Chapter 15

Equations and Definitions

Properties of a Single Rotar

\[ A_\beta = \frac{L_p}{\lambda_c} = T_p \omega_c = \sqrt{\frac{Gm^2}{hc}} = \frac{m}{m_p} = \frac{E_i}{E_p} = \frac{\omega_c}{\omega_p} = \sqrt{\frac{\beta_q}{P_p}} \quad A_\beta = \text{rotar strain amplitude} \]

\[ \lambda_c = \frac{h}{mc} = \frac{c}{\omega_c} = \frac{hc}{E_i} = \frac{L_p^2}{R_s} = \frac{L_p}{A_\beta} \quad \lambda_c = \text{rotar radius (Compton radius)} \]

\[ \omega_c = \frac{mc^2}{h} = \frac{c}{\lambda_c} = A_\beta \omega_p \quad \omega_c = \text{Compton angular frequency} \]

\[ E_i = mc^2 = \omega_c h = \frac{hc}{R_q} = \frac{p_c}{\omega_c} = F_m \lambda_c = A_\beta E_p \quad E_i = \text{internal energy} \]

\[ m = \frac{E_i}{c^2} = \frac{h}{\lambda_c c} = \frac{\omega_c h}{c^2} = T_p^2 \omega_c Z_s = A_\beta m_p \quad m = \text{rotar mass} \]

\[ P_c = E_i \omega_c = \omega_c^2 h = \frac{E_i^2}{h} = \frac{hc^2}{\lambda_c^2} = \frac{m^2 c^4}{h} = A_\beta^2 P_p \quad P_c = \text{circulating power} \]

\[ F_m = \frac{m^2 c^3}{h} = \frac{hc}{\lambda_c^2} = \frac{h \omega_c^2}{c} = A_\beta^2 F_p \quad F_m = \text{maximum force at distance } \lambda_c \]

\[ U_q = \frac{E_i}{h^3} = \frac{m^4 c^5}{G} = A_\beta^4 U_p \quad U_q = \text{rotar volume energy density} \]

\[ \beta_q = \frac{Gm^2}{hc} = A_\beta^2 \quad \beta_q = \text{gravitational magnitude at rotar radius} \]

\[ N = \frac{r}{\lambda_c} = \frac{rm_c}{h} \quad N = \text{distance (r) from a rotar expressed as the number of } \lambda_c \text{ units} \]

\[ A_e = \frac{\sqrt{\alpha} L_p \lambda_c}{r^2} = \sqrt{\alpha} \frac{H_\beta}{N^2} \quad A_e = \text{electromagnetic standing wave strain amplitude (oscillating)} \]

\[ A_E = \sqrt{\alpha} \frac{L_p}{r} = \sqrt{\alpha} \frac{H_\beta}{N} \quad A_E = \text{electromagnetic non-oscillating strain amplitude} \]

\[ A_g = \frac{L_p^2}{r^2} = \frac{H_\beta^2}{N^2} \quad A_g = \text{gravitational standing wave strain amplitude oscillating at } 2\omega_c \]

\[ A_G = \beta = \frac{Gm^2}{c^2 r} = \frac{H_\beta^2}{N} \quad A_G = \text{gravitational non-oscillating strain amplitude} \]

\[ A_f = \frac{L_p}{r} \quad A_f = \text{hypothetical fundamental amplitude before cancelation} \]

5 Wave-Amplitude Equations

\[ J = k A^2 \omega^2 Z \quad J = \text{intensity (w/m}^2) \]

\[ U = k A^2 \omega^2 Z/c = P \quad U = \text{energy density (J/m}^3) \quad (U = J/c) \text{ and } U = P \]

\[ E = k A^2 \omega^2 Z V/c \quad E = \text{energy (J)} \quad (E = JV/c) \]

\[ P = k A^2 \omega^2 Z A \quad P = \text{power (J/s)} \quad (P = JA) \]

\[ F = k A^2 \omega^2 Z A/c \quad F = \text{force (N)} \quad (F = JA/c) \]
Planck Units

\begin{align*}
L_p &= \text{Planck length} \\
&= T_p c = \sqrt{\hbar G/c^3} \\
&= 1.616 \times 10^{-35} \text{ m} \\
m_p &= \text{Planck mass} \\
&= \sqrt{\hbar c/G} \\
&= 2.176 \times 10^{-8} \text{ kg} \\
T_p &= \text{Planck time} \\
&= L_p / c = \sqrt{\hbar G/c^5} \\
&= 5.391 \times 10^{-44} \text{ s} \\
q_p &= \text{Planck charge} \\
&= e / \sqrt{\alpha} = \sqrt{\frac{4 \pi \varepsilon_0 \hbar c}{\mu_0}} \\
&= 1.876 \times 10^{-18} \text{ Coulomb} \\
E_p &= \text{Planck energy} \\
&= m_p c^2 = \sqrt{\hbar c^5 / G} \\
&= 1.956 \times 10^9 \text{ J} \\
\omega_p &= \text{Planck angular frequency} \\
&= 1 / T_p = \sqrt{c^7 / \hbar G} \\
&= 1.855 \times 10^{43} \text{ s}^{-1} \\
F_p &= \text{Planck force} \\
&= E_p / L_p = c^4 / G \\
&= 1.210 \times 10^{44} \text{ N} \\
P_p &= \text{Planck power} \\
&= E_p / T_p = c^5 / G \\
&= 3.628 \times 10^{52} \text{ W} \\
p_p &= \text{Planck momentum} \\
&= E_p / c = \sqrt{\hbar c^3 / G} \\
&= 6.525 \text{ kg m/s} \\
U_p &= \text{Planck energy density} \\
&= E_p / L_p^3 = c^7 / \hbar G^2 \\
&= 4.636 \times 10^{113} \text{ J/m}^3 \\
\rho_p &= \text{Planck density} \\
&= m_p / L_p^3 = c^5 / \hbar G^2 \\
&= 5.155 \times 10^{96} \text{ kg/m}^3 \\
\mathcal{V}_p &= \text{Planck electrical potential} \\
&= E_p / q_p = \sqrt{c^4 / 4 \pi \varepsilon_0 G} \\
&= 1.043 \times 10^{27} \text{ V} \\
\mathcal{E}_p &= \text{Planck electric field} \\
&= F_p / q_p = \sqrt{c^7 / 4 \pi \varepsilon_0 \hbar G^2} \\
&= 6.450 \times 10^{61} \text{ V/m} \\
\mathcal{B}_p &= \text{Planck magnetic field} \\
&= Z / \varphi_p = \sqrt{\mu_0 c^7 / 4 \pi \hbar G^2} \\
&= 2.152 \times 10^{53} \text{ Tesla} \\
\mathcal{I}_p &= \text{Planck current} \\
&= \mathcal{I}_p / T_p = \sqrt{4 \pi \varepsilon_0 c^6 / G} \\
&= 3.480 \times 10^{18} \text{ amp} \\
Z_p &= \text{Planck impedance} \\
&= \hbar / q_p^2 = 1 / 4 \pi \varepsilon_0 c \\
&= 29.98 \Omega
\end{align*}

Gravitational \( \Gamma \) and \( \beta \) (excludes cosmology equalities)

\begin{align*}
\Gamma &= \frac{dt}{d\tau} = \frac{1}{\sqrt{1 - \frac{2m}{c^2 r}}} \\
&= 1 - \frac{\beta}{1 - \beta} \\
&= \text{gravitational gamma}
\end{align*}

\begin{align*}
\alpha &= 1 + \frac{6m}{c^2 r} \\
&\approx 1 + \beta \\
&= \text{weak gravity approximations}
\end{align*}

\begin{align*}
\beta &= \frac{1 - \frac{dt}{d\tau}}{1 - \sqrt{1 - \frac{2m}{c^2 R}}} \\
&= 1 - \frac{1}{1 - \Gamma} \\
&= \text{gravitational magnitude}
\end{align*}

\begin{align*}
\beta &= \frac{Gm}{c^2 r} \\
&\approx \frac{gr}{c^2} = \frac{R_s}{r} \\
&= \text{weak gravity approximation}
\end{align*}

\begin{align*}
\beta_q &= H_{\beta q} \approx \frac{Gm^2}{hc} \\
&= \text{gravitational magnitude in a rotar at } \lambda_c
\end{align*}

Properties of Spacetime

\begin{align*}
Z_s &= \frac{c^3}{G} = 4.038 \times 10^{35} \text{ kg/s} \\
&= \text{impedance of spacetime}
\end{align*}

\begin{align*}
K_s &= \frac{F_p}{\lambda^2} \\
&= \text{bulk modulus of spacetime} \\
&= K \left( \frac{\Delta p}{\Delta V / V} \right)
\end{align*}

\begin{align*}
U_i &= \frac{c^2 \omega^2}{G} = \frac{F_p}{\lambda^2} = \left( \frac{\omega}{\omega_p} \right)^2 U_p \\
&= \text{interactive energy density of spacetime}
\end{align*}

\begin{align*}
A_{\max} &= \frac{F_p}{\lambda} = T_p \omega \\
&= \text{maximum displacement amplitude of a dipole wave in spacetime}
\end{align*}
Charge Conversion Constant
\[ \eta \equiv \frac{L_p}{q_p} \equiv \sqrt{\alpha L_p} e = \sqrt{\frac{1}{4\pi \varepsilon_0 F_p}} = 8.617 \times 10^{-18} \text{ m/Coulomb} \]
\[ \eta = \text{charge conversion constant} \]

Characteristics of an Electron
\[ A_\beta = 4.1851 \times 10^{-23} \]
\[ \lambda_c = 3.8616 \times 10^{-13} \text{ m} \]
\[ \omega_c = 7.7634 \times 10^{20} \text{ s}^{-1} \]
\[ v_c = 1.2356 \times 10^{20} \text{ Hz} \]
\[ E_i = 8.1871 \times 10^{-14} \text{ J} \]
\[ m_e = 9.1094 \times 10^{-31} \text{ kg} \]
\[ e = 1.6022 \times 10^{-19} \text{ Coulomb} \]
\[ P_c = 6.3560 \times 10^7 \text{ w} \]
\[ F_m = 0.21201 \text{ N} \]
\[ R_s = 6.7635 \times 10^{-58} \text{ } \]
\[ U = \frac{E_i}{\lambda_c^3} = 1.4218 \times 10^{24} \text{ J/m}^3 \]
\[ U = (3/4\pi)E_i/\lambda_c^3 = 3.3942 \times 10^{23} \text{ J/m}^3 \]
\[ a_g = 9.7404 \times 10^6 \text{ m/s}^2 \]
\[ g_q = 4.0764 \times 10^{-16} \text{ m/s}^2 \]
\[ \mathbb{E}_c \approx 19.796 \text{ amps} \]
\[ \mathbb{B}_c \approx 3.22 \times 10^7 \text{ Tesla} \]

Some Useful Dimensional Analysis Conversions

<table>
<thead>
<tr>
<th>Dimensional Analysis Symbols:</th>
<th>U → M/LT^2</th>
<th>G → L^3/MT^2</th>
<th>h → ML^2/T</th>
<th>Z → M/T</th>
<th>E → ML^2/T^2</th>
<th>F → ML/T^2</th>
<th>( \varepsilon_0 ) → T^2Q^2/ML^3</th>
<th>( \mu_0 ) → ML/Q^2</th>
<th>( \mathbb{E} ) → ML/T^2Q</th>
<th>( \mathbb{H} ) → Q/LT</th>
<th>( \Omega ) → ML^2/T^2Q^2</th>
<th>( \mathcal{V} ) → ML^2/T^2Q</th>
</tr>
</thead>
<tbody>
<tr>
<td>U → energy density</td>
<td>M = mass</td>
<td>L = length</td>
<td>T = time</td>
<td>Z = impedance of spacetime</td>
<td>E = energy</td>
<td>F = force</td>
<td>( \varepsilon_0 ) = permittivity</td>
<td>( \mu_0 ) = permeability</td>
<td>( \mathbb{E} ) = electric field</td>
<td>( \mathbb{H} ) = “H” magnetic field (ampere/meter)</td>
<td>( \mathcal{B} ) = “B” magnetic field (Tesla)</td>
<td>( \Omega ) = resistance</td>
</tr>
</tbody>
</table>

Normalized Transformations
(assumes coordinate rate of time and proper length is coordinate length)

\[ L_o = L_g \quad \text{unit of length} \quad M_o = M_g / \Gamma \quad \text{unit of mass} \]
\[ T_o = T_g / \Gamma \quad \text{unit of time} \quad Q_o = Q_g \quad \text{charge (coulombs)} \]
\[ \Theta_o = \Theta_g \quad \text{temperature} \]
\[ C_o = \Gamma C_g \quad \text{normalized speed of light} \]
\[ dR = dL/\Gamma \quad \text{circumferential radius} \]
\[ E_o = \Gamma E_g \quad \text{energy} \]
\[ v_o = \Gamma v_g \quad \text{velocity} \]
\[ F_o = \Gamma F_g \quad \text{force} \]
\[ P_o = \Gamma^2 P_g \quad \text{power} \]
\[ G_o = \Gamma^3 G_g \quad \text{gravitational constant} \]
\[ U_o = \Gamma U_g \quad \text{energy density} \]
\[ \rho_o = \rho_g/\Gamma \quad \text{density} \]
\[ \omega_o = \Gamma \omega_g \quad \text{frequency} \]
\[ k_o = \Gamma k_g \quad \text{Boltzmann’s constant} \]

**Transformation of Planck Units into Spacetime Units**

<table>
<thead>
<tr>
<th>Planck Units</th>
<th>Standard Conversion</th>
<th>Spacetime Conversion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planck length</td>
<td>[ L_p = \sqrt{\hbar G}/c^3 ]</td>
<td>[ L_p = cT_p ]</td>
</tr>
<tr>
<td>Planck mass</td>
<td>[ m_p = \sqrt{\hbar c/G} ]</td>
<td>[ m_p = Z_s T_p ]</td>
</tr>
<tr>
<td>Planck frequency</td>
<td>[ \omega_p = \sqrt{c^5/\hbar G} ]</td>
<td>[ \omega_p = 1/T_p ]</td>
</tr>
<tr>
<td>Planck impedance</td>
<td>[ Z_p = 1/(4\pi\varepsilon_o c) ]</td>
<td>[ Z_p = Z_s ]</td>
</tr>
<tr>
<td>Planck charge</td>
<td>[ q_p = \sqrt{4\pi\varepsilon_o \hbar c} ]</td>
<td>[ q_p = cT_p ]</td>
</tr>
<tr>
<td>Planck energy</td>
<td>[ E_p = \sqrt{\hbar c^5/G} ]</td>
<td>[ E_p = c^2 T_p Z_s ]</td>
</tr>
<tr>
<td>Planck force</td>
<td>[ F_p = c^4/G ]</td>
<td>[ F_p = cZ_s ]</td>
</tr>
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<td>Planck power</td>
<td>[ P_p = c^5/G ]</td>
<td>[ P_p = c^2 Z_s ]</td>
</tr>
<tr>
<td>Planck energy density</td>
<td>[ U_p = c^7/\hbar G^2 ]</td>
<td>[ U_p = Z_s/c^2 T_p^2 ]</td>
</tr>
</tbody>
</table>

**Transformation of Standard Units into Spacetime Units**

\[ \eta \equiv \frac{L_0}{q_p} = \frac{\sqrt{\alpha L_0}}{e} = \frac{1}{\sqrt{4\pi\varepsilon_o F_p}} = 8.617 \times 10^{-18} \text{ m/Coulomb} \]
\[ \eta = \text{charge conversion constant} \]

**Name**

- Elementary charge (\( e \))
- Planck charge (\( q_p \))
- Coulomb force constant (\( 1/4\pi\varepsilon_o \))
- Permeability of free space (\( \mu_o \))
- Electric field of EM radiation (\( \mathcal{E}_\gamma \))
- Magnetic field of EM radiation (\( \mathcal{B}_\gamma \))
- Impedance of free space (\( Z_\infty \))
- Planck impedance (\( Z_\gamma \))
- Planck constant (\( \hbar \))
- Gravitational constant (\( G \))

**Spacetime Conversion**

- \( e = \sqrt{\alpha} L_0/\eta = \sqrt{\alpha} cT_0/\eta \)
- \( q_p = L_0/\eta \)
- \( 1/4\pi\varepsilon_o = cZ_\infty/\eta^2 \)
- \( \mu_o/4\pi = \eta^2 Z_s/c \)
- \( \mathcal{E}_\gamma = H\omega\sqrt{Z_s Z_\infty} = H\omega Z_s \eta \)
- \( \mathcal{B}_\gamma = H\omega\sqrt{Z_s^2/Z_\infty} = H\omega/\eta \)
- \( Z_\infty = \eta^4 4\pi Z_s \)
- \( Z_\gamma = \eta^2 Z_s \)
- \( \hbar = c^2 T_p^2 Z_s = L_p^2 Z_s \)
- \( G = c^3/Z_s \)
Useful Cosmic Information
\[ \mathcal{H} = 2.29 \times 10^{-18} \text{ m/s/m} = 70.8 \text{ km/s/Mpc} \quad \mathcal{H} = \text{Hubble parameter} \]
1 parsec (pc) = 3.086 \times 10^{16} \text{ m} = 3.262 \text{ light years}
1 light year (ly) = 9.4607 \times 10^{15} \text{ m} = 6.3241 \times 10^{4} \text{ AU}
Solar mass \quad 1.989 \times 10^{30} \text{ kg} \quad \text{Solar radius} \quad 6.96 \times 10^{8} \text{ m}
Earth mass \quad 5.974 \times 10^{24} \text{ kg}
Earth radius \quad 6.378 \times 10^{6} \text{ m} \text{ (equator)} \text{ and} \quad 6.357 \times 10^{6} \text{ m} \text{ (polar)}
Earth: average acceleration of gravity \quad 9.807 \text{ m/s}^2 \text{ at equator:} \quad 9.78 \text{ m/s}^2
Earth – Sun (mean radial distance) \quad 1.496 \times 10^{11} \text{ m} = 1 \text{ AU}
Milky Way galaxy; mass: (1.2 to 3) \times 10^{42} \text{ kg}; radius: \sim 50,000 \text{ ly}; rotation rate \sim 200,000 \text{ years}
Sun distance to galactic center \sim 27,000 \text{ ly}
CMB \sim 2.735 \text{ °K}, \sim 4 \times 10^8 \text{ photons/m}^3, \text{CMB energy density} \; 4.2 \times 10^{-14} \text{ J/m}^3
Sun’s motion relative to the CMB \approx 369 \text{ km/s}
Planck spacetime: \( U_{ps} = 5.53 \times 10^{112} \text{ J/m}^3 \), quantized energy units: \( \frac{1}{2} E_p = 9.78 \times 10^8 \text{ J} \)

Cosmology

\[ \Gamma_u(t) = a_u(t) = \frac{dt}{d\tau_u} \quad \Gamma_u = \text{background gamma of the universe} \]
\[ \Gamma_u(t) = \frac{a_u(t)}{a_p} = \frac{dL}{d\ell} \]
\[ \mathcal{C} = \frac{c}{\Gamma_u(t)} = \frac{d\ell}{dt} \quad \mathcal{C} = \text{coordinate speed of light in the universe} \]
\[ \mathcal{C} = \frac{d\tau_u}{d\tau} = c/\Gamma_u \quad \mathcal{C} = \text{hybrid speed of light} \]
\[ \mathcal{H} = \frac{da_u}{a_o} = \frac{d\tau_u}{d\tau} \quad \mathcal{H} = \frac{a_u}{a_o} = \frac{\Gamma_u}{\Gamma_{uo}} \quad \mathcal{H} = \text{Hubble parameter} \]
\[ \frac{\lambda_2}{\lambda_1} = \frac{\Gamma_{uo1}}{\Gamma_{uo2}} = \frac{v_2}{v_1} = \frac{a_2}{a_1} = 1 + z \]
\[ \frac{U_{ps}}{U_{obs}} = \frac{\Gamma_{uo}^3 \times \Gamma_{eq}}{\Gamma_{uo}} \quad \frac{U_{ps}}{U_{obs}} = \text{energy density ratio - Planck spacetime / observable spacetime} \]
\[ U_{ps} = 5.53 \times 10^{112} \text{ J/m}^3 \quad U_{ps} = \text{Planck spacetime energy density} \]
Symbol Definitions (Roman alphabet):

\( A = \) wave amplitude
\( \mathcal{A} = \) area
\( \alpha = \) acceleration
\( A_f = \) fundamental amplitude of a spacetime wave prior to any cancellation \( A_f = L_p/r \)
\( A_\beta = \) strain amplitude in the rotar volume of a rotar
\( A_{\beta e} = \) wave amplitude required for a rotar’s electromagnetic characteristics at \( \lambda_c \)
\( A_{\beta g} = \) amplitude of the nonlinear wave at distance \( \lambda_c \) \( (A_{\beta g} = A_{\beta}^2) \)
\( A_{\beta w} = \) speculative amplitude of the weak force
\( A_e = \) amplitude of the wave responsible for electric field of charge \( e \) \( A_e = \sqrt{\alpha} \frac{L_p}{r^2} \)
\( A_e = \) electromagnetic non-oscillating strain amplitude \( A_e = \sqrt{\alpha} \frac{L_p}{r} = \sqrt{\alpha} \frac{A_\beta}{N} = \mathcal{V} \)
\( A_{eq} = \) electric field standing wave amplitude at distance \( \lambda_c \) \( A_{eq} = \sqrt{\alpha} L_p/\lambda_c \)
\( A_{gw} = \) amplitude of a gravitational wave \( (A_{gw} = 2 \Delta L/L \approx k \cdot G \cdot \omega^2 I \cdot e/c^4 r) \)
\( A_{max} = \) maximum strain amplitude permitted for a dipole wave
\( a_0 = \) cross sectional area in bulk modulus calculation
\( a_p = \) cosmological comoving scale factor at the present time
\( a_u = \) cosmological scale factor of Planck spacetime (when \( \Gamma = 1 \))
\( a_v = \) cosmological scale factor of the universe relative to Planck spacetime
\( a_{em} = \) cosmological scale factor at emission
\( a_{obs} = \) cosmological scale factor at observation
\( a_g = \) rotar’s grav acceleration at the center of the rotar volume
\( B = \) “B” magnetic field; magnetic flux density; magnetic induction
\( B_e = \) electron’s internal magnetic field \( B_e \approx 3.22 \times 10^7 \text{ Tesla} \)
\( B_o \) and \( B_g = \) normalized magnetic flux density
\( c = \) speed of light \( (3 \times 10^8 \text{ m/s}) \)
\( C_o = \) normalized speed of light in zero gravity \( C_o = c \)
\( C_g = \) normalized speed of light in gravity \( C_o = \Gamma \cdot C_g \)
\( C_r = \) speed of light in the radial direction relative to \( C_o \)
\( C_t = \) speed of light in the tangential direction relative to \( C_o \)
\( C = \) hybrid coordinate speed of light \( C = d\mathbb{R}/d\tau_u \)
\( C_o = \) cosmological coordinate speed of light \( C_o = d\mathbb{R}/dt = c/\Gamma_o^2 \)
\( C_t = \) cosmological coordinate speed of light for \( \Gamma_o = 1 \)
\( C_T = \) coordinate speed of light in the tangential direction (Schwarzschild metric \( dR = 0 \))
\( C_R = \) coordinate speed of light in the radial direction (Schwarzschild metric \( d\Omega = 0 \))
\( a_m = \) dipole moment
\( e = \) elementary electrical charge \( (e = 1.6 \times 10^{-19} \text{ coulomb}) \)
\( E = \) energy
\( E = \) energy in Planck units: \( E = E/E_p \)
\( E_i = \) electric field
\( E_f = \) electric field strength in EM radiation
\( E_i = \) internal energy for a particle: \( E_i = mc^2 = \omega c \hbar \)
\( E_p = \) Planck energy \( E_p = \sqrt{\hbar \cdot c^5 \cdot G} = 1.956 \times 10^9 \text{ J} \)
\( E_e = \) energy in the electric field external to “r” for charge \( e \) \( E_e = ahc/2r \)
\( E_{el} \) = elastic potential energy in the context of bulk modulus
\( E_g \) = energy of the mass in gravity but measured using the zero gravity standard of energy
\( \dot{E}_g \) = normalized energy of an object in gravity but measured using zero gravity standards
\( E_k \) = kinetic energy of mass falling from zero gravity to distance \( r \) from mass \( M \)
\( E_o \) = energy of a mass in zero gravity measured using the zero gravity standard of energy
\( E_Y \) = Young’s modulus \( E_Y = \text{stress/strain} = FL_o/A_o\Delta L \)
\( E_u \) = Cosmological unit of energy for \( \Gamma_u > 1 \)
\( E_1 \) = Cosmological unit of energy for \( \Gamma_u = 1 \)
\( F \) = force
\( F_e \) = electromagnetic force - assumes charge \( e \) particles \( F_e = e^2/4\pi\varepsilon_o a^2 \)
\( F_e \) = electromagnetic force in dimensionless Planck units - assumes charge \( e \) particles
\( F_p \) = electromagnetic force - assumes Planck charge particles \( F_p = q_p^2/4\pi\varepsilon_o a^2 \)
\( F_g \) = electromagnetic force in dimensionless Planck units - assumes Planck charge particles
\( F_g \) = gravitational force \( F_g = (GMm)/r^2 \)
\( F_g \) = gravitational force in Planck units: \( F_g = F_g/F_p \)
\( \dot{F}_g \) = normalized force in gravity but using zero gravity standards (note symbol duplication)
\( F_o \) = normalized force in zero gravity
\( F_m \) = maximum force possible at a distance of \( \lambda_c = m^2c^3/\hbar \)
\( F_s \) = the strong force at distance \( \lambda_c \)
\( F_p \) = Planck force \( F_p = c^4/G \)
\( F_r \) = relativistic force \( F_r = P/c \)
\( F_w \) = weak force at distance \( \lambda_c \)
\( g \) = acceleration of gravity
\( G \) = gravitational constant
\( G_o \) and \( G_g \) = normalized gravitational constant using zero gravity standards
\( g_{00}, g_{11}, g_{22}, g_{33} = \text{general relativity matrix coefficients} \)
\( \mathcal{B} \) = “B” magnetic field; magnetic field strength; magnetic field intensity
\( \mathcal{B} \) = magnetic field strength in EM radiation
\( \mathcal{H} \) = Hubble parameter currently \( \mathcal{H} \approx 2.29 \times 10^{-18} \text{ m/s/m} \)
\( h \) = Planck constant \( h = 6.626 \times 10^{-34} \text{ J s} \)
\( \hbar \) = reduced Planck constant: \( \hbar \text{ bar} = h/2\pi = 1.055 \times 10^{-34} \text{ J s} \)
\( \mathcal{I} \) = electrical current
\( \mathcal{I}_e \) = electron’s equivalent circulating current \( I_e = ev_e \approx 19.796 \text{ amps} \)
\( J \) = intensity
\( I \) = moment of inertia
\( k \) = dimensionless constants (\( k_1, k_2, \text{ etc.} \))
\( k' = 3/8\pi \) (a constant used in cosmology)
\( K_b \) = bulk modulus
\( K_b \) = bulk modulus
\( K_p \) = Planck bulk modulus \( c^7/hG^2 \)
\( K_s \) = bulk modulus of spacetime: \( K_s = F_p/\mathcal{A}^2 = F_p(\omega/c)^2 \)
\( L \) = dimensional analysis symbol representing length
\( L_g \) = normalized length \( dL_g = cd\tau \)
\( L_o \) = normalized length \( dL_o = cd\tau \)
\( L_0 = \) in the context of Young’s modulus, \( L_0 \) is the original length before stress

\( L = \) angular momentum

\( L_0 \) and \( L_g \) = normalized angular momentum

\( L_r \& L_t = \) proper length in the radial or tangential direction respectively

\( l_p = \) Planck length = \( \sqrt{\frac{\hbar G}{c^3}} = 1.616 \times 10^{-35} \text{ m} \) (a static unit of length)

\( l_p = \) dynamic Planck length (wave amplitude of \( l_p \))

\( l_u = \) cosmological unit of length for \( \Gamma_u > 1 \)

\( m = \) mass

\( m = \) mass in dimensionless Planck units: \( \frac{m}{m_p} \)

\( m_p = \) Planck mass \( m_p = \sqrt{\frac{\hbar c}{G}} = 2.176 \times 10^{-8} \text{ kg} \)

\( m_e = \) mass of an electron \( = 9.1094 \times 10^{-31} \text{ kg} \)

\( m_k = \) pseudo rest mass when index of refraction \( n > 1 \)

\( N = \) dimensional analysis symbol representing mass

\( \tilde{M}_0 \) and \( M_g = \) normalized unit of mass

\( \tilde{M}_u = \) cosmological unit of mass for \( \Gamma_u > 1 \)

\( \tilde{M}_0, \tilde{M}_u = \) cosmological unit of mass for \( \Gamma_u = 1 \)

\( N = \) an integer number

\( N = \) the distance between two rotars expressed as a multiple of \( \lambda_c \) \( (N = r/\lambda_c) \)

\( n_k = \) the index of refraction which includes the optical Kerr effect contribution

\( n_o = \) the index of refraction at zero intensity

\( p = \) momentum

\( p_p = \) Planck momentum \( p_p = m_pc = \sqrt{\frac{\hbar c^3}{G}} \approx 6.525 \text{ kg m/s} \)

\( P = \) power

\( P_c = \) a Particle’s circulating power: \( P_c = E_i \omega_c \)

\( P_r = \) circulating power in Planck units: \( \frac{P_r}{P_p} \)

\( \mathbb{P} = \) pressure

\( \mathbb{P}_p = \) Planck pressure \( \mathbb{P}_p = c^2/G = 4.636 \times 10^{113} \text{ N/m}^2 \) (\( \approx U_p \))

\( P_p = \) Planck power \( P_p = c^5/G = 3.63 \times 10^{52} \text{ W} \)

\( \mathbb{P}_q = \) pressure generated by a rotar \( \mathbb{P}_q = \omega_c h/c^3 = E_i/\lambda_c^3 = U_q \)

\( q = \) electrical charge

\( Q_0, Q_g = \) dimensional analysis units of charge used in various transformations

\( Q_1 = \) cosmological unit of charge for \( \Gamma_u = 1 \)

\( Q_o = \) cosmological unit of charge for \( \Gamma_u > 1 \)

\( q_p = \) Planck charge \( q_p = \sqrt{4\pi\varepsilon_0\hbar c} = e/\sqrt{\alpha} \approx 11.7 e \approx 1.876 \times 10^{-18} \text{ Coulomb} \)

\( r = \) radial distance (proper length)

\( R = \) circumferential radius from general relativity (circumference/\( 2\pi \))

\( \mathbb{R} = \) a unit of coordinate length pertaining to cosmology \( d\mathbb{R} = dL_u/\Gamma_u \)

\( \mathbb{R}_3 = \) cosmological unit of length for \( \Gamma_u = 1 \)

\( r_h = \) radius of the Hubble sphere

\( r_{ph} = \) radius of the particle horizon

\( R_s = \) classical Schwarzschild radius: \( R_s = Gm/c^2 \)

\( r_s = \) relativistic Schwarzschild radius \( r_s = 2Gm/c^2 \)

\( \lambda_c \equiv \) rotar radius of a rotar \( \lambda_c \equiv h/mc \) (\( \lambda_c \equiv \) reduced Compton radius)

\( \lambda_c = \) rotar radius in Planck units: \( \lambda_c = \lambda_c/L_p \)

\( t = \) either time or coordinate time (depends on context)
\( t_c \) = time indicated on the coordinate clock
\( T \) = dimensional analysis symbol representing time
\( T_g \) = normalized unit of time in gravity
\( T_0 \) = normalized unit of time in zero gravity
\( T_u \) = cosmological unit of time for \( \Gamma_u > 1 \)
\( T_1 \) = cosmological unit of time for \( \Gamma_u = 1 \)
\( t_p \) = Planck time  
\( t_p = \sqrt{\hbar G/c^5} = 5.391 \times 10^{-44} \text{s} \)
\( T_p \) = dynamic Planck time (a wave amplitude with dimension of Plank time)
\( T \) = temperature
\( T_p \) = Planck temperature = \( E_p/k_B \approx 1.4168 \times 10^{32} \text{°K} \)
\( u_d \) = de Broglie wave group velocity  
\( U \) = energy density
\( U_{el} \) = energy density of elastic potential energy (bulk modulus)
\( U_i \) = interactive energy density encountered by a wave in spacetime  
\( U_i = c^2 \omega^2 / G \)
\( U_o \) = energy density in coordinate units (assumes \( \Gamma = 1 \) )
\( U_g \) = energy density in a location with gravity (\( \Gamma > 1 \) )
\( U_o \) = energy density in the universe when \( \Gamma_u > 1 \)
\( U_p \) = Planck energy density  
\( U_p = c^7 / hG^2 = 4.636 \times 10^{113} \text{J/m}^3 \)
\( U_{ps} \) = energy density of Planck spacetime  
\( U_{ps} = (3/8\pi)(c^7 / hG^2) \approx 5.53 \times 10^{112} \text{J/m}^3 \)
\( u_q \) = energy density of a rotor  
\( u_q = E_i / \lambda_c^3 = (\omega c^4 h / c^3) = \rho_p q \)
\( U_u \) = cosmological unit of energy density for \( \Gamma_u > 1 \)
\( U_1 \) = cosmological unit of energy density for \( \Gamma_u = 1 \)
\( v \) = velocity
\( v_e \) = escape velocity  
\( V \) = Volume
\( V_r \) = rotar volume  
\( V_r = \lambda_c^3 \) (cubic)  
\( V_r = (4\pi/3) \lambda_c^3 \) (spherical)
\( V \) = Electrical potential
\( V_p \) = Planck electrical potential (voltage)  
\( w_d \) = de Broglie wave phase velocity  
\( w_d = c^2 / \nu \)
\( w_m \) = velocity of the modulation wave envelope (moving resonator)  
\( \bar{x} \) = maximum displacement produced by dipole wave in spacetime
\( z \) = cosmological redshift
\( z_{eq} \) = cosmological redshift since the radiation/matter equality transition
\( \Gamma_{eq} \) = \( \Gamma \) at the radiation/matter equality transition
\( Z \) = impedance
\( Z_s \) = impedance of spacetime  
\( Z_s = c^3 / G = 4.04 \times 10^{35} \text{kg/s} \)
\( Z_{su} \) = cosmological impedance of spacetime for \( \Gamma_u = 1 \)
\( Z_{su} \) = cosmological impedance of spacetime for \( \Gamma_u > 1 \)
\( Z_e \) = electromagnetic impedance of free space  
\( Z_e \approx 377 \text{Ω} \)
\( Z_a \) = acoustic impedance  
\( Z_a = \rho c_3 \) (density \times speed of sound)
\( Z_{oo} \) = normalized impedance of free space (zero gravity)
\( Z_{og} \) = normalized impedance of free space (in gravity)
\( Z_p \) = Planck impedance (electromagnetic)  
\( Z_p = 1 / 4\pi \rho c \approx 29.98 \text{Ω} \)
Greek Symbols

\( \alpha = \) fine structure constant \( \alpha = e^2 / 4\pi\varepsilon_0hc \approx 1/137.036 \)

\( \beta = \) gravitational magnitude \( \beta \equiv 1 - (1 - 2Gm/c^2R)^{1/2} = 1 - 1/\Gamma = 1 - dt/dt \approx gm/c^2r \)

\( \beta_q = \) gravitational magnitude at distance \( \lambda_c \)

\( \beta_0 = \) background gravitational magnitude \( \beta_0 = 1 - 1/\Gamma_0 = 1 - d\tau_0/dt \)

\( \Gamma = \) gravitational gamma \( \Gamma = (1-2Gm/rc^2)^{-1/2} \)

\( \Gamma_q = \) gravitational gamma at distance of \( \lambda_c \)

\( \Gamma_u = \) background gravitational gamma of the universe \( \Gamma_u = dt/d\tau_u = a_u/a_p \)

\( \Gamma_{uo} = \) the current value of \( \Gamma_u \) where: \( \Gamma_{uo} \approx 2.6 \times 10^{31} \)

\( \Gamma_{obs} = \Gamma_u \) at the time an observation of a photon is made

\( \Gamma_{em} = \Gamma_u \) at the time of emission of a photon

\( \Gamma_{eq} = \Gamma_u \) at the radiation/matter equality transition

\( \gamma = \) special relativity gamma \( \gamma = (1 - v^2/c^2)^{1/2} \)

\( \varepsilon = \) asymmetry of an object - uniform sphere has \( \varepsilon = 0 \), two equal point masses have \( \varepsilon = 1 \)

\( \varepsilon_0 = \) permittivity of vacuum

\( \xi = \) spin axis probability

\( \xi_a = \) acoustic amplitude (particle displacement)

\( \eta = \) charge conversion constant \( \eta \equiv L_p/Q_p = 8.617 \times 10^{-18} \) meters/Coulomb

\( \Theta_o \) and \( \Theta_g = \) normalized temperature

\( \theta = \) angle symbol

\( \lambda = \) wavelength

\( \lambda = \) reduced wavelength; \( \lambda = \lambda/2\pi = c/\omega \)

\( \lambda_d = \) De Broglie wavelength \( \lambda_d = h/mv \)

\( \lambda_{dd} = \) wavelength of confined photon in moving frame of reference (relativistic contraction)

\( \lambda_m = \) modulation envelope wavelength; \( \lambda_m = \lambda_o c/\nu \)

\( \lambda_c = \) Compton wavelength \( \lambda_c = h/mc \)

\( \lambda_c = \) reduced Compton wavelength \( \lambda_c = h/mc = \lambda_c/2\pi \)

\( \lambda_o = \) original wavelength or wavelength in zero gravity

\( \lambda_g = \) wavelength in gravity (blue shifted)

\( \lambda_{em} \) & \( \lambda_{obs} = \) wavelength at emission and observation respectively

\( \lambda_f = \) wavelength of confined light (chapter 1)

\( \lambda = \) wavelength of light when measured in units of coordinate length.

\( \Lambda = \) cosmological constant

\( \mu_B = \) Bohr magnetron \( \mu_B = e\hbar/2m_e = 9.274 \times 10^{-24} \) J/Tesla

\( \mu_o = \) permeability of vacuum \( \mu_o = 4\pi \times 10^{-7} \) m kg/C^2 = 1.257 \times 10^{-6} m kg/C^2

\( \nu = \) frequency

\( \nu_c = \) Compton frequency \( \nu_c = mc^2/h \)

\( u_{obs} \) & \( u_{em} = \) cosmological observed frequency & emitted frequency

\( \rho = \) matter density

\( \rho_p = \) Planck density \( \rho_p = c^5/hG^2 \)
\( \sigma \) = Stefan-Boltzmann constant: \( \sigma = 5.670373 \times 10^{-8} \text{ W m}^{-2} \text{ K}^{-4} \)

\( \tau \) = proper time – time interval on a local clock

\( \tau_d \) = time indicated on the dipole clock

\( \tau_{obs} \) = (cosmological) proper age of the universe at the time an observation is made

\( \tau_{em} \) = (cosmological) proper age of the universe at the time of emission of a photon

\( \tau_u \) = (cosmological) proper age of the universe at arbitrary time (cosmic time)

\( \tau_{uo} \) = (cosmological) current proper age of the universe (cosmic time)

\( \tau_u \) = (cosmological) age of the universe in nondimensional Planck units \( \tau_u = \tau_u / \tau_p \)

\( \tau \) = emission lifetime

\( \chi \) = distance in comoving coordinates

\( \Psi \) = psi function

\( \omega \) = angular frequency

\( \omega_c \) = Compton angular frequency of a Particle \( \omega_c = mc^2 / \hbar \)

\( \omega_c \) = Compton angular frequency in Planck units: \( \omega_c = \omega_c / \omega_p \)

\( \omega_p \) = Planck angular frequency \( \omega_p = \sqrt{c^5 / \hbar G} = 1.855 \times 10^{43} \text{ s}^{-1} \)

\( \Omega \) = a solid angle in a spherical coordinate system \( d\Omega^2 = d\theta^2 + \sin^2 \theta \ d\phi^2 \)

\( \Omega \) = symbol representing electrical resistance

\( \Omega_m \) = matter density parameter

\( \Omega_A \) = cosmological constant density parameter
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