In[22]:=
```
V = {t, r, e, f};
g = Table[0, {4}, {4}];
g[[1, 1]] = -1 + 2 * G / c^2 * M / r;
g[[2, 2]] = +1;
g[[3, 3]] = r^2;
g[[4, 4]] = r^2 * Sin[e]^2;
g[[1, 4]] = 0;
g[[4, 1]] = g[[1, 4]];
invg = Inverse[g]; (*逆ア度ケ*)
dg1 = Outer[D, g, V];(* ∂g_αβ / ∂x^γ *)
dg2 = Transpose[dg1, {1, 3, 2}];
dg3 = Transpose[dg1, {2, 3, 1}];
(*シ算克氏シ号*)
G0 = Simplify[(1 / 2) invg. (dg1 + dg2 - dg3)];
(* 1/2 g^μα ( ∂g_αβ / ∂x^γ + ∂g_αγ / ∂x^β - ∂g_βγ / ∂x^α ) *)
ddg1 = Outer[D, G0, V];(*克氏シ号做偏ォ数*)
ddg2 = Transpose[ddg1, {1, 2, 4, 3}];
G1 = Table[Sum[G0[[m, j, k]] G0[[i, l, m]],
   {m, 4}], {i, 4}, {j, 4}, {k, 4}, {l, 4}];
G2 = Transpose[G1, {1, 2, 4, 3}];
R = -Simplify[ddg1 - ddg2 + G1 - G2];
(*尼曼曲率ュ量*)
Rc =
 Simplify[Table[Sum[ R[[i, j, i, n]], {i, 4}],
   {j, 4}, {n, 4}]];(*里奇ュ量*)
Rs = Simplify[Sum[ Rc[[i, j]] invg[[i, j]],
  {i, 4}, {j, 4}]]; (*曲率ア量*)
R1 = Simplify[Table[
  Sum[R[[m, j, k, l]] g[[i, m]], {m, 4}],
  {i, 4}, {j, 4}, {k, 4}, {l, 4}]];
MatrixForm[g]
Do[Print[{i, j, k}, G0[[i, j, k]]],
```

```
 {i, 4}, {j, 4}, {k, 4}]
Do[Print[{i, j, k, l}, R[[i, j, k, l]]],
 {i, 4}, {j, 4}, {k, 4}, {l, 4}]
Do[Print[{i, j}, Rc[[i, j]]], {i, 4}, {j, 4}]
Rs
```

Out[30]= Null^3

Out[32]= Null^3

Out[38]//MatrixForm=

$$\begin{pmatrix} -1+\frac{2GM}{c^2 r} & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & r^2 & 0 \\ 0 & 0 & 0 & r^2 \text{Sin}[e]^2 \end{pmatrix}$$

$\{1, 1, 1\}\ 0$

$\{1, 1, 2\}\ \frac{GM}{r\left(-2GM+c^2 r\right)}$

$\{1, 1, 3\}\ 0$

$\{1, 1, 4\}\ 0$

$\{1, 2, 1\}\ \frac{GM}{r\left(-2GM+c^2 r\right)}$

$\{1, 2, 2\}\ 0$

$\{1, 2, 3\}\ 0$

$\{1, 2, 4\}\ 0$

$\{1, 3, 1\}\ 0$

$\{1, 3, 2\}\ 0$

$\{1, 3, 3\}\ 0$

$\{1, 3, 4\}\ 0$

$\{1, 4, 1\}\ 0$

$\{1, 4, 2\}\ 0$

$\{1, 4, 3\}\ 0$

$\{1, 4, 4\}\ 0$

$\{2, 1, 1\}\ \frac{GM}{c^2 r^2}$

$\{2, 1, 2\}\ 0$

$\{2, 1, 3\}\ 0$

$\{2, 1, 4\}\ 0$

$\{2, 2, 1\}\ 0$

$\{2, 2, 2\}\ 0$

$\{2, 2, 3\}\ 0$

$\{2, 2, 4\}\ 0$

{2, 3, 1}0

{2, 3, 2}0

{2, 3, 3}-r

{2, 3, 4}0

{2, 4, 1}0

{2, 4, 2}0

{2, 4, 3}0

{2, 4, 4}-r Sin[e]^2

{3, 1, 1}0

{3, 1, 2}0

{3, 1, 3}0

{3, 1, 4}0

{3, 2, 1}0

{3, 2, 2}0

$\{3, 2, 3\}\frac{1}{r}$

{3, 2, 4}0

{3, 3, 1}0

$\{3, 3, 2\}\frac{1}{r}$

{3, 3, 3}0

{3, 3, 4}0

{3, 4, 1}0

{3, 4, 2}0

{3, 4, 3}0

{3, 4, 4}-Cos[e] Sin[e]

{4, 1, 1}0

{4, 1, 2}0

{4, 1, 3}0

{4, 1, 4}0

{4, 2, 1}0

{4, 2, 2}0

{4, 2, 3}0

$\{4, 2, 4\}\frac{1}{r}$

{4, 3, 1}0

{4, 3, 2}0

{4, 3, 3}0

{4, 3, 4}Cot[e]

{4, 4, 1}0

$$\{4, 4, 2\}\ \frac{1}{r}$$

$$\{4, 4, 3\}\ \text{Cot}[e]$$

$$\{4, 4, 4\}\ 0$$

$$\{1, 1, 1, 1\}\ 0$$

$$\{1, 1, 1, 2\}\ 0$$

$$\{1, 1, 1, 3\}\ 0$$

$$\{1, 1, 1, 4\}\ 0$$

$$\{1, 1, 2, 1\}\ 0$$

$$\{1, 1, 2, 2\}\ 0$$

$$\{1, 1, 2, 3\}\ 0$$

$$\{1, 1, 2, 4\}\ 0$$

$$\{1, 1, 3, 1\}\ 0$$

$$\{1, 1, 3, 2\}\ 0$$

$$\{1, 1, 3, 3\}\ 0$$

$$\{1, 1, 3, 4\}\ 0$$

$$\{1, 1, 4, 1\}\ 0$$

$$\{1, 1, 4, 2\}\ 0$$

$$\{1, 1, 4, 3\}\ 0$$

$$\{1, 1, 4, 4\}\ 0$$

$$\{1, 2, 1, 1\}\ 0$$

$$\{1, 2, 1, 2\}\ -\frac{G\,M\left(3\,G\,M-2\,c^2\,r\right)}{r^2\left(-2\,G\,M+c^2\,r\right)^2}$$

$$\{1, 2, 1, 3\}\ 0$$

$$\{1, 2, 1, 4\}\ 0$$

$$\{1, 2, 2, 1\}\ -\frac{G\,M\left(-3\,G\,M+2\,c^2\,r\right)}{r^2\left(-2\,G\,M+c^2\,r\right)^2}$$

$$\{1, 2, 2, 2\}\ 0$$

$$\{1, 2, 2, 3\}\ 0$$

$$\{1, 2, 2, 4\}\ 0$$

$$\{1, 2, 3, 1\}\ 0$$

$$\{1, 2, 3, 2\}\ 0$$

$$\{1, 2, 3, 3\}\ 0$$

$$\{1, 2, 3, 4\}\ 0$$

$$\{1, 2, 4, 1\}\ 0$$

$$\{1, 2, 4, 2\}\ 0$$

$$\{1, 2, 4, 3\}\ 0$$

$$\{1, 2, 4, 4\}\ 0$$

$$\{1, 3, 1, 1\}\ 0$$

$$\{1, 3, 1, 2\}\ 0$$

$$\{1, 3, 1, 3\}\ -\frac{G\,M}{-2\,G\,M + c^2\,r}$$

$$\{1, 3, 1, 4\}\ 0$$

$$\{1, 3, 2, 1\}\ 0$$

$$\{1, 3, 2, 2\}\ 0$$

$$\{1, 3, 2, 3\}\ 0$$

$$\{1, 3, 2, 4\}\ 0$$

$$\{1, 3, 3, 1\}\ -\frac{G\,M}{2\,G\,M - c^2\,r}$$

$$\{1, 3, 3, 2\}\ 0$$

$$\{1, 3, 3, 3\}\ 0$$

$$\{1, 3, 3, 4\}\ 0$$

$$\{1, 3, 4, 1\}\ 0$$

$$\{1, 3, 4, 2\}\ 0$$

$$\{1, 3, 4, 3\}\ 0$$

$$\{1, 3, 4, 4\}\ 0$$

$$\{1, 4, 1, 1\}\ 0$$

$$\{1, 4, 1, 2\}\ 0$$

$$\{1, 4, 1, 3\}\ 0$$

$$\{1, 4, 1, 4\}\ -\frac{G\,M\,\text{Sin}[e]^2}{-2\,G\,M + c^2\,r}$$

$$\{1, 4, 2, 1\}\ 0$$

$$\{1, 4, 2, 2\}\ 0$$

$$\{1, 4, 2, 3\}\ 0$$

$$\{1, 4, 2, 4\}\ 0$$

$$\{1, 4, 3, 1\}\ 0$$

$$\{1, 4, 3, 2\}\ 0$$

$$\{1, 4, 3, 3\}\ 0$$

$$\{1, 4, 3, 4\}\ 0$$

$$\{1, 4, 4, 1\}\ -\frac{G\,M\,\text{Sin}[e]^2}{2\,G\,M - c^2\,r}$$

$$\{1, 4, 4, 2\}\ 0$$

$$\{1, 4, 4, 3\}\ 0$$

$$\{1, 4, 4, 4\}\ 0$$

$$\{2, 1, 1, 1\}\ 0$$

$$\{2, 1, 1, 2\}\ -\frac{G\,M\,\left(3\,G\,M - 2\,c^2\,r\right)}{c^2\,r^3\,\left(-2\,G\,M + c^2\,r\right)}$$

$$\{2, 1, 1, 3\}\ 0$$

$$\{2, 1, 1, 4\}\ 0$$

$$\{2, 1, 2, 1\} - \frac{G M \left(-3 G M + 2 c^2 r\right)}{c^2 r^3 \left(-2 G M + c^2 r\right)}$$

$$\{2, 1, 2, 2\} 0$$

$$\{2, 1, 2, 3\} 0$$

$$\{2, 1, 2, 4\} 0$$

$$\{2, 1, 3, 1\} 0$$

$$\{2, 1, 3, 2\} 0$$

$$\{2, 1, 3, 3\} 0$$

$$\{2, 1, 3, 4\} 0$$

$$\{2, 1, 4, 1\} 0$$

$$\{2, 1, 4, 2\} 0$$

$$\{2, 1, 4, 3\} 0$$

$$\{2, 1, 4, 4\} 0$$

$$\{2, 2, 1, 1\} 0$$

$$\{2, 2, 1, 2\} 0$$

$$\{2, 2, 1, 3\} 0$$

$$\{2, 2, 1, 4\} 0$$

$$\{2, 2, 2, 1\} 0$$

$$\{2, 2, 2, 2\} 0$$

$$\{2, 2, 2, 3\} 0$$

$$\{2, 2, 2, 4\} 0$$

$$\{2, 2, 3, 1\} 0$$

$$\{2, 2, 3, 2\} 0$$

$$\{2, 2, 3, 3\} 0$$

$$\{2, 2, 3, 4\} 0$$

$$\{2, 2, 4, 1\} 0$$

$$\{2, 2, 4, 2\} 0$$

$$\{2, 2, 4, 3\} 0$$

$$\{2, 2, 4, 4\} 0$$

$$\{2, 3, 1, 1\} 0$$

$$\{2, 3, 1, 2\} 0$$

$$\{2, 3, 1, 3\} 0$$

$$\{2, 3, 1, 4\} 0$$

$$\{2, 3, 2, 1\} 0$$

$$\{2, 3, 2, 2\} 0$$

$$\{2, 3, 2, 3\} 0$$

$$\{2, 3, 2, 4\} 0$$

$$\{2, 3, 3, 1\} 0$$

$$\{2, 3, 3, 2\} 0$$

{2, 3, 3, 3}0

{2, 3, 3, 4}0

{2, 3, 4, 1}0

{2, 3, 4, 2}0

{2, 3, 4, 3}0

{2, 3, 4, 4}0

{2, 4, 1, 1}0

{2, 4, 1, 2}0

{2, 4, 1, 3}0

{2, 4, 1, 4}0

{2, 4, 2, 1}0

{2, 4, 2, 2}0

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{2, 4, 2, 4}0

{2, 4, 3, 1}0

{2, 4, 3, 2}0

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{2, 4, 3, 4}0

{2, 4, 4, 1}0

{2, 4, 4, 2}0

{2, 4, 4, 3}0

{2, 4, 4, 4}0

{3, 1, 1, 1}0

{3, 1, 1, 2}0

$\{3, 1, 1, 3\} -\frac{G\,M}{c^2\,r^3}$

{3, 1, 1, 4}0

{3, 1, 2, 1}0

{3, 1, 2, 2}0

{3, 1, 2, 3}0

{3, 1, 2, 4}0

$\{3, 1, 3, 1\} \frac{G\,M}{c^2\,r^3}$

{3, 1, 3, 2}0

{3, 1, 3, 3}0

{3, 1, 3, 4}0

{3, 1, 4, 1}0

{3, 1, 4, 2}0

{3, 1, 4, 3}0

{3, 1, 4, 4}0

{3, 2, 1, 1}0

{3, 2, 1, 2}0

{3, 2, 1, 3}0

{3, 2, 1, 4}0

{3, 2, 2, 1}0

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{3, 2, 2, 4}0

{3, 2, 3, 1}0

{3, 2, 3, 2}0

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{3, 3, 1, 2}0

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{3, 3, 2, 1}0

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{3, 3, 3, 2}0

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{3, 3, 4, 1}0

{3, 3, 4, 2}0

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{3, 4, 1, 1}0

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{3, 4, 2, 1}0

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{3, 4, 2, 4}0

{3, 4, 3, 1}0

{3, 4, 3, 2}0

{3, 4, 3, 3}0

{3, 4, 3, 4}0

{3, 4, 4, 1}0

{3, 4, 4, 2}0

{3, 4, 4, 3}0

{3, 4, 4, 4}0

{4, 1, 1, 1}0

{4, 1, 1, 2}0

{4, 1, 1, 3}0

$$\{4, 1, 1, 4\} -\frac{G M}{c^2 r^3}$$

{4, 1, 2, 1}0

{4, 1, 2, 2}0

{4, 1, 2, 3}0

{4, 1, 2, 4}0

{4, 1, 3, 1}0

{4, 1, 3, 2}0

{4, 1, 3, 3}0

{4, 1, 3, 4}0

$$\{4, 1, 4, 1\} \frac{G M}{c^2 r^3}$$

{4, 1, 4, 2}0

{4, 1, 4, 3}0

{4, 1, 4, 4}0

{4, 2, 1, 1}0

{4, 2, 1, 2}0

{4, 2, 1, 3}0

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{4, 2, 2, 2}0

{4, 2, 2, 3}0

{4, 2, 2, 4}0

{4, 2, 3, 1}0

{4, 2, 3, 2}0

{4, 2, 3, 3}0

$$\{4, 2, 3, 4\}0$$

$$\{4, 2, 4, 1\}0$$

$$\{4, 2, 4, 2\}0$$

$$\{4, 2, 4, 3\}0$$

$$\{4, 2, 4, 4\}0$$

$$\{4, 3, 1, 1\}0$$

$$\{4, 3, 1, 2\}0$$

$$\{4, 3, 1, 3\}0$$

$$\{4, 3, 1, 4\}0$$

$$\{4, 3, 2, 1\}0$$

$$\{4, 3, 2, 2\}0$$

$$\{4, 3, 2, 3\}0$$

$$\{4, 3, 2, 4\}0$$

$$\{4, 3, 3, 1\}0$$

$$\{4, 3, 3, 2\}0$$

$$\{4, 3, 3, 3\}0$$

$$\{4, 3, 3, 4\}0$$

$$\{4, 3, 4, 1\}0$$

$$\{4, 3, 4, 2\}0$$

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$$\{4, 3, 4, 4\}0$$

$$\{4, 4, 1, 1\}0$$

$$\{4, 4, 1, 2\}0$$

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$$\{4, 4, 2, 1\}0$$

$$\{4, 4, 2, 2\}0$$

$$\{4, 4, 2, 3\}0$$

$$\{4, 4, 2, 4\}0$$

$$\{4, 4, 3, 1\}0$$

$$\{4, 4, 3, 2\}0$$

$$\{4, 4, 3, 3\}0$$

$$\{4, 4, 3, 4\}0$$

$$\{4, 4, 4, 1\}0$$

$$\{4, 4, 4, 2\}0$$

$$\{4, 4, 4, 3\}0$$

$$\{4, 4, 4, 4\}0$$

$$\{1, 1\}\frac{G^2 M^2}{c^2 r^3 \left(2 G M - c^2 r\right)}$$

{1, 2} 0

{1, 3} 0

{1, 4} 0

{2, 1} 0

$$\{2, 2\} -\frac{G M \left(3 G M - 2 c^2 r\right)}{r^2 \left(-2 G M + c^2 r\right)^2}$$

{2, 3} 0

{2, 4} 0

{3, 1} 0

{3, 2} 0

$$\{3, 3\} \frac{G M}{2 G M - c^2 r}$$

{3, 4} 0

{4, 1} 0

{4, 2} 0

{4, 3} 0

$$\{4, 4\} \frac{G M \text{Sin}[e]^2}{2 G M - c^2 r}$$

Out[42]=
$$\frac{2 G^2 M^2}{r^2 \left(-2 G M + c^2 r\right)^2}$$