10^{14}$	$\mathrm{A\,J^{-1}}$	2.5×10^{-8}
magnetic flux quantum $h/2e$	Φ_0	$2.067\,833\,667(52) \times 10^{-15}$	Wb	2.5×10^{-8}
conductance quantum $2e^2/h$	G_0	$7.748\,091\,7004(53) \times 10^{-5}$	S	6.8×10^{-10}
inverse of conductance quantum	G_0^{-1}	$12\,906.403\,7787(88)$	Ω	6.8×10^{-10}
Josephson constant[1] $2e/h$	K_J	$483\,597.891(12) \times 10^9$	$\mathrm{Hz\,V^{-1}}$	2.5×10^{-8}
von Klitzing constant[2] $h/e^2 = \mu_0 c/2\alpha$	R_K	$25\,812.807\,557(18)$	Ω	6.8×10^{-10}
Bohr magneton $e\hbar/2m_e$	μ_B	$927.400\,915(23) \times 10^{-26}$	$\mathrm{J\,T^{-1}}$	2.5×10^{-8}
in eV $\mathrm{T^{-1}}$		$5.788\,381\,7555(79) \times 10^{-5}$	$\mathrm{eV\,T^{-1}}$	1.4×10^{-9}
	μ_B/h	$13.996\,246\,04(35) \times 10^9$	$\mathrm{Hz\,T^{-1}}$	2.5×10^{-8}
	μ_B/hc	$46.686\,4515(12)$	$\mathrm{m^{-1}\,T^{-1}}$	2.5×10^{-8}
	μ_B/k	$0.671\,7131(12)$	$\mathrm{K\,T^{-1}}$	1.7×10^{-6}
nuclear magneton $e\hbar/2m_p$	μ_N	$5.050\,783\,24(13) \times 10^{-27}$	$\mathrm{J\,T^{-1}}$	2.5×10^{-8}
in eV $\mathrm{T^{-1}}$		$3.152\,451\,2326(45) \times 10^{-8}$	$\mathrm{eV\,T^{-1}}$	1.4×10^{-9}
	μ_N/h	$7.622\,593\,84(19)$	$\mathrm{MHz\,T^{-1}}$	2.5×10^{-8}
	μ_N/hc	$2.542\,623\,616(64) \times 10^{-2}$	$\mathrm{m^{-1}\,T^{-1}}$	2.5×10^{-8}
	μ_N/k	$3.658\,2637(64) \times 10^{-4}$	$\mathrm{K\,T^{-1}}$	1.7×10^{-6}

[1] See the "Adopted values" table for the conventional value adopted internationally for realizing representations of the volt using the Josephson effect.

[2] See the "Adopted values" table for the conventional value adopted internationally for realizing representations of the ohm using the quantum Hall effect.

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	$7.297\,352\,5376(50) \times 10^{-3}$		6.8×10^{-10}
inverse fine-structure constant	α^{-1}	$137.035\,999\,679(94)$		6.8×10^{-10}
Rydberg constant $\alpha^2 m_e c/2h$	R_∞	$10\,973\,731.568\,527(73)$	$\mathrm{m^{-1}}$	6.6×10^{-12}
	$R_\infty c$	$3.289\,841\,960\,361(22) \times 10^{15}$	Hz	6.6×10^{-12}
	$R_\infty hc$	$2.179\,871\,97(11) \times 10^{-18}$	J	5.0×10^{-8}
$R_\infty hc$ in eV		$13.605\,691\,93(34)$	eV	2.5×10^{-8}
Bohr radius $\alpha/4\pi R_\infty = 4\pi\epsilon_0\hbar^2/m_e e^2$	a_0	$0.529\,177\,208\,59(36) \times 10^{-10}$	m	6.8×10^{-10}
Hartree energy $e^2/4\pi\epsilon_0 a_0 = 2R_\infty hc$ $= \alpha^2 m_e c^2$	E_h	$4.359\,743\,94(22) \times 10^{-18}$	J	5.0×10^{-8}
in eV		$27.211\,383\,86(68)$	eV	2.5×10^{-8}
quantum of circulation	$h/2m_e$	$3.636\,947\,5199(50) \times 10^{-4}$	$\mathrm{m^2\,s^{-1}}$	1.4×10^{-9}
	h/m_e	$7.273\,895\,040(10) \times 10^{-4}$	$\mathrm{m^2\,s^{-1}}$	1.4×10^{-9}
		Electroweak		
Fermi coupling constant[1]	$G_F/(\hbar c)^3$	$1.166\,37(1) \times 10^{-5}$	$\mathrm{GeV^{-2}}$	8.6×10^{-6}
weak mixing angle[2] θ_W (on-shell scheme) $\sin^2\theta_W = s_W^2 \equiv 1 - (m_W/m_Z)^2$	$\sin^2\theta_W$	$0.222\,55(56)$		2.5×10^{-3}
		Electron, e⁻		
electron mass	m_e	$9.109\,382\,15(45) \times 10^{-31}$	kg	5.0×10^{-8}
in u, $m_e = A_r(\mathrm{e})$ u (electron relative atomic mass times u)		$5.485\,799\,0943(23) \times 10^{-4}$	u	4.2×10^{-10}
energy equivalent	$m_e c^2$	$8.187\,104\,38(41) \times 10^{-14}$	J	5.0×10^{-8}
in MeV		$0.510\,998\,910(13)$	MeV	2.5×10^{-8}
electron-muon mass ratio	m_e/m_μ	$4.836\,331\,71(12) \times 10^{-3}$		2.5×10^{-8}
electron-tau mass ratio	m_e/m_τ	$2.875\,64(47) \times 10^{-4}$		1.6×10^{-4}
electron-proton mass ratio	m_e/m_p	$5.446\,170\,2177(24) \times 10^{-4}$		4.3×10^{-10}
electron-neutron mass ratio	m_e/m_n	$5.438\,673\,4459(33) \times 10^{-4}$		6.0×10^{-10}
electron-deuteron mass ratio	m_e/m_d	$2.724\,437\,1093(12) \times 10^{-4}$		4.3×10^{-10}
electron to alpha particle mass ratio	m_e/m_α	$1.370\,933\,555\,70(58) \times 10^{-4}$		4.2×10^{-10}
electron charge to mass quotient	$-e/m_e$	$-1.758\,820\,150(44) \times 10^{11}$	$\mathrm{C\,kg^{-1}}$	2.5×10^{-8}
electron molar mass $N_A m_e$	$M(\mathrm{e}), M_e$	$5.485\,799\,0943(23) \times 10^{-7}$	$\mathrm{kg\,mol^{-1}}$	4.2×10^{-10}
Compton wavelength $h/m_e c$	λ_C	$2.426\,310\,2175(33) \times 10^{-12}$	m	1.4×10^{-9}
$\lambda_C/2\pi = \alpha a_0 = \alpha^2/4\pi R_\infty$	$\lambda\!\!\!^{-}_C$	$386.159\,264\,59(53) \times 10^{-15}$	m	1.4×10^{-9}
classical electron radius $\alpha^2 a_0$	r_e	$2.817\,940\,2894(58) \times 10^{-15}$	m	2.1×10^{-9}
Thomson cross section $(8\pi/3)r_e^2$	σ_e	$0.665\,245\,8558(27) \times 10^{-28}$	$\mathrm{m^2}$	4.1×10^{-9}
electron magnetic moment	μ_e	$-928.476\,377(23) \times 10^{-26}$	$\mathrm{J\,T^{-1}}$	2.5×10^{-8}
to Bohr magneton ratio	μ_e/μ_B	$-1.001\,159\,652\,181\,11(74)$		7.4×10^{-13}
to nuclear magneton ratio	μ_e/μ_N	$-1838.281\,970\,92(80)$		4.3×10^{-10}
electron magnetic moment anomaly $\lvert\mu_e\rvert/\mu_B - 1$	a_e	$1.159\,652\,181\,11(74) \times 10^{-3}$		6.4×10^{-10}
electron g-factor $-2(1 + a_e)$	g_e	$-2.002\,319\,304\,3622(15)$		7.4×10^{-13}
electron-muon				

Fundamental Physical Constants --- Atomic and Nuclear Constants

Quantity	Symbol	Value	Unit	Relative std. uncert. u_r
magnetic moment ratio	μ_e/μ_μ	206.766 9877(52)		2.5×10^{-8}
electron-proton magnetic moment ratio	μ_e/μ_p	−658.210 6848(54)		8.1×10^{-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	−2143.923 498(18)		8.4×10^{-9}
electron to shielded helion magnetic 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	$1.760\,859\,770(44) \times 10^{11}$	$s^{-1}\ T^{-1}$	2.5×10^{-8}
	$\gamma_e/2\pi$	28 024.953 64(70)	MHz T^{-1}	2.5×10^{-8}
		Muon, μ^-		
muon mass	m_μ	$1.883\,531\,30(11) \times 10^{-28}$	kg	5.6×10^{-8}
in u, $m_\mu = A_r(\mu)$ u (muon relative atomic mass times u)		0.113 428 9256(29)	u	2.5×10^{-8}
energy equivalent	$m_\mu c^2$	$1.692\,833\,510(95) \times 10^{-11}$	J	5.6×10^{-8}
in MeV		105.658 3668(38)	MeV	3.6×10^{-8}
muon-electron mass ratio	m_μ/m_e	206.768 2823(52)		2.5×10^{-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 5261(29)		2.5×10^{-8}
muon-neutron mass ratio	m_μ/m_n	0.112 454 5167(29)		2.5×10^{-8}
muon molar mass $N_A m_\mu$	$M(\mu), M_\mu$	$0.113\,428\,9256(29) \times 10^{-3}$	kg mol^{-1}	2.5×10^{-8}
muon Compton wavelength $h/m_\mu c$	$\lambda_{C,\mu}$	$11.734\,441\,04(30) \times 10^{-15}$	m	2.5×10^{-8}
$\lambda_{C,\mu}/2\pi$	$\bar{\lambda}_{C,\mu}$	$1.867\,594\,295(47) \times 10^{-15}$	m	2.5×10^{-8}
muon magnetic moment	μ_μ	$-4.490\,447\,86(16) \times 10^{-26}$	J T^{-1}	3.6×10^{-8}
to Bohr magneton ratio	μ_μ/μ_B	$-4.841\,970\,49(12) \times 10^{-3}$		2.5×10^{-8}
to nuclear magneton ratio	μ_μ/μ_N	−8.890 597 05(23)		2.5×10^{-8}
muon magnetic moment anomaly $\|\mu_\mu\|/(e\hbar/2m_\mu) - 1$	a_μ	$1.165\,920\,69(60) \times 10^{-3}$		5.2×10^{-7}
muon g-factor $-2(1 + a_\mu)$	g_μ	−2.002 331 8414(12)		6.0×10^{-10}
muon-proton magnetic moment ratio	μ_μ/μ_p	−3.183 345 137(85)		2.7×10^{-8}
		Tau, τ^-		
tau mass[3]	m_τ	$3.167\,77(52) \times 10^{-27}$	kg	1.6×10^{-4}
in u, $m_\tau = A_r(\tau)$ u (tau 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}

Fundamental Physical Constants — Atomic and Nuclear Constants

Quantity	Symbol	Value	Unit	Relative std. uncert. u_r
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}
$\lambda_{C,\tau}/2\pi$	$\bar{\lambda}_{C,\tau}$	$0.111\,046(18) \times 10^{-15}$	m	1.6×10^{-4}
		Proton, p		
proton mass	m_p	$1.672\,621\,637(83) \times 10^{-27}$	kg	5.0×10^{-8}
in u, $m_p = A_r(\text{p})$ u (proton relative atomic mass times u)		1.007 276 466 77(10)	u	1.0×10^{-10}
energy equivalent	$m_p c^2$	$1.503\,277\,359(75) \times 10^{-10}$	J	5.0×10^{-8}
in MeV		938.272 013(23)	MeV	2.5×10^{-8}
proton-electron mass ratio	m_p/m_e	1836.152 672 47(80)		4.3×10^{-10}
proton-muon mass ratio	m_p/m_μ	8.880 243 39(23)		2.5×10^{-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 24(46)		4.6×10^{-10}
proton charge to mass quotient	e/m_p	$9.578\,833\,92(24) \times 10^{7}$	C kg^{-1}	2.5×10^{-8}
proton molar mass $N_A m_p$	$M(\text{p}), M_p$	$1.007\,276\,466\,77(10) \times 10^{-3}$	kg mol^{-1}	1.0×10^{-10}
proton Compton wavelength $h/m_p c$	$\lambda_{C,p}$	$1.321\,409\,8446(19) \times 10^{-15}$	m	1.4×10^{-9}
$\lambda_{C,p}/2\pi$	$\bar{\lambda}_{C,p}$	$0.210\,308\,908\,61(30) \times 10^{-15}$	m	1.4×10^{-9}
proton rms charge radius	R_p	$0.8768(69) \times 10^{-15}$	m	7.8×10^{-3}
proton magnetic moment	μ_p	$1.410\,606\,662(37) \times 10^{-26}$	J T^{-1}	2.6×10^{-8}
to Bohr magneton ratio	μ_p/μ_B	$1.521\,032\,209(12) \times 10^{-3}$		8.1×10^{-9}
to nuclear magneton ratio	μ_p/μ_N	2.792 847 356(23)		8.2×10^{-9}
proton g-factor $2\mu_p/\mu_N$	g_p	5.585 694 713(46)		8.2×10^{-9}
proton-neutron magnetic moment ratio	μ_p/μ_n	−1.459 898 06(34)		2.4×10^{-7}
shielded proton magnetic moment (H_2O, sphere, 25 °C)	μ'_p	$1.410\,570\,419(38) \times 10^{-26}$	J T^{-1}	2.7×10^{-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	2.792 775 598(30)		1.1×10^{-8}
proton magnetic shielding correction $1 - \mu'_p/\mu_p$ (H_2O, sphere, 25 °C)	σ'_p	$25.694(14) \times 10^{-6}$		5.3×10^{-4}
proton gyromagnetic ratio $2\mu_p/\hbar$	γ_p	$2.675\,222\,099(70) \times 10^{8}$	s^{-1} T^{-1}	2.6×10^{-8}
	$\gamma_p/2\pi$	42.577 4821(11)	MHz T^{-1}	2.6×10^{-8}
shielded proton gyromagnetic ratio $2\mu'_p/\hbar$ (H_2O, sphere, 25 °C)	γ'_p	$2.675\,153\,362(73) \times 10^{8}$	s^{-1} T^{-1}	2.7×10^{-8}
	$\gamma'_p/2\pi$	42.576 3881(12)	MHz T^{-1}	2.7×10^{-8}
		Neutron, n		
neutron mass	m_n	$1.674\,927\,211(84) \times 10^{-27}$	kg	5.0×10^{-8}
in u, $m_n = A_r(\text{n})$ u (neutron				

Fundamental Physical Constants — Atomic and Nuclear Constants

Quantity	Symbol	Value	Unit	Relative std. uncert. u_r
relative atomic mass times u)		1.008 664 915 97(43)	u	4.3×10^{-10}
energy equivalent	$m_n c^2$	$1.505\,349\,505(75) \times 10^{-10}$	J	5.0×10^{-8}
in MeV		939.565 346(23)	MeV	2.5×10^{-8}
neutron-electron mass ratio	m_n/m_e	1838.683 6605(11)		6.0×10^{-10}
neutron-muon mass ratio	m_n/m_μ	8.892 484 09(23)		2.5×10^{-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	1.001 378 419 18(46)		4.6×10^{-10}
neutron molar mass $N_A m_n$	$M(\mathrm{n}), M_n$	$1.008\,664\,915\,97(43) \times 10^{-3}$	kg mol^{-1}	4.3×10^{-10}
neutron Compton wavelength $h/m_n c$	$\lambda_{C,n}$	$1.319\,590\,8951(20) \times 10^{-15}$	m	1.5×10^{-9}
$\lambda_{C,n}/2\pi$	$\bar{\lambda}_{C,n}$	$0.210\,019\,413\,82(31) \times 10^{-15}$	m	1.5×10^{-9}
neutron magnetic moment	μ_n	$-0.966\,236\,41(23) \times 10^{-26}$	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 $2\|\mu_n\|/\hbar$	γ_n	$1.832\,471\,85(43) \times 10^{8}$	s^{-1} T^{-1}	2.4×10^{-7}
	$\gamma_n/2\pi$	29.164 6954(69)	MHz T^{-1}	2.4×10^{-7}
		Deuteron, d		
deuteron mass	m_d	$3.343\,583\,20(17) \times 10^{-27}$	kg	5.0×10^{-8}
in u, $m_d = A_r(\mathrm{d})$ u (deuteron relative atomic mass times u)		2.013 553 212 724(78)	u	3.9×10^{-11}
energy equivalent	$m_d c^2$	$3.005\,062\,72(15) \times 10^{-10}$	J	5.0×10^{-8}
in MeV		1875.612 793(47)	MeV	2.5×10^{-8}
deuteron-electron mass ratio	m_d/m_e	3670.482 9654(16)		4.3×10^{-10}
deuteron-proton mass ratio	m_d/m_p	1.999 007 501 08(22)		1.1×10^{-10}
deuteron molar mass $N_A m_d$	$M(\mathrm{d}), M_d$	$2.013\,553\,212\,724(78) \times 10^{-3}$	kg mol^{-1}	3.9×10^{-11}
deuteron rms charge radius	R_d	$2.1402(28) \times 10^{-15}$	m	1.3×10^{-3}
deuteron magnetic moment	μ_d	$0.433\,073\,465(11) \times 10^{-26}$	J T^{-1}	2.6×10^{-8}
to Bohr magneton ratio	μ_d/μ_B	$0.466\,975\,4556(39) \times 10^{-3}$		8.4×10^{-9}
to nuclear magneton ratio	μ_d/μ_N	0.857 438 2308(72)		8.4×10^{-9}
deuteron g-factor μ_d/μ_N	g_d	0.857 438 2308(72)		8.4×10^{-9}
deuteron-electron magnetic moment ratio	μ_d/μ_e	$-4.664\,345\,537(39) \times 10^{-4}$		8.4×10^{-9}
deuteron-proton magnetic moment ratio	μ_d/μ_p	0.307 012 2070(24)		7.7×10^{-9}
deuteron-neutron				

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Quantity	Symbol	Value	Unit	Relative std. uncert. u_r
magnetic moment ratio	μ_d/μ_n	$-0.448\,206\,52(11)$		2.4×10^{-7}
		Triton, t		
triton mass	m_t	$5.007\,355\,88(25) \times 10^{-27}$	kg	5.0×10^{-8}
in u, $m_t = A_r(t)$ u (triton relative atomic mass times u)		$3.015\,500\,7134(25)$	u	8.3×10^{-10}
energy equivalent	$m_t c^2$	$4.500\,387\,03(22) \times 10^{-10}$	J	5.0×10^{-8}
in MeV		$2808.920\,906(70)$	MeV	2.5×10^{-8}
triton-electron mass ratio	m_t/m_e	$5496.921\,5269(51)$		9.3×10^{-10}
triton-proton mass ratio	m_t/m_p	$2.993\,717\,0309(25)$		8.4×10^{-10}
triton molar mass $N_A m_t$	$M(t), M_t$	$3.015\,500\,7134(25) \times 10^{-3}$	kg mol^{-1}	8.3×10^{-10}
triton magnetic moment	μ_t	$1.504\,609\,361(42) \times 10^{-26}$	J T^{-1}	2.8×10^{-8}
to Bohr magneton ratio	μ_t/μ_B	$1.622\,393\,657(21) \times 10^{-3}$		1.3×10^{-8}
to nuclear magneton ratio	μ_t/μ_N	$2.978\,962\,448(38)$		1.3×10^{-8}
triton g-factor $2\mu_t/\mu_N$	g_t	$5.957\,924\,896(76)$		1.3×10^{-8}
triton-electron magnetic moment ratio	μ_t/μ_e	$-1.620\,514\,423(21) \times 10^{-3}$		1.3×10^{-8}
triton-proton magnetic moment ratio	μ_t/μ_p	$1.066\,639\,908(10)$		9.8×10^{-9}
triton-neutron magnetic moment ratio	μ_t/μ_n	$-1.557\,185\,53(37)$		2.4×10^{-7}
		Helion, h		
helion mass[4]	m_h	$5.006\,411\,92(25) \times 10^{-27}$	kg	5.0×10^{-8}
in u, $m_h = A_r(h)$ u (helion relative atomic mass times u)		$3.014\,932\,2473(26)$	u	8.6×10^{-10}
energy equivalent	$m_h c^2$	$4.499\,538\,64(22) \times 10^{-10}$	J	5.0×10^{-8}
in MeV		$2808.391\,383(70)$	MeV	2.5×10^{-8}
helion-electron mass ratio	m_h/m_e	$5495.885\,2765(52)$		9.5×10^{-10}
helion-proton mass ratio	m_h/m_p	$2.993\,152\,6713(26)$		8.7×10^{-10}
helion molar mass $N_A m_h$	$M(h), M_h$	$3.014\,932\,2473(26) \times 10^{-3}$	kg mol^{-1}	8.6×10^{-10}
shielded helion magnetic moment (gas, sphere, 25 °C)	μ'_h	$-1.074\,552\,982(30) \times 10^{-26}$	J T^{-1}	2.8×10^{-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	$-2.127\,497\,718(25)$		1.2×10^{-8}
shielded helion to proton magnetic moment ratio (gas, sphere, 25 °C)	μ'_h/μ_p	$-0.761\,766\,558(11)$		1.4×10^{-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 $2\|\mu'_h\|/\hbar$ (gas, sphere, 25 °C)	γ'_h	$2.037\,894\,730(56) \times 10^{8}$	s^{-1} T^{-1}	2.8×10^{-8}
	$\gamma'_h/2\pi$	$32.434\,101\,98(90)$	MHz T^{-1}	2.8×10^{-8}

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Quantity	Symbol	Value	Unit	Relative std. uncert. u_r
		Alpha particle, α		
alpha particle mass	m_α	$6.644\,656\,20(33) \times 10^{-27}$	kg	5.0×10^{-8}
in u, $m_\alpha = A_r(\alpha)$ u (alpha particle relative atomic mass times u)		$4.001\,506\,179\,127(62)$	u	1.5×10^{-11}
energy equivalent	$m_\alpha c^2$	$5.971\,919\,17(30) \times 10^{-10}$	J	5.0×10^{-8}
in MeV		$3727.379\,109(93)$	MeV	2.5×10^{-8}
alpha particle to electron mass ratio	m_α/m_e	$7294.299\,5365(31)$		4.2×10^{-10}
alpha particle to proton mass ratio	m_α/m_p	$3.972\,599\,689\,51(41)$		1.0×10^{-10}
alpha particle molar mass $N_A m_\alpha$	$M(\alpha), M_\alpha$	$4.001\,506\,179\,127(62) \times 10^{-3}$	kg mol^{-1}	1.5×10^{-11}

[1] Value recommended by the Particle Data Group (Yao, *et al.*, 2006).

[2] Based on the ratio of the masses of the W and Z bosons m_W/m_Z recommended by the Particle Data Group (Yao, *et al.*, 2006). The value for $\sin^2\theta_W$ they recommend, which is based on a particular variant of the modified minimal subtraction ($\overline{\rm MS}$) scheme, is $\sin^2\hat{\theta}_W(M_Z) = 0.231\,22(15)$.

[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 (Yao, *et al.*, 2006), but with a standard uncertainty of 0.29 MeV rather than the quoted uncertainty of −0.26 MeV, +0.29 MeV.

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