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In[1]:=  $\eta = \{ \{-c^2, 0, 0, 0\}, \{0, 1, 0, 0\}, \{0, 0, 1, 0\}, \{0, 0, 0, 1\} \}$ 
Out[1]:=  $\{ \{-c^2, 0, 0, 0\}, \{0, 1, 0, 0\}, \{0, 0, 1, 0\}, \{0, 0, 0, 1\} \}$ 

In[2]:= coords = {t, x, y, z}
Out[2]:= {t, x, y, z}

In[3]:= (*the quadrupole tensor is *)

In[4]:= q[t_, u_, v_] := M*p[t][[u]]*p[t][[v]]

In[5]:= (*with pt[t][[u]] being a four-coordinate position function
      $X^{\mu}(t)$ that describes the position of the stars in the binary*)

In[6]:= pReplace =
      p  $\rightarrow$  Function[{t}, {t, Subscript[r, o] * Cos[ $\omega$  t], Subscript[r, o] * Sin[ $\omega$  t], 0}]
Out[6]:= p  $\rightarrow$  Function[{t}, {t, ro Cos[ $\omega$  t], ro Sin[ $\omega$  t], 0}]

(*let's populate the entries of the second time-
derivative of the quadrupole tensor*)

In[57]:= Qddot = Array[ Simplify[D[Evaluate[ q[t, #1, #2] /. pReplace], {t, 2}]] &, {4, 4}]

Part::partw : Part 2 of p[t] does not exist. >>
Part::partw : Part 3 of p[t] does not exist. >>
Part::partw : Part 4 of p[t] does not exist. >>
General::stop : Further output of Part::partw will be suppressed during this calculation. >>

Out[57]:=  $\{ \{ 2 M, -M \omega (t \omega \cos[t \omega] + 2 \sin[t \omega]) r_o, M \omega (2 \cos[t \omega] - t \omega \sin[t \omega]) r_o, 0 \},$ 
 $\{ -M \omega (t \omega \cos[t \omega] + 2 \sin[t \omega]) r_o, -2 M \omega^2 \cos[2 t \omega] r_o^2, -2 M \omega^2 \sin[2 t \omega] r_o^2, 0 \},$ 
 $\{ M \omega (2 \cos[t \omega] - t \omega \sin[t \omega]) r_o, -2 M \omega^2 \sin[2 t \omega] r_o^2, 2 M \omega^2 \cos[2 t \omega] r_o^2, 0 \},$ 
 $\{ 0, 0, 0, 0 \} \}$ 

In[9]:= (*let's populate the entries of the metric perturbation.  $\epsilon$ 
      is the parameter of the strength of the perturbation *)

In[58]:=  $\gamma = (2 / (3 R)) Qddot$ 

Out[58]:=  $\{ \{ \frac{4 M}{3 R}, -\frac{2 M \omega (t \omega \cos[t \omega] + 2 \sin[t \omega]) r_o}{3 R}, \frac{2 M \omega (2 \cos[t \omega] - t \omega \sin[t \omega]) r_o}{3 R}, 0 \},$ 
 $\{ -\frac{2 M \omega (t \omega \cos[t \omega] + 2 \sin[t \omega]) r_o}{3 R}, -\frac{4 M \omega^2 \cos[2 t \omega] r_o^2}{3 R}, -\frac{4 M \omega^2 \sin[2 t \omega] r_o^2}{3 R}, 0 \},$ 
 $\{ \frac{2 M \omega (2 \cos[t \omega] - t \omega \sin[t \omega]) r_o}{3 R}, -\frac{4 M \omega^2 \sin[2 t \omega] r_o^2}{3 R}, \frac{4 M \omega^2 \cos[2 t \omega] r_o^2}{3 R}, 0 \},$ 
 $\{ 0, 0, 0, 0 \} \}$ 

In[40]:= (*evaluated at the retarded time*)
tRetardedReplace = t  $\rightarrow$  t - R / c

Out[40]:= t  $\rightarrow$  -  $\frac{R}{c}$  + t

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In[37]:= (*with a replacement for the Minkowski cartesian background coordinates*)
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In[25]:= RReplace = R → Sqrt[x^2 + y^2 + z^2]
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Out[25]= R →  $\sqrt{x^2 + y^2 + z^2}$ 
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In[59]:=  $\gamma$  // MatrixForm
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Out[59]//MatrixForm=
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$$\begin{pmatrix} \frac{4M}{3R} & -\frac{2M\omega(t\omega\cos[t\omega]+2\sin[t\omega])r_o}{3R} & \frac{2M\omega(2\cos[t\omega]-t\omega\sin[t\omega])r_o}{3R} & 0 \\ -\frac{2M\omega(t\omega\cos[t\omega]+2\sin[t\omega])r_o}{3R} & -\frac{4M\omega^2\cos[2t\omega]r_o^2}{3R} & -\frac{4M\omega^2\sin[2t\omega]r_o^2}{3R} & 0 \\ \frac{2M\omega(2\cos[t\omega]-t\omega\sin[t\omega])r_o}{3R} & -\frac{4M\omega^2\sin[2t\omega]r_o^2}{3R} & \frac{4M\omega^2\cos[2t\omega]r_o^2}{3R} & 0 \\ 0 & 0 & 0 & 0 \end{pmatrix}$$

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In[46]:= (*Evaluate the metric tensor on the coordinates (described by RReplace)*)
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```
In[60]:= gMetric = Evaluate[η + ε γ /. tRetardedReplace /. RReplace]
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$$\text{Out[60]} = \left\{ \left\{ -c^2 + \frac{4 M \epsilon}{3 \sqrt{x^2 + y^2 + z^2}}, \right. \right. \\ \left. - \frac{2 M \epsilon \omega \left(\left(t - \frac{\sqrt{x^2 + y^2 + z^2}}{c} \right) \omega \cos \left[\left(t - \frac{\sqrt{x^2 + y^2 + z^2}}{c} \right) \omega \right] + 2 \sin \left[\left(t - \frac{\sqrt{x^2 + y^2 + z^2}}{c} \right) \omega \right] \right) r_o}{3 \sqrt{x^2 + y^2 + z^2}}, \right. \\ \left. \frac{2 M \epsilon \omega \left(2 \cos \left[\left(t - \frac{\sqrt{x^2 + y^2 + z^2}}{c} \right) \omega \right] - \left(t - \frac{\sqrt{x^2 + y^2 + z^2}}{c} \right) \omega \sin \left[\left(t - \frac{\sqrt{x^2 + y^2 + z^2}}{c} \right) \omega \right] \right) r_o}{3 \sqrt{x^2 + y^2 + z^2}}, 0 \right\}, \\ \left\{ - \frac{2 M \epsilon \omega \left(\left(t - \frac{\sqrt{x^2 + y^2 + z^2}}{c} \right) \omega \cos \left[\left(t - \frac{\sqrt{x^2 + y^2 + z^2}}{c} \right) \omega \right] + 2 \sin \left[\left(t - \frac{\sqrt{x^2 + y^2 + z^2}}{c} \right) \omega \right] \right) r_o}{3 \sqrt{x^2 + y^2 + z^2}}, \right. \\ \left. 1 - \frac{4 M \epsilon \omega^2 \cos \left[2 \left(t - \frac{\sqrt{x^2 + y^2 + z^2}}{c} \right) \omega \right] r_o^2}{3 \sqrt{x^2 + y^2 + z^2}}, - \frac{4 M \epsilon \omega^2 \sin \left[2 \left(t - \frac{\sqrt{x^2 + y^2 + z^2}}{c} \right) \omega \right] r_o^2}{3 \sqrt{x^2 + y^2 + z^2}}, 0 \right\}, \\ \left\{ \frac{2 M \epsilon \omega \left(2 \cos \left[\left(t - \frac{\sqrt{x^2 + y^2 + z^2}}{c} \right) \omega \right] - \left(t - \frac{\sqrt{x^2 + y^2 + z^2}}{c} \right) \omega \sin \left[\left(t - \frac{\sqrt{x^2 + y^2 + z^2}}{c} \right) \omega \right] \right) r_o}{3 \sqrt{x^2 + y^2 + z^2}}, \right. \\ \left. - \frac{4 M \epsilon \omega^2 \sin \left[2 \left(t - \frac{\sqrt{x^2 + y^2 + z^2}}{c} \right) \omega \right] r_o^2}{3 \sqrt{x^2 + y^2 + z^2}}, \right. \\ \left. 1 + \frac{4 M \epsilon \omega^2 \cos \left[2 \left(t - \frac{\sqrt{x^2 + y^2 + z^2}}{c} \right) \omega \right] r_o^2}{3 \sqrt{x^2 + y^2 + z^2}}, 0 \right\}, \{0, 0, 0, 1\} \}$$

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In[12]:= (* the inverse metric *)
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In[61]:= gInv = Inverse[gMetric];
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In[56]:=
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In[14]:= (*now we define the christoffel symbols,
the Riemann, Ricci and Einstein tensors*)
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In[15]:= Γ[gg_, γ_, ξ_, κ_] :=
(1/2) Sum[gInv[[γ, α]] (D[gg[[α, κ]], coords[[ξ]]] + D[gg[[α, ξ]],
coords[[κ]]] - D[gg[[ξ, κ]], coords[[α]]]), {α, 1, 4}]
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In[16]:= Riemann[gg_, γ_, ξ_, κ_, θ_] :=
  D[Γ[gg, γ, ξ, θ], coords[[κ]]] - D[Γ[gg, γ, ξ, κ], coords[[θ]]] +
  Sum[Γ[gg, γ, κ, α] Γ[gg, α, ξ, θ] - Γ[gg, γ, θ, α] Γ[gg, α, ξ, κ], {α, 1, 4}]

In[30]:= Ricci[gg_, ii_, jj_] := Sum[Riemann[gg, a1, ii, a1, jj], {a1, 1, 4}]

In[31]:= ScalarR[hh_] := Sum[gInv[[a1, a2]] Ricci[hh, a1, a2], {a1, 1, 4}, {a2, 1, 4}]

In[32]:= TensorEinsteinG[gg_, ii_, jj_] :=
  Sum[gInv[[ii, a1]] gInv[[jj, a2]] Ricci[gg, a1, a2], {a1, 1, 4}, {a2, 1, 4}] -
  (1/2) ScalarR[gg] gInv[[ii, jj]]

In[50]:=

In[52]:= (*Take first-order correction on ε to Einstein tensor*)
GravG =
  Array[Simplify[SeriesCoefficient[TensorEinsteinG[gMetric, #1, #2], {ε, 0, 1}]] &,
    {4, 4}]

```

$$\begin{aligned}
\text{Out[52]} = & \left\{ \left\{ \frac{1}{3 c^4 (x^2 + y^2 + z^2)^{5/2}} \right. \right. \\
& 2 M \omega^2 \left(\left(-3 c^2 (x^2 - y^2) - 12 c x y \sqrt{x^2 + y^2 + z^2} \omega + 4 (x^2 - y^2) (x^2 + y^2 + z^2) \omega^2 \right) \right. \\
& \left. \cos \left[2 \left(t - \frac{\sqrt{x^2 + y^2 + z^2}}{c} \right) \omega \right] + \right. \\
& \left. 2 \left(-3 c^2 x y + 3 c (x^2 - y^2) \sqrt{x^2 + y^2 + z^2} \omega + 4 x y (x^2 + y^2 + z^2) \omega^2 \right) \right. \\
& \left. \sin \left[2 \left(t - \frac{\sqrt{x^2 + y^2 + z^2}}{c} \right) \omega \right] \right) r_o^2, \frac{1}{3 c^5 (x^2 + y^2 + z^2)^{5/2}} \\
& M \omega r_o \left(\left(- (y^2 + z^2) (x^2 + y^2 + z^2)^{3/2} \omega^3 + c^2 \sqrt{x^2 + y^2 + z^2} \omega (4 x^2 - 2 (y^2 + z^2) + 3 t x y \omega) + \right. \right. \\
& \left. c^3 (-6 x y + 2 t x^2 \omega - t (y^2 + z^2) \omega) + c (x^2 + y^2 + z^2) \omega^2 (x y + t (y^2 + z^2) \omega) \right) \\
& \cos \left[\left(t - \frac{\sqrt{x^2 + y^2 + z^2}}{c} \right) \omega \right] + (x y (x^2 + y^2 + z^2)^{3/2} \omega^3 + \\
& c (x^2 + y^2 + z^2) \omega^2 (2 x^2 + 3 (y^2 + z^2) - t x y \omega) + c^3 (4 x^2 - 2 (y^2 + z^2) + 3 t x y \omega) + \\
& \left. c^2 \sqrt{x^2 + y^2 + z^2} \omega (6 x y - 2 t x^2 \omega + t (y^2 + z^2) \omega) \right) \sin \left[\left(t - \frac{\sqrt{x^2 + y^2 + z^2}}{c} \right) \omega \right] +
\end{aligned}$$

$$\begin{aligned}
& 4 \, c^2 \, (x^2 + y^2 + z^2) \, \omega^2 \left(\left(-c \, y + 2 \, x \, \sqrt{x^2 + y^2 + z^2} \, \omega \right) \cos \left[2 \left(t - \frac{\sqrt{x^2 + y^2 + z^2}}{c} \right) \omega \right] + \right. \\
& \quad \left. \left(c \, x + 2 \, y \, \sqrt{x^2 + y^2 + z^2} \, \omega \right) \sin \left[2 \left(t - \frac{\sqrt{x^2 + y^2 + z^2}}{c} \right) \omega \right] \right) r_o, \frac{1}{3 \, c^5 \, (x^2 + y^2 + z^2)^{5/2}} \\
& M \, \omega \, r_o \left(\left(x \, y \, (x^2 + y^2 + z^2)^{3/2} \, \omega^3 - c \, (x^2 + y^2 + z^2) \, \omega^2 \, (3 \, x^2 + 2 \, y^2 + 3 \, z^2 + t \, x \, y \, \omega) + \right. \right. \\
& \quad c^3 \, (2 \, x^2 - 4 \, y^2 + 2 \, z^2 + 3 \, t \, x \, y \, \omega) - c^2 \, \sqrt{x^2 + y^2 + z^2} \, \omega \, (-6 \, x \, y + t \, x^2 \, \omega + t \, (-2 \, y^2 + z^2) \, \omega) \Big) \\
& \quad \cos \left[\left(t - \frac{\sqrt{x^2 + y^2 + z^2}}{c} \right) \omega \right] - \left((x^2 + z^2) \, (x^2 + y^2 + z^2)^{3/2} \, \omega^3 + c^2 \, \sqrt{x^2 + y^2 + z^2} \, \right. \\
& \quad \omega \, (2 \, x^2 - 4 \, y^2 + 2 \, z^2 + 3 \, t \, x \, y \, \omega) - c \, (x^2 + y^2 + z^2) \, \omega^2 \, (-x \, y + t \, x^2 \, \omega + t \, z^2 \, \omega) + \\
& \quad \left. c^3 \, (-6 \, x \, y + t \, x^2 \, \omega + t \, (-2 \, y^2 + z^2) \, \omega) \right) \sin \left[\left(t - \frac{\sqrt{x^2 + y^2 + z^2}}{c} \right) \omega \right] - \\
& \quad 4 \, c^2 \, (x^2 + y^2 + z^2) \, \omega^2 \left(\left(c \, x + 2 \, y \, \sqrt{x^2 + y^2 + z^2} \, \omega \right) \cos \left[2 \left(t - \frac{\sqrt{x^2 + y^2 + z^2}}{c} \right) \omega \right] + \right. \\
& \quad \left. \left(c \, y - 2 \, x \, \sqrt{x^2 + y^2 + z^2} \, \omega \right) \sin \left[2 \left(t - \frac{\sqrt{x^2 + y^2 + z^2}}{c} \right) \omega \right] \right) r_o, \frac{1}{3 \, c^5 \, (x^2 + y^2 + z^2)^{5/2}} \\
& M \, z \, \omega \left(\left(x \, (x^2 + y^2 + z^2)^{3/2} \, \omega^3 - c \, (x^2 + y^2 + z^2) \, \omega^2 \, (-y + t \, x \, \omega) + c^3 \, (-6 \, y + 3 \, t \, x \, \omega) + \right. \right. \\
& \quad 3 \, c^2 \, \sqrt{x^2 + y^2 + z^2} \, \omega \, (2 \, x + t \, y \, \omega) \Big) \cos \left[\left(t - \frac{\sqrt{x^2 + y^2 + z^2}}{c} \right) \omega \right] + \\
& \quad \left(y \, (x^2 + y^2 + z^2)^{3/2} \, \omega^3 - 3 \, c^2 \, \sqrt{x^2 + y^2 + z^2} \, \omega \, (-2 \, y + t \, x \, \omega) - c \, (x^2 + y^2 + z^2) \, \omega^2 \, (x + t \, y \, \omega) + \right. \\
& \quad \left. 3 \, c^3 \, (2 \, x + t \, y \, \omega) \right) \sin \left[\left(t - \frac{\sqrt{x^2 + y^2 + z^2}}{c} \right) \omega \right] r_o \Big\}, \left\{ \frac{1}{3 \, c^5 \, (x^2 + y^2 + z^2)^{5/2}} \right. \\
& M \, \omega \, r_o \left(\left(- (y^2 + z^2) \, (x^2 + y^2 + z^2)^{3/2} \, \omega^3 + c^2 \, \sqrt{x^2 + y^2 + z^2} \, \omega \, (4 \, x^2 - 2 \, (y^2 + z^2) + 3 \, t \, x \, y \, \omega) + \right. \right. \\
& \quad \left. \left. c^3 \, (-6 \, x \, y + 2 \, t \, x^2 \, \omega - t \, (y^2 + z^2) \, \omega) + c \, (x^2 + y^2 + z^2) \, \omega^2 \, (x \, y + t \, (y^2 + z^2) \, \omega) \right) \right)
\end{aligned}$$

$$\begin{aligned}
& \cos \left[\left(t - \frac{\sqrt{x^2 + y^2 + z^2}}{c} \right) \omega \right] + \left(x y (x^2 + y^2 + z^2)^{3/2} \omega^3 + \right. \\
& c (x^2 + y^2 + z^2) \omega^2 (2 x^2 + 3 (y^2 + z^2) - t x y \omega) + c^3 (4 x^2 - 2 (y^2 + z^2) + 3 t x y \omega) + \\
& c^2 \sqrt{x^2 + y^2 + z^2} \omega (6 x y - 2 t x^2 \omega + t (y^2 + z^2) \omega) \left. \right) \sin \left[\left(t - \frac{\sqrt{x^2 + y^2 + z^2}}{c} \right) \omega \right] + \\
& 4 c^2 (x^2 + y^2 + z^2) \omega^2 \left(\left(-c y + 2 x \sqrt{x^2 + y^2 + z^2} \omega \right) \cos \left[2 \left(t - \frac{\sqrt{x^2 + y^2 + z^2}}{c} \right) \omega \right] + \right. \\
& \left. \left(c x + 2 y \sqrt{x^2 + y^2 + z^2} \omega \right) \sin \left[2 \left(t - \frac{\sqrt{x^2 + y^2 + z^2}}{c} \right) \omega \right] \right) r_o, \\
& \frac{1}{3 c^4 (x^2 + y^2 + z^2)^{5/2}} 2 M \left(c^2 (2 x^2 - y^2 - z^2) + y (x^2 + y^2 + z^2) \omega^2 \right. \\
& \left(c (c t + 3 \sqrt{x^2 + y^2 + z^2}) \omega \cos \left[\left(t - \frac{\sqrt{x^2 + y^2 + z^2}}{c} \right) \omega \right] + \right. \\
& \left. \left(3 c^2 - c t \sqrt{x^2 + y^2 + z^2} \omega^2 + (x^2 + y^2 + z^2) \omega^2 \right) \sin \left[\left(t - \frac{\sqrt{x^2 + y^2 + z^2}}{c} \right) \omega \right] \right) r_o - \\
& c^2 \omega^2 \left(\left(c^2 (x^2 + y^2 - 2 z^2) - 4 (x^2 + y^2) (x^2 + y^2 + z^2) \omega^2 \right) \cos \left[2 \left(t - \frac{\sqrt{x^2 + y^2 + z^2}}{c} \right) \omega \right] - \right. \\
& \left. 2 c (x^2 + y^2 - 2 z^2) \sqrt{x^2 + y^2 + z^2} \omega \sin \left[2 \left(t - \frac{\sqrt{x^2 + y^2 + z^2}}{c} \right) \omega \right] \right) r_o^2, \\
& \frac{1}{3 c^4 (x^2 + y^2 + z^2)^{5/2}} M \left(6 c^2 x y + (x^2 + y^2 + z^2) \omega^2 \right. \\
& \left(- \left(y (x^2 + y^2 + z^2) \omega^2 + c^2 (3 y + t x \omega) + c \sqrt{x^2 + y^2 + z^2} \omega (3 x - t y \omega) \right) \right. \\
& \cos \left[\left(t - \frac{\sqrt{x^2 + y^2 + z^2}}{c} \right) \omega \right] - \left(x (x^2 + y^2 + z^2) \omega^2 - c \sqrt{x^2 + y^2 + z^2} \omega (3 y + t x \omega) + \right. \\
& \left. c^2 (3 x - t y \omega) \right) \sin \left[\left(t - \frac{\sqrt{x^2 + y^2 + z^2}}{c} \right) \omega \right] \left. \right) r_o +
\end{aligned}$$

$$\begin{aligned}
& 2 \, c^2 \, \omega^2 \left(-2 \, c \, (x^2 + y^2 - 2 \, z^2) \, \sqrt{x^2 + y^2 + z^2} \, \omega \, \text{Cos} \left[2 \left(t - \frac{\sqrt{x^2 + y^2 + z^2}}{c} \right) \omega \right] + \right. \\
& \quad \left. (-c^2 \, (x^2 + y^2 - 2 \, z^2) + 4 \, (x^2 + y^2) \, (x^2 + y^2 + z^2) \, \omega^2) \, \text{Sin} \left[2 \left(t - \frac{\sqrt{x^2 + y^2 + z^2}}{c} \right) \omega \right] \right) r_o^2, \\
& \frac{1}{3 \, c^4 \, (x^2 + y^2 + z^2)^{5/2}} M \, z \left(6 \, c^2 \, x - (x^2 + y^2 + z^2) \, \omega^2 \right. \\
& \quad \left(3 \, c^2 - c \, t \, \sqrt{x^2 + y^2 + z^2} \, \omega^2 + (x^2 + y^2 + z^2) \, \omega^2 \right) \, \text{Cos} \left[\left(t - \frac{\sqrt{x^2 + y^2 + z^2}}{c} \right) \omega \right] - \\
& \quad c \, (c \, t + 3 \, \sqrt{x^2 + y^2 + z^2}) \, \omega \, \text{Sin} \left[\left(t - \frac{\sqrt{x^2 + y^2 + z^2}}{c} \right) \omega \right] \right) r_o - \\
& 2 \, c^2 \, \omega^2 \left(\left(3 \, c^2 \, x + 6 \, c \, y \, \sqrt{x^2 + y^2 + z^2} \, \omega - 4 \, x \, (x^2 + y^2 + z^2) \, \omega^2 \right) \, \text{Cos} \left[2 \left(t - \frac{\sqrt{x^2 + y^2 + z^2}}{c} \right) \omega \right] + \right. \\
& \quad \left. (3 \, c^2 \, y - 6 \, c \, x \, \sqrt{x^2 + y^2 + z^2} \, \omega - 4 \, y \, (x^2 + y^2 + z^2) \, \omega^2) \, \text{Sin} \left[2 \left(t - \frac{\sqrt{x^2 + y^2 + z^2}}{c} \right) \omega \right] \right) r_o^2 \Bigg\}, \\
& \left\{ \frac{1}{3 \, c^5 \, (x^2 + y^2 + z^2)^{5/2}} M \, \omega \, r_o \left(x \, y \, (x^2 + y^2 + z^2)^{3/2} \, \omega^3 - c \, (x^2 + y^2 + z^2) \, \omega^2 \right. \right. \\
& \quad (3 \, x^2 + 2 \, y^2 + 3 \, z^2 + t \, x \, y \, \omega) + c^3 \, (2 \, x^2 - 4 \, y^2 + 2 \, z^2 + 3 \, t \, x \, y \, \omega) - \\
& \quad c^2 \, \sqrt{x^2 + y^2 + z^2} \, \omega \, (-6 \, x \, y + t \, x^2 \, \omega + t \, (-2 \, y^2 + z^2) \, \omega) \Bigg) \, \text{Cos} \left[\left(t - \frac{\sqrt{x^2 + y^2 + z^2}}{c} \right) \omega \right] - \\
& \quad \left((x^2 + z^2) \, (x^2 + y^2 + z^2)^{3/2} \, \omega^3 + c^2 \, \sqrt{x^2 + y^2 + z^2} \, \omega \, (2 \, x^2 - 4 \, y^2 + 2 \, z^2 + 3 \, t \, x \, y \, \omega) - \right. \\
& \quad c \, (x^2 + y^2 + z^2) \, \omega^2 \, (-x \, y + t \, x^2 \, \omega + t \, z^2 \, \omega) + c^3 \, (-6 \, x \, y + t \, x^2 \, \omega + t \, (-2 \, y^2 + z^2) \, \omega) \Bigg) \\
& \quad \left. \text{Sin} \left[\left(t - \frac{\sqrt{x^2 + y^2 + z^2}}{c} \right) \omega \right] - 4 \, c^2 \, (x^2 + y^2 + z^2) \, \omega^2 \right. \\
& \quad \left(c \, x + 2 \, y \, \sqrt{x^2 + y^2 + z^2} \, \omega \right) \, \text{Cos} \left[2 \left(t - \frac{\sqrt{x^2 + y^2 + z^2}}{c} \right) \omega \right] + \\
& \quad \left. (c \, y - 2 \, x \, \sqrt{x^2 + y^2 + z^2} \, \omega) \, \text{Sin} \left[2 \left(t - \frac{\sqrt{x^2 + y^2 + z^2}}{c} \right) \omega \right] \right) r_o \Bigg\},
\end{aligned}$$

$$\begin{aligned}
& \frac{1}{3 c^4 (x^2 + y^2 + z^2)^{5/2}} M \left(6 c^2 x y + (x^2 + y^2 + z^2) \omega^2 \right. \\
& \quad \left(- \left(y (x^2 + y^2 + z^2) \omega^2 + c^2 (3 y + t x \omega) + c \sqrt{x^2 + y^2 + z^2} \omega (3 x - t y \omega) \right) \right. \\
& \quad \left. \cos \left[\left(t - \frac{\sqrt{x^2 + y^2 + z^2}}{c} \right) \omega \right] - \left(x (x^2 + y^2 + z^2) \omega^2 - c \sqrt{x^2 + y^2 + z^2} \omega (3 y + t x \omega) + \right. \right. \\
& \quad \left. \left. c^2 (3 x - t y \omega) \right) \sin \left[\left(t - \frac{\sqrt{x^2 + y^2 + z^2}}{c} \right) \omega \right] \right) r_o + \\
& \quad 2 c^2 \omega^2 \left(-2 c (x^2 + y^2 - 2 z^2) \sqrt{x^2 + y^2 + z^2} \omega \cos \left[2 \left(t - \frac{\sqrt{x^2 + y^2 + z^2}}{c} \right) \omega \right] + \right. \\
& \quad \left. (-c^2 (x^2 + y^2 - 2 z^2) + 4 (x^2 + y^2) (x^2 + y^2 + z^2) \omega^2) \sin \left[2 \left(t - \frac{\sqrt{x^2 + y^2 + z^2}}{c} \right) \omega \right] \right) r_o^2 \Bigg), \\
& \frac{1}{3 c^4 (x^2 + y^2 + z^2)^{5/2}} 2 M \left(-c^2 (x^2 - 2 y^2 + z^2) + x (x^2 + y^2 + z^2) \omega^2 \right. \\
& \quad \left(\left(3 c^2 - c t \sqrt{x^2 + y^2 + z^2} \omega^2 + (x^2 + y^2 + z^2) \omega^2 \right) \cos \left[\left(t - \frac{\sqrt{x^2 + y^2 + z^2}}{c} \right) \omega \right] - \right. \\
& \quad \left. c (c t + 3 \sqrt{x^2 + y^2 + z^2}) \omega \sin \left[\left(t - \frac{\sqrt{x^2 + y^2 + z^2}}{c} \right) \omega \right] \right) r_o + \\
& \quad c^2 \omega^2 \left((c^2 (x^2 + y^2 - 2 z^2) - 4 (x^2 + y^2) (x^2 + y^2 + z^2) \omega^2) \cos \left[2 \left(t - \frac{\sqrt{x^2 + y^2 + z^2}}{c} \right) \omega \right] - \right. \\
& \quad \left. 2 c (x^2 + y^2 - 2 z^2) \sqrt{x^2 + y^2 + z^2} \omega \sin \left[2 \left(t - \frac{\sqrt{x^2 + y^2 + z^2}}{c} \right) \omega \right] \right) r_o^2 \Bigg), \\
& - \frac{1}{3 c^4 (x^2 + y^2 + z^2)^{5/2}} M z \left(-6 c^2 y + (x^2 + y^2 + z^2) \omega^2 \right. \\
& \quad \left(c (c t + 3 \sqrt{x^2 + y^2 + z^2}) \omega \cos \left[\left(t - \frac{\sqrt{x^2 + y^2 + z^2}}{c} \right) \omega \right] + \right.
\end{aligned}$$

$$\begin{aligned}
& \left(3 c^2 - c t \sqrt{x^2 + y^2 + z^2} \omega^2 + (x^2 + y^2 + z^2) \omega^2 \right) \sin \left[\left(t - \frac{\sqrt{x^2 + y^2 + z^2}}{c} \right) \omega \right] r_o - \\
& 2 c^2 \omega^2 \left(\left(3 c^2 y - 6 c x \sqrt{x^2 + y^2 + z^2} \omega - 4 y (x^2 + y^2 + z^2) \omega^2 \right) \cos \left[2 \left(t - \frac{\sqrt{x^2 + y^2 + z^2}}{c} \right) \omega \right] + \right. \\
& \left. \left(-3 c^2 x - 6 c y \sqrt{x^2 + y^2 + z^2} \omega + 4 x (x^2 + y^2 + z^2) \omega^2 \right) \right. \\
& \left. \sin \left[2 \left(t - \frac{\sqrt{x^2 + y^2 + z^2}}{c} \right) \omega \right] \right) r_o^2 \Bigg\}, \\
& \left\{ \frac{1}{3 c^5 (x^2 + y^2 + z^2)^{5/2}} M z \omega \left(x (x^2 + y^2 + z^2)^{3/2} \omega^3 - c (x^2 + y^2 + z^2) \omega^2 (-y + t x \omega) + \right. \right. \\
& c^3 (-6 y + 3 t x \omega) + 3 c^2 \sqrt{x^2 + y^2 + z^2} \omega (2 x + t y \omega) \Bigg) \cos \left[\left(t - \frac{\sqrt{x^2 + y^2 + z^2}}{c} \right) \omega \right] + \\
& \left(y (x^2 + y^2 + z^2)^{3/2} \omega^3 - 3 c^2 \sqrt{x^2 + y^2 + z^2} \omega (-2 y + t x \omega) - c (x^2 + y^2 + z^2) \omega^2 (x + t y \omega) + \right. \\
& \left. 3 c^3 (2 x + t y \omega) \right) \sin \left[\left(t - \frac{\sqrt{x^2 + y^2 + z^2}}{c} \right) \omega \right] r_o, \frac{1}{3 c^4 (x^2 + y^2 + z^2)^{5/2}} \\
& M z \left(6 c^2 x - (x^2 + y^2 + z^2) \omega^2 \left(\left(3 c^2 - c t \sqrt{x^2 + y^2 + z^2} \omega^2 + (x^2 + y^2 + z^2) \omega^2 \right) \cos \left[\left(t - \frac{\sqrt{x^2 + y^2 + z^2}}{c} \right) \omega \right] - \right. \right. \\
& \left. \left. c (c t + 3 \sqrt{x^2 + y^2 + z^2}) \omega \sin \left[\left(t - \frac{\sqrt{x^2 + y^2 + z^2}}{c} \right) \omega \right] \right) r_o - \right. \\
& 2 c^2 \omega^2 \left(\left(3 c^2 x + 6 c y \sqrt{x^2 + y^2 + z^2} \omega - 4 x (x^2 + y^2 + z^2) \omega^2 \right) \cos \left[2 \left(t - \frac{\sqrt{x^2 + y^2 + z^2}}{c} \right) \omega \right] + \right. \\
& \left. \left(3 c^2 y - 6 c x \sqrt{x^2 + y^2 + z^2} \omega - 4 y (x^2 + y^2 + z^2) \omega^2 \right) \sin \left[2 \left(t - \frac{\sqrt{x^2 + y^2 + z^2}}{c} \right) \omega \right] \right) r_o^2 \Bigg), \\
& - \frac{1}{3 c^4 (x^2 + y^2 + z^2)^{5/2}} M z \left(-6 c^2 y + (x^2 + y^2 + z^2) \omega^2 \right. \\
& \left. \left(c (c t + 3 \sqrt{x^2 + y^2 + z^2}) \omega \cos \left[\left(t - \frac{\sqrt{x^2 + y^2 + z^2}}{c} \right) \omega \right] + \right. \right.
\end{aligned}$$

$$\begin{aligned}
& \left(3 c^2 - c t \sqrt{x^2 + y^2 + z^2} \omega^2 + (x^2 + y^2 + z^2) \omega^2 \right) \sin \left[\left(t - \frac{\sqrt{x^2 + y^2 + z^2}}{c} \right) \omega \right] \right) r_o - \\
& 2 c^2 \omega^2 \left(\left(3 c^2 y - 6 c x \sqrt{x^2 + y^2 + z^2} \omega - 4 y (x^2 + y^2 + z^2) \omega^2 \right) \cos \left[2 \left(t - \frac{\sqrt{x^2 + y^2 + z^2}}{c} \right) \omega \right] + \right. \\
& \left. \left(-3 c^2 x - 6 c y \sqrt{x^2 + y^2 + z^2} \omega + 4 x (x^2 + y^2 + z^2) \omega^2 \right) \sin \left[2 \left(t - \frac{\sqrt{x^2 + y^2 + z^2}}{c} \right) \omega \right] \right) \\
& r_o^2 \left. , \frac{1}{3 c^4 (x^2 + y^2 + z^2)^{5/2}} 2 M \left(-c^2 (x^2 + y^2 - 2 z^2) + \right. \right. \\
& \left. \left. (x^2 + y^2 + z^2) \omega^2 \left(x (x^2 + y^2 + z^2) \omega^2 + c \sqrt{x^2 + y^2 + z^2} \omega (3 y - t x \omega) + c^2 (3 x + t y \omega) \right) \right. \right. \\
& \left. \cos \left[\left(t - \frac{\sqrt{x^2 + y^2 + z^2}}{c} \right) \omega \right] + \left(y (x^2 + y^2 + z^2) \omega^2 + c^2 (3 y - t x \omega) - \right. \right. \\
& \left. \left. c \sqrt{x^2 + y^2 + z^2} \omega (3 x + t y \omega) \right) \sin \left[\left(t - \frac{\sqrt{x^2 + y^2 + z^2}}{c} \right) \omega \right] \right) r_o + \\
& c^2 \omega^2 \left(\left(3 c^2 (x^2 - y^2) + 12 c x y \sqrt{x^2 + y^2 + z^2} \omega - 4 (x^2 - y^2) (x^2 + y^2 + z^2) \omega^2 \right) \right. \\
& \left. \cos \left[2 \left(t - \frac{\sqrt{x^2 + y^2 + z^2}}{c} \right) \omega \right] + 2 \left(3 c^2 x y + 3 c (-x^2 + y^2) \sqrt{x^2 + y^2 + z^2} \omega - \right. \right. \\
& \left. \left. 4 x y (x^2 + y^2 + z^2) \omega^2 \right) \sin \left[2 \left(t - \frac{\sqrt{x^2 + y^2 + z^2}}{c} \right) \omega \right] \right) r_o^2 \left. \right\} \}
\end{aligned}$$

In[53]:= GravG // MatrixForm

Out[53]//MatrixForm=

$$\left(\begin{array}{c} \frac{M \omega r_o \left(\left(- (y^2+z^2) (x^2+y^2+z^2)^{3/2} \omega^3 + c^2 \sqrt{x^2+y^2+z^2} \omega (4 x^2 - 2 (y^2+z^2) + 3 t x y \omega) + c^3 (-6 x y + 2 t x^2 \omega - t (y^2+z^2) \omega) + c (x^2+y^2+z^2) \omega^2 (x y + t \right. \right.}{M \omega r_o \left(\left(x y (x^2+y^2+z^2)^{3/2} \omega^3 - c (x^2+y^2+z^2) \omega^2 (3 x^2 + 2 y^2 + 3 z^2 + t x y \omega) + c^3 (2 x^2 - 4 y^2 + 2 z^2 + 3 t x y \omega) - c^2 \sqrt{x^2+y^2+z^2} \omega (-6 x y + t x^2 \omega + t (-2 \right. \right.} \\ \left. \left. \left. \frac{M z \omega \left(\left(x (x^2+y^2+z^2)^{3/2} \omega^3 - c (x^2+y^2+z^2) \omega^2 (3 x^2 + 2 y^2 + 3 z^2 + t x y \omega) + c^3 (2 x^2 - 4 y^2 + 2 z^2 + 3 t x y \omega) - c^2 \sqrt{x^2+y^2+z^2} \omega (-6 x y + t x^2 \omega + t (-2 \right. \right. \right. \right. \end{array} \right)$$