

ضرائب کریستوفل:

$$\Gamma_{tt}^t = 0 \quad (1)$$

$$\Gamma_{tr}^t = -\frac{mR}{(R^2 + z^2)^{\frac{3}{2}}} \quad (2)$$

$$\Gamma_{t\varphi}^t = 0 \quad (3)$$

$$\Gamma_{tz}^t = -\frac{mz}{(R^2 + z^2)^{\frac{3}{2}}} \quad (4)$$

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$$\Gamma_{rt}^t = \frac{mR}{(R^2 + z^2)^{\frac{3}{2}}} \quad (5)$$

$$\Gamma_{rr}^t = 0 \quad (6)$$

$$\Gamma_{r\varphi}^t = -\frac{maR(R^2 - 2z^2)}{(R^2 + z^2)^{\frac{5}{2}}} \quad (7)$$

$$\Gamma_{rz}^t = 0 \quad (8)$$

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$$\Gamma_{\varphi t}^t = 0 \quad (9)$$

$$\Gamma_{\varphi r}^t = \frac{maR(R^2 - 2z^2)}{(R^2 + z^2)^{\frac{5}{2}}} \quad (10)$$

$$\Gamma_{\varphi\varphi}^t = 0 \quad (11)$$

$$\Gamma_{\varphi z}^t = \frac{3maR^2z}{(R^2 + z^2)^{\frac{5}{2}}} \quad (12)$$

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$$\Gamma_{zt}^t = \frac{mz}{(R^2 + z^2)^{\frac{3}{2}}} \quad (13)$$

$$\Gamma_{zr}^t = 0 \quad (14)$$

$$\Gamma_{z\varphi}^t = -\frac{3maR^2z}{(R^2 + z^2)^{\frac{5}{2}}} \quad (15)$$

$$\Gamma_{zz}^t = 0 \quad (16)$$

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$$\Gamma_{tt}^r = \frac{mR}{(R^2 + z^2)^{\frac{3}{2}}} \quad (17)$$

$$\Gamma_{tr}^r = 0 \quad (18)$$

$$\Gamma_{t\varphi}^r = -\frac{maR(R^2 - 2z^2)}{(R^2 + z^2)^{\frac{5}{2}}} \quad (19)$$

$$\Gamma_{tz}^r = 0 \quad (20)$$

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$$\Gamma_{rt}^r = 0 \quad (21)$$

$$\Gamma_{rr}^r = \frac{mR}{(R^2 + z^2)^{\frac{3}{2}}} \quad (22)$$

$$\Gamma_{r\varphi}^r = 0 \quad (23)$$

$$\Gamma_{rz}^r = -\frac{mz}{(R^2 + z^2)^{\frac{3}{2}}} \quad (24)$$

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$$\Gamma_{\varphi t}^r = -\frac{maR(R^2 - 2z^2)}{(R^2 + z^2)^{\frac{5}{2}}} \quad (25)$$

$$\Gamma_{\varphi r}^r = 0 \quad (26)$$

$$\Gamma_{\varphi\varphi}^r = -\frac{R\left((R^2 + z^2)^{\frac{3}{2}} + R^2m + 2mz^2\right)}{(R^2 + z^2)^{\frac{3}{2}}} \quad (27)$$

$$\Gamma_{\varphi z}^r = 0 \quad (28)$$

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$$\Gamma_{zt}^r = 0 \quad (29)$$

$$\Gamma_{zr}^r = \frac{mz}{(R^2 + z^2)^{\frac{3}{2}}} \quad (30)$$

$$\Gamma_{z\varphi}^r = 0 \quad (31)$$

$$\Gamma_{zz}^r = \frac{mR}{(R^2 + z^2)^{\frac{3}{2}}} \quad (32)$$

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$$\Gamma_{tt}^\varphi = 0 \quad (33)$$

$$\Gamma_{tr}^\varphi = \frac{maR(R^2 - 2z^2)}{(R^2 + z^2)^{\frac{5}{2}}} \quad (34)$$

$$\Gamma_{t\varphi}^\varphi = 0 \quad (35)$$

$$\Gamma_{tz}^\varphi = \frac{3maR^2z}{(R^2 + z^2)^{\frac{5}{2}}} \quad (36)$$

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$$\Gamma_{rt}^\varphi = -\frac{maR(R^2 - 2z^2)}{(R^2 + z^2)^{\frac{5}{2}}} \quad (37)$$

$$\Gamma_{rr}^\varphi = 0 \quad (38)$$

$$\Gamma_{r\varphi}^\varphi = -\frac{R\left((R^2 + z^2)^{\frac{3}{2}} + R^2m + 2mz^2\right)}{(R^2 + z^2)^{\frac{3}{2}}} \quad (40)$$

$$\Gamma_{rz}^\varphi = 0 \quad (41)$$

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$$\Gamma_{\varphi t}^\varphi = 0 \quad (42)$$

$$\Gamma_{\varphi r}^\varphi = \frac{R\left((R^2 + z^2)^{\frac{3}{2}} + R^2m + 2mz^2\right)}{(R^2 + z^2)^{\frac{3}{2}}} \quad (43)$$

$$\Gamma_{\varphi\varphi}^\varphi = 0 \quad (44)$$

$$\Gamma_{\varphi z}^{\varphi} = -\frac{mzR^2}{(R^2 + z^2)^{\frac{3}{2}}} \quad (45)$$

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$$\Gamma_{zt}^{\varphi} = -\frac{3maR^2z}{(R^2 + z^2)^{\frac{5}{2}}} \quad (46)$$

$$\Gamma_{zr}^{\varphi} = 0 \quad (47)$$

$$\Gamma_{z\varphi}^{\varphi} = \frac{mzR^2}{(R^2 + z^2)^{\frac{3}{2}}} \quad (48)$$

$$\Gamma_{zz}^{\varphi} = 0 \quad (49)$$

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$$\Gamma_{tt}^z = \frac{mz}{(R^2 + z^2)^{\frac{3}{2}}} \quad (50)$$

$$\Gamma_{tr}^z = 0 \quad (51)$$

$$\Gamma_{t\varphi}^z = -\frac{3maR^2z}{(R^2 + z^2)^{\frac{5}{2}}} \quad (52)$$

$$\Gamma_{tz}^z = 0 \quad (53)$$

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$$\Gamma_{rt}^z = 0 \quad (54)$$

$$\Gamma_{rr}^z = \frac{mz}{(R^2 + z^2)^{\frac{3}{2}}} \quad (55)$$

$$\Gamma_{r\varphi}^z = 0 \quad (56)$$

$$\Gamma_{rz}^z = \frac{mR}{(R^2 + z^2)^{\frac{3}{2}}} \quad (57)$$

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$$\Gamma_{\varphi t}^z = -\frac{3maR^2z}{(R^2 + z^2)^{\frac{5}{2}}} \quad (58)$$

$$\Gamma_{\varphi r}^z = 0 \quad (59)$$

$$\Gamma_{\varphi\varphi}^z = \frac{mzR^2}{(R^2 + z^2)^{\frac{3}{2}}} \quad (60)$$

$$\Gamma_{\varphi z}^z = 0 \quad (61)$$

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$$\Gamma_{zt}^z = 0 \quad (62)$$

$$\Gamma_{zr}^z = -\frac{mR}{(R^2 + z^2)^{\frac{3}{2}}} \quad (63)$$

$$\Gamma_{z\varphi}^z = 0 \quad (63)$$

$$\Gamma_{zz}^z = \frac{mz}{(R^2 + z^2)^{\frac{3}{2}}} \quad (64)$$

ضرائب کریستوفل برای قرص با در نظر گرفتن $z = 0$:

$$\Gamma_{tt}^t = 0 \quad (1)$$

$$\Gamma_{tr}^t = -\frac{m}{R^2} \quad (2)$$

$$\Gamma_{t\varphi}^t = 0 \quad (3)$$

$$\Gamma_{tz}^t = 0 \quad (4)$$

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$$\Gamma_{rt}^t = \frac{m}{R^2} \quad (5)$$

$$\Gamma_{rr}^t = 0 \quad (6)$$

$$\Gamma_{r\varphi}^t = -\frac{ma}{R^2} \quad (7)$$

$$\Gamma_{rz}^t = 0 \quad (8)$$

=====

$$\Gamma_{\varphi t}^t = 0 \quad (9)$$

$$\Gamma_{\varphi r}^t = \frac{ma}{R^2} \quad (10)$$

$$\Gamma_{\varphi\varphi}^t = 0 \quad (11)$$

$$\Gamma_{\varphi z}^t = 0 \quad (12)$$

=====

$$\Gamma_{zt}^t = 0 \quad (13)$$

$$\Gamma_{zr}^t = 0 \quad (14)$$

$$\Gamma_{z\varphi}^t = 0 \quad (15)$$

$$\Gamma_{zz}^t = 0 \quad (16)$$

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$$\Gamma_{tt}^r = \frac{m}{R^2} \quad (17)$$

$$\Gamma_{tr}^r = 0 \quad (18)$$

$$\Gamma_{t\phi}^r = -\frac{ma}{R^2} \quad (19)$$

$$\Gamma_{tz}^r = 0 \quad (20)$$

=====

$$\Gamma_{rt}^r = 0 \quad (21)$$

$$\Gamma_{rr}^r = \frac{m}{R^2} \quad (22)$$

$$\Gamma_{r\phi}^r = 0 \quad (23)$$

$$\Gamma_{rz}^r = 0 \quad (24)$$

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$$\Gamma_{\phi t}^r = -\frac{ma}{R^2} \quad (25)$$

$$\Gamma_{\phi r}^r = 0 \quad (26)$$

$$\Gamma_{\phi\phi}^r = -(R + m) \quad (27)$$

$$\Gamma_{\phi z}^r = 0 \quad (28)$$

=====

$$\Gamma_{zt}^r = 0 \quad (29)$$

$$\Gamma_{zr}^r = 0 \quad (30)$$

$$\Gamma_{z\phi}^r = 0 \quad (31)$$

$$\Gamma_{zz}^r = \frac{m}{R^2} \quad (32)$$

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$$\Gamma_{tt}^\phi = 0 \quad (33)$$

$$\Gamma_{tr}^\phi = \frac{ma}{R^2} \quad (34)$$

$$\Gamma_{t\phi}^\phi = 0 \quad (35)$$

$$\Gamma_{tz}^\phi = 0 \quad (36)$$

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$$\Gamma_{rt}^\varphi = -\frac{ma}{R^2} \quad (37)$$

$$\Gamma_{rr}^\varphi = 0 \quad (38)$$

$$\Gamma_{r\varphi}^\varphi = -(R + m) \quad (40)$$

$$\Gamma_{rz}^\varphi = 0 \quad (41)$$

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$$\Gamma_{\varphi t}^\varphi = 0 \quad (42)$$

$$\Gamma_{\varphi r}^\varphi = (R + m) \quad (43)$$

$$\Gamma_{\varphi\varphi}^\varphi = 0 \quad (44)$$

$$\Gamma_{\varphi z}^\varphi = 0 \quad (45)$$

=====

$$\Gamma_{zt}^\varphi = 0 \quad (46)$$

$$\Gamma_{zr}^\varphi = 0 \quad (47)$$

$$\Gamma_{z\varphi}^\varphi = 0 \quad (48)$$

$$\Gamma_{zz}^\varphi = 0 \quad (49)$$

=====

$$\Gamma_{tt}^z = 0 \quad (50)$$

$$\Gamma_{tr}^z = 0 \quad (51)$$

$$\Gamma_{t\varphi}^z = 0 \quad (52)$$

$$\Gamma_{tz}^z = 0 \quad (53)$$

=====

$$\Gamma_{rt}^z = 0 \quad (54)$$

$$\Gamma_{rr}^z = 0 \quad (55)$$

$$\Gamma_{r\varphi}^z = 0 \quad (56)$$

$$\Gamma_{rz}^z = \frac{m}{R^2} \quad (57)$$

=====

$$\Gamma_{\varphi t}^z = 0 \quad (58)$$

$$\Gamma_{\varphi r}^z = 0 \quad (59)$$

$$\Gamma_{\varphi\varphi}^z = 0 \quad (60)$$

$$\Gamma_{\varphi z}^z = 0 \quad (61)$$

=====

$$\Gamma_{zt}^z = 0 \quad (62)$$

$$\Gamma_{zr}^z = -\frac{m}{R^2} \quad (63)$$

$$\Gamma_{z\varphi}^z = 0 \quad (63)$$

$$\Gamma_{zz}^z = 0 \quad (64)$$

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$$\Gamma_{tr}^t = \Gamma_{zr}^z = -\frac{m}{R^2}$$

$$\Gamma_{rt}^t = \Gamma_{tt}^r = \Gamma_{rr}^r = \Gamma_{zz}^r = \Gamma_{rz}^z = \frac{m}{R^2}$$

$$\Gamma_{r\varphi}^t = \Gamma_{t\varphi}^r = \Gamma_{\varphi t}^r = \Gamma_{rt}^\varphi = -\frac{ma}{R^2}$$

$$\Gamma_{\varphi r}^t = \Gamma_{tr}^\varphi = \frac{ma}{R^2}$$

$$\Gamma_{\varphi\varphi}^r = \Gamma_{r\varphi}^\varphi = -(R + m)$$

$$\Gamma_{\varphi r}^\varphi = (R + m)$$

ضرائب کریستوفل برای جت با در نظر گرفتن $R = 0$:

$$\Gamma_{tt}^t = 0 \quad (1)$$

$$\Gamma_{tr}^t = 0 \quad (2)$$

$$\Gamma_{t\varphi}^t = 0 \quad (3)$$

$$\Gamma_{tz}^t = -\frac{m}{z^2} \quad (4)$$

=====

$$\Gamma_{rt}^t = 0 \quad (5)$$

$$\Gamma_{rr}^t = 0 \quad (6)$$

$$\Gamma_{r\varphi}^t = 0 \quad (7)$$

$$\Gamma_{rz}^t = 0 \quad (8)$$

=====

$$\Gamma_{\varphi t}^t = 0 \quad (9)$$

$$\Gamma_{\varphi r}^t = 0 \quad (10)$$

$$\Gamma_{\varphi\varphi}^t = 0 \quad (11)$$

$$\Gamma_{\varphi z}^t = 0 \quad (12)$$

=====

$$\Gamma_{zt}^t = \frac{m}{z^2} \quad (13)$$

$$\Gamma_{zr}^t = 0 \quad (14)$$

$$\Gamma_{z\varphi}^t = 0 \quad (15)$$

$$\Gamma_{zz}^t = 0 \quad (16)$$

=====

$$\Gamma_{tt}^r = 0 \quad (17)$$

$$\Gamma_{tr}^r = 0 \quad (18)$$

$$\Gamma_{t\varphi}^r = 0 \quad (19)$$

$$\Gamma_{tz}^r = 0 \quad (20)$$

=====

$$\Gamma_{rt}^r = 0 \quad (21)$$

$$\Gamma_{rr}^r = 0 \quad (22)$$

$$\Gamma_{r\varphi}^r = 0 \quad (23)$$

$$\Gamma_{rz}^r = -\frac{m}{z^2} \quad (24)$$

=====

$$\Gamma_{\varphi t}^r = 0 \quad (25)$$

$$\Gamma_{\varphi r}^r = 0 \quad (26)$$

$$\Gamma_{\varphi\varphi}^r = 0 \quad (27)$$

$$\Gamma_{\varphi z}^r = 0 \quad (28)$$

=====

$$\Gamma_{zt}^r = 0 \quad (29)$$

$$\Gamma_{zr}^r = \frac{m}{z^2} \quad (30)$$

$$\Gamma_{z\varphi}^r = 0 \quad (31)$$

$$\Gamma_{zz}^r = 0 \quad (32)$$

=====

$$\Gamma_{tt}^\varphi = 0 \quad (33)$$

$$\Gamma_{tr}^\varphi = 0 \quad (34)$$

$$\Gamma_{t\varphi}^\varphi = 0 \quad (35)$$

$$\Gamma_{tz}^\varphi = 0 \quad (36)$$

=====

$$\Gamma_{rt}^\varphi = 0 \quad (37)$$

$$\Gamma_{rr}^\varphi = 0 \quad (38)$$

$$\Gamma_{r\varphi}^\varphi = 0 \quad (40)$$

$$\Gamma_{rz}^\varphi = 0 \quad (41)$$

=====

$$\Gamma_{\phi t}^{\phi} = 0 \quad (42)$$

$$\Gamma_{\phi r}^{\phi} = 0 \quad (43)$$

$$\Gamma_{\phi\phi}^{\phi} = 0 \quad (44)$$

$$\Gamma_{\phi z}^{\phi} = 0 \quad (45)$$

=====

$$\Gamma_{zt}^{\phi} = 0 \quad (46)$$

$$\Gamma_{zr}^{\phi} = 0 \quad (47)$$

$$\Gamma_{z\phi}^{\phi} = 0 \quad (48)$$

$$\Gamma_{zz}^{\phi} = 0 \quad (49)$$

=====

$$\Gamma_{tt}^z = \frac{m}{z^2} \quad (50)$$

$$\Gamma_{tr}^z = 0 \quad (51)$$

$$\Gamma_{t\phi}^z = 0 \quad (52)$$

$$\Gamma_{tz}^z = 0 \quad (53)$$

=====

$$\Gamma_{rt}^z = 0 \quad (54)$$

$$\Gamma_{rr}^z = \frac{m}{z^2} \quad (55)$$

$$\Gamma_{r\phi}^z = 0 \quad (56)$$

$$\Gamma_{rz}^z = 0 \quad (57)$$

=====

$$\Gamma_{\phi t}^z = 0 \quad (58)$$

$$\Gamma_{\phi r}^z = 0 \quad (59)$$

$$\Gamma_{\phi\phi}^z = 0 \quad (60)$$

$$\Gamma_{\phi z}^z = 0 \quad (61)$$

=====

$$\Gamma_{zt}^z = 0 \quad (62)$$

$$\Gamma_{zr}^z = 0 \quad (63)$$

$$\Gamma_{z\varphi}^z = 0 \quad (63)$$

$$\Gamma_{zz}^z = \frac{m}{z^2} \quad (64)$$

$$\Gamma_{tz}^t = \Gamma_{rz}^r = -\frac{m}{z^2}$$

$$\Gamma_{zt}^t = \Gamma_{zr}^r = \Gamma_{tt}^z = \Gamma_{rr}^z = \Gamma_{zz}^z = \frac{m}{z^2}$$

ضرائب کریستوفل برای قرص با در نظر گرفتن $z = 0$:

$$\Gamma_{tr}^t = \Gamma_{zr}^z = -\frac{m}{R^2}$$

$$\Gamma_{rt}^t = \Gamma_{tt}^r = \Gamma_{rr}^r = \Gamma_{zz}^r = \Gamma_{rz}^z = \frac{m}{R^2}$$

$$\Gamma_{r\varphi}^t = \Gamma_{t\varphi}^r = \Gamma_{\varphi t}^r = \Gamma_{rt}^\varphi = -\frac{ma}{R^2}$$

$$\Gamma_{\varphi r}^t = \Gamma_{tr}^\varphi = \frac{ma}{R^2}$$

$$\Gamma_{\varphi\varphi}^r = \Gamma_{r\varphi}^\varphi = -(R + m)$$

$$\Gamma_{\varphi r}^\varphi = (R + m)$$

ضرائب کریستوفل برای جت با در نظر گرفتن $R = 0$:

$$\Gamma_{tz}^t = \Gamma_{rz}^r = -\frac{m}{z^2}$$

$$\Gamma_{zt}^t = \Gamma_{zr}^r = \Gamma_{tt}^z = \Gamma_{rr}^z = \Gamma_{zz}^z = \frac{m}{z^2}$$