restart : *clear* :

R R_0

$$\sigma(q, r) := \frac{q}{4 \cdot \pi \cdot r^2}$$

$$(q, r) \to \frac{1}{4} \frac{q}{\pi r^2} \quad (1)$$

$$\frac{d}{d\theta} S := 2 \cdot \pi \cdot r^2 \cdot \sin(\theta)$$

$$\varphi_R(q, r, R_0) := \int_0^{\pi} \frac{2 \cdot \pi \cdot r^2 \cdot \sin(\theta) \cdot \sigma(q, r)}{\sqrt{(R_0)^2 - 2 \cdot R_0 \cdot r \cdot \cos(\theta) + (r)^2}} \, d\theta$$

$$(q, r, R_0) \to \int_0^{\pi} \frac{2 \pi r^2 \sin(\theta) \sigma(q, r)}{\sqrt{R_0^2 - 2 R_0 r \cos(\theta) + r^2}} \, d\theta \quad (2)$$

$\varphi_R(q, r, R_0)$

$$\int_0^{\pi} \frac{1}{2} \frac{\sin(\theta) q}{\sqrt{R_0^2 - 2 R_0 r \cos(\theta) + r^2}} \, d\theta \quad (3)$$

$\varphi_R(q, 1, R_0) + \varphi_R(-q, 2, R_0)$

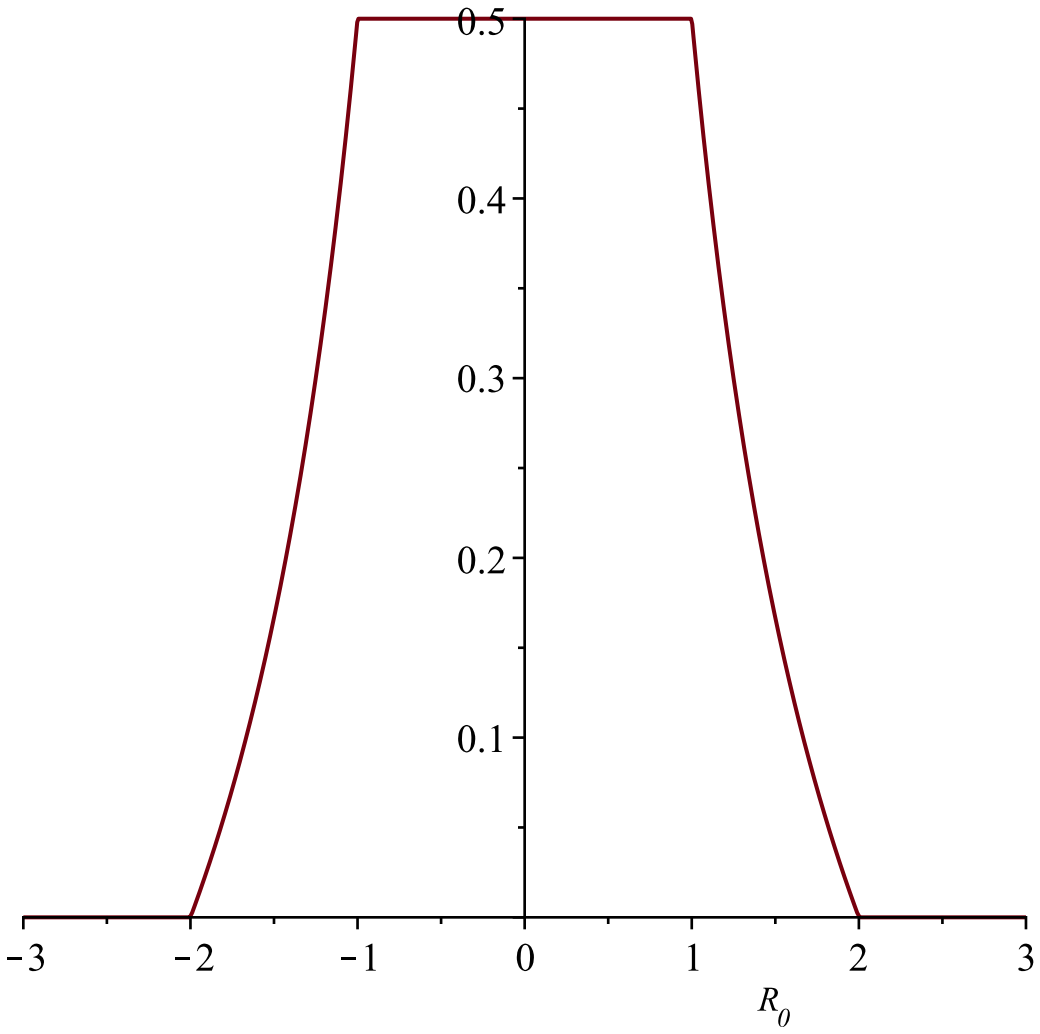
$$\int_0^{\pi} \frac{1}{2} \frac{\sin(\theta) q}{\sqrt{R_0^2 - 2 R_0 \cos(\theta) + 1}} \, d\theta + \int_0^{\pi} \left(-\frac{1}{2} \frac{\sin(\theta) q}{\sqrt{R_0^2 - 4 R_0 \cos(\theta) + 4}} \right) d\theta \quad (4)$$

evalf $\left(\varphi_R(1, 1, R_0) + \varphi_R(-1, 2, R_0) \right)$

$$\int_{0.}^{3.141592654} \frac{0.5000000000 \sin(\theta)}{\sqrt{R_0^2 - 2. R_0 \cos(\theta) + 1.}} \, d\theta + \int_{0.}^{3.141592654} \left(-\frac{0.5000000000 \sin(\theta)}{\sqrt{R_0^2 - 4. R_0 \cos(\theta) + 4.}} \right) d\theta \quad (5)$$

2 - 1

$with(plots) : plot\left(\varphi_R(1, 1, R_0) + \varphi_R(-1, 2, R_0), R_0 = -3..3\right)$



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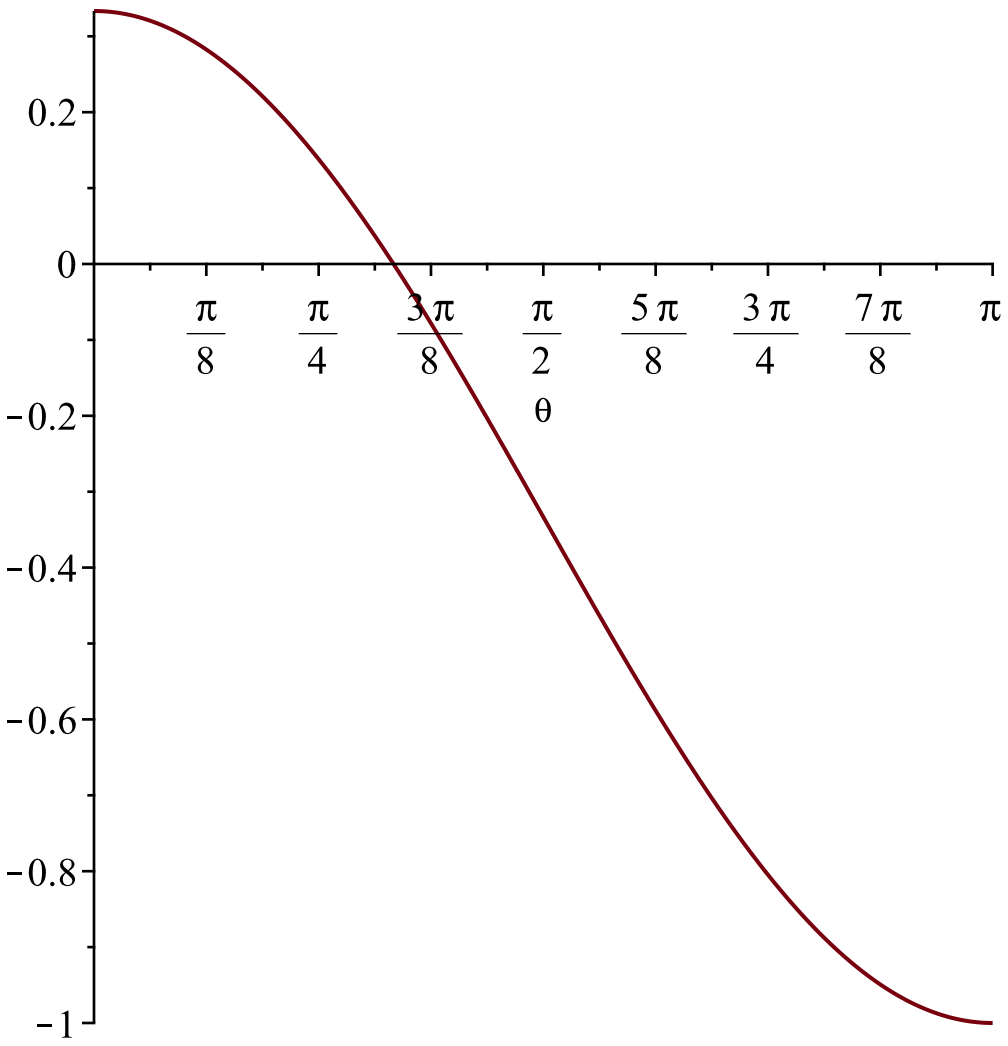
$$vr\left(v, c, r, R_0, \theta\right) := \frac{v}{c} \cdot \left(R_0 \cdot \cos(\theta) - r\right)$$

$$\left(v, c, r, R_0, \theta\right) \rightarrow \frac{v\left(R_0 \cos(\theta) - r\right)}{c} \quad \textbf{(6)}$$

$plot\left(vr(1, 3, 1, 2, \theta), \theta = 0..\pi\right)$



R_0 ,

R v .

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$$\varphi_{lw}(q, v, c, r, R_0) := \int_0^{\pi} \frac{2\cdot\pi\cdot r^2\cdot\sin(\theta)\cdot\sigma(q, r)}{\sqrt{(R_0)^2 - 2\cdot R_0\cdot r\cdot\cos(\theta) + (r)^2} - \frac{v}{c}\cdot(R_0\cdot\cos(\theta) - r)}\, d\theta$$

$$(q, v, c, r, R_0) \rightarrow \int_0^{\pi} \frac{2\,\pi\, r^2\sin(\theta)\,\sigma(q, r)}{\sqrt{R_0^2 - 2\,R_0\, r\cos(\theta) + r^2} - \frac{v\,(R_0\cos(\theta) - r)}{c}}\, d\theta \qquad \textbf{(7)}$$

$\varphi_{lw}(q, v, c, r, R_0)$

$$\int_0^{\pi} \frac{1}{2} \frac{\sin(\theta)\, q}{\sqrt{R_0^{\,2} - 2\, R_0\, r \cos(\theta) + r^2} - \frac{v\left(R_0 \cos(\theta) - r\right)}{c}}\, d\theta \qquad \textbf{(8)}$$

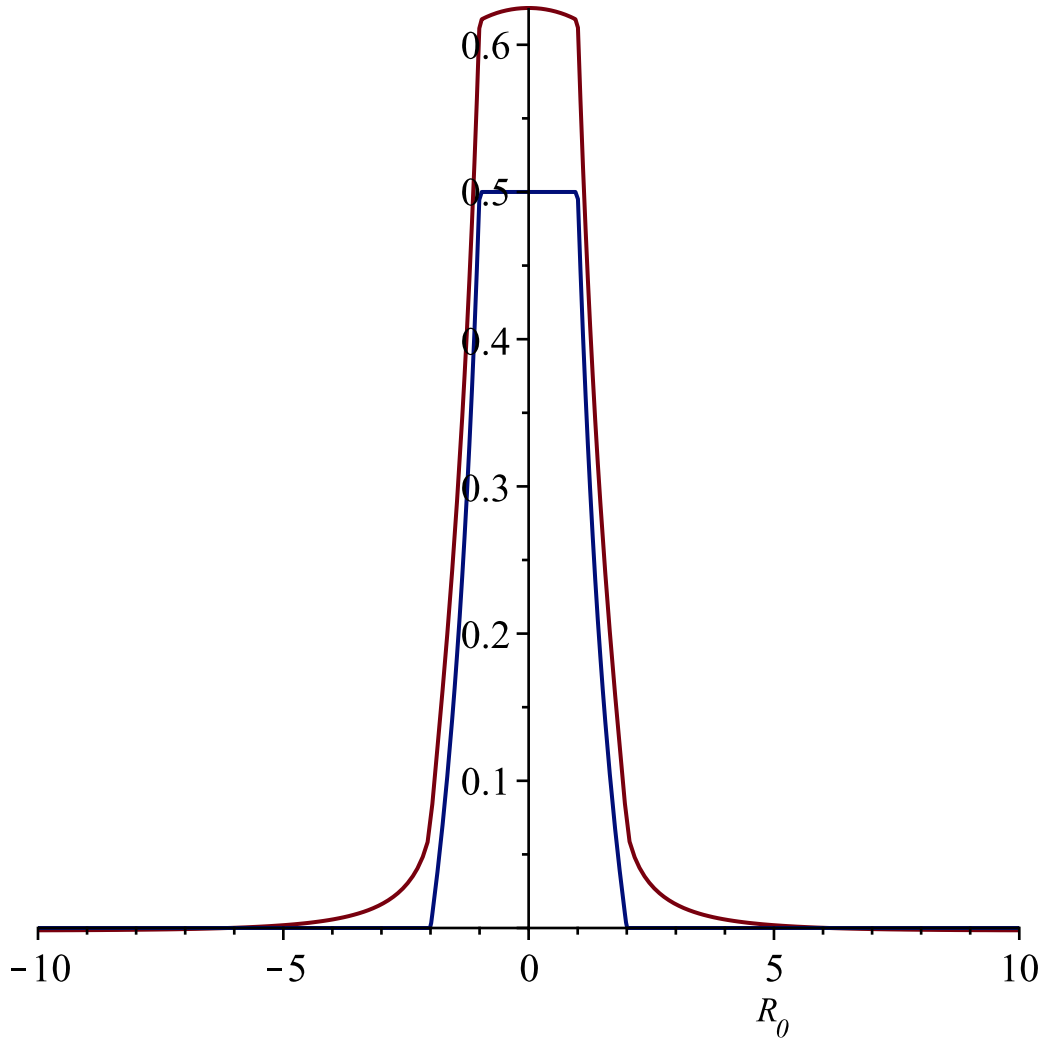
.

$R_+ := 1 :$ $R_- := 2 :$

$c := 3 :$

,

$with(plots) : plot\left(\left[\varphi_R(1, R_+, R_0) + \varphi_{lw}(-1, 1, c, R_-, R_0), \varphi_R(1, R_+, R_0) + \varphi_R(-1, R_-, R_0) \right], R_0 = -10..10 \right)$



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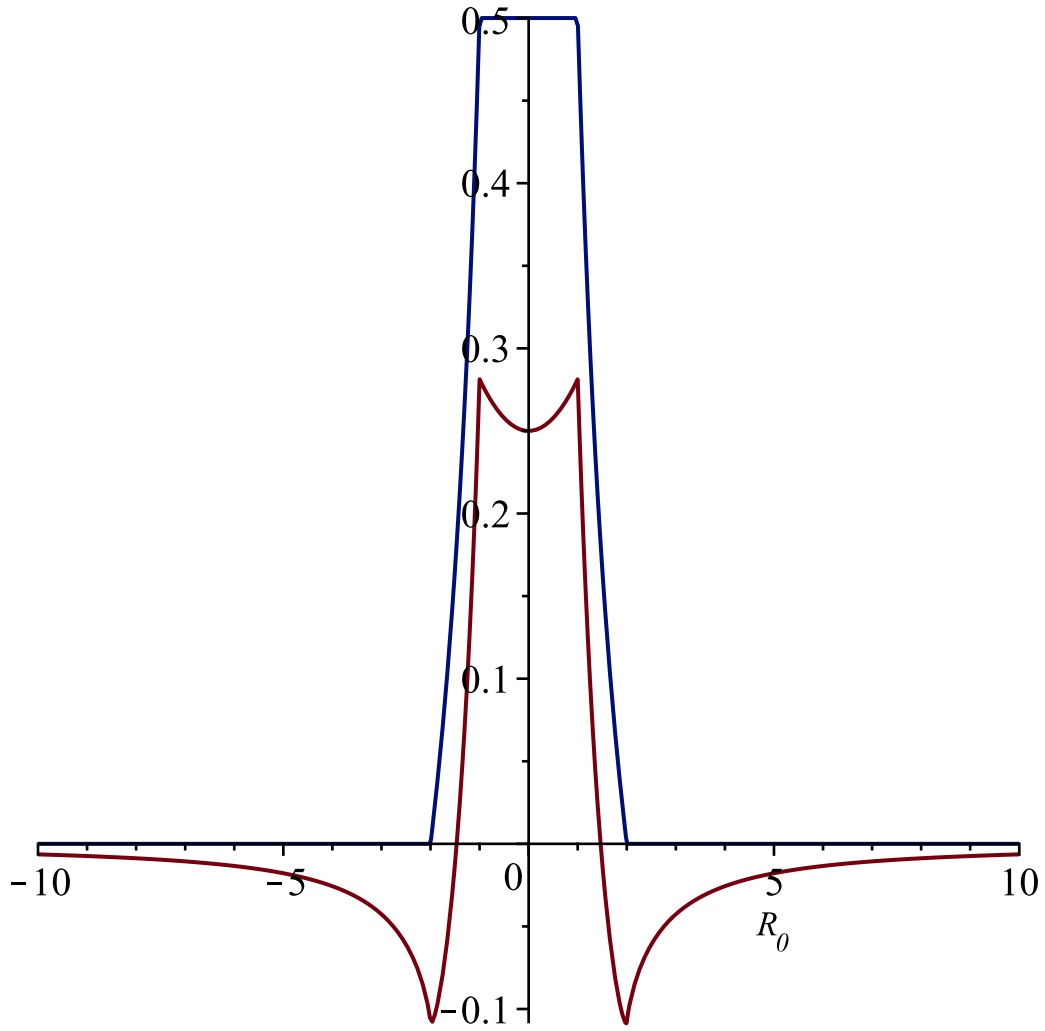
$$with(plots):plot\left(\left[\varphi_R(1,R_+,R_0)+\varphi_{lw}(-1,-1,c,R_-,R_0),\varphi_R(1,R_+,R_0)+\varphi_R(-1,R_-,R_0)\right],R_0=-10..10\right)$$



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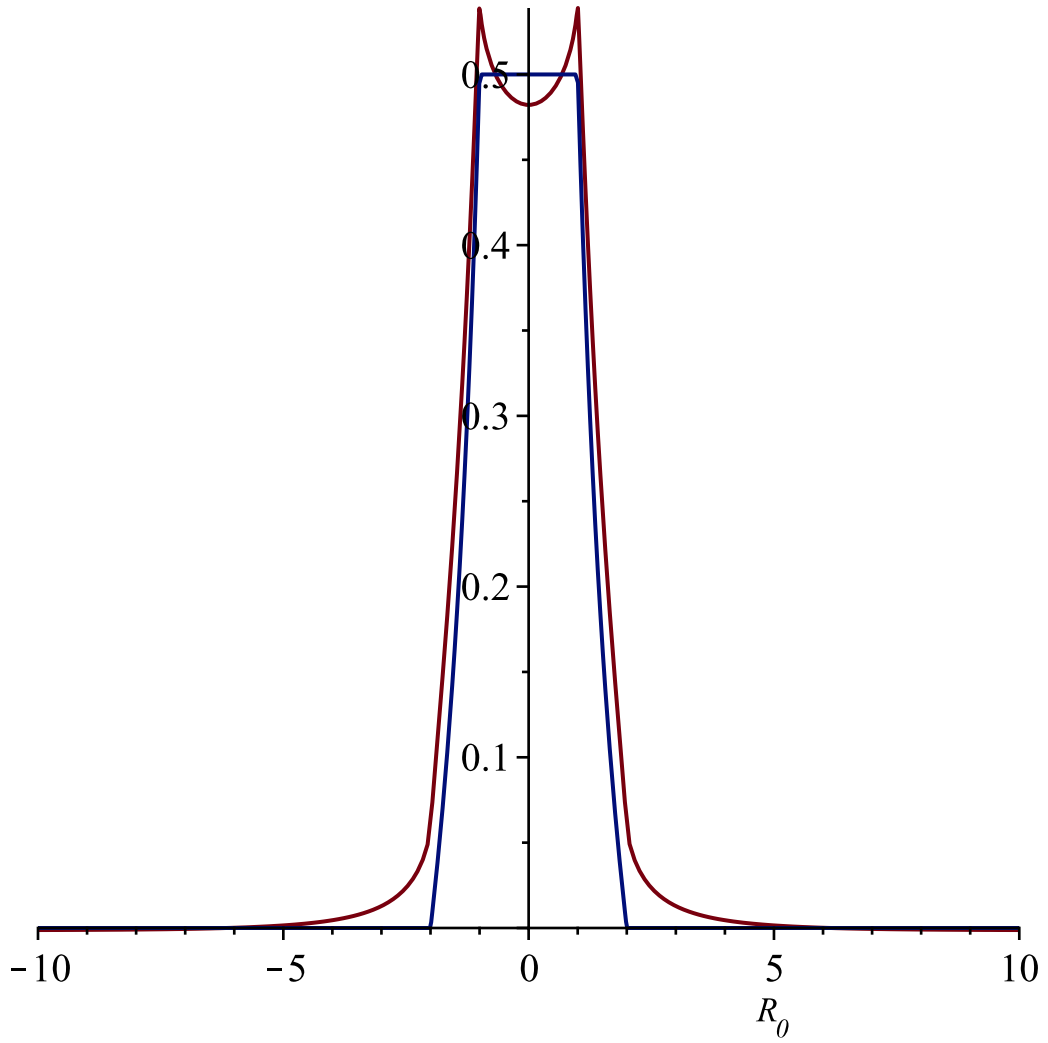
$$with(plots):plot\left(\left[\varphi_{lw}(1,0.5,c,R_+,R_0)+\varphi_{lw}(-1,1,c,R_-,R_0),\varphi_R(1,R_+,R_0)+\varphi_R(-1,R_-,R_0)\right],R_0=-10..10\right)$$



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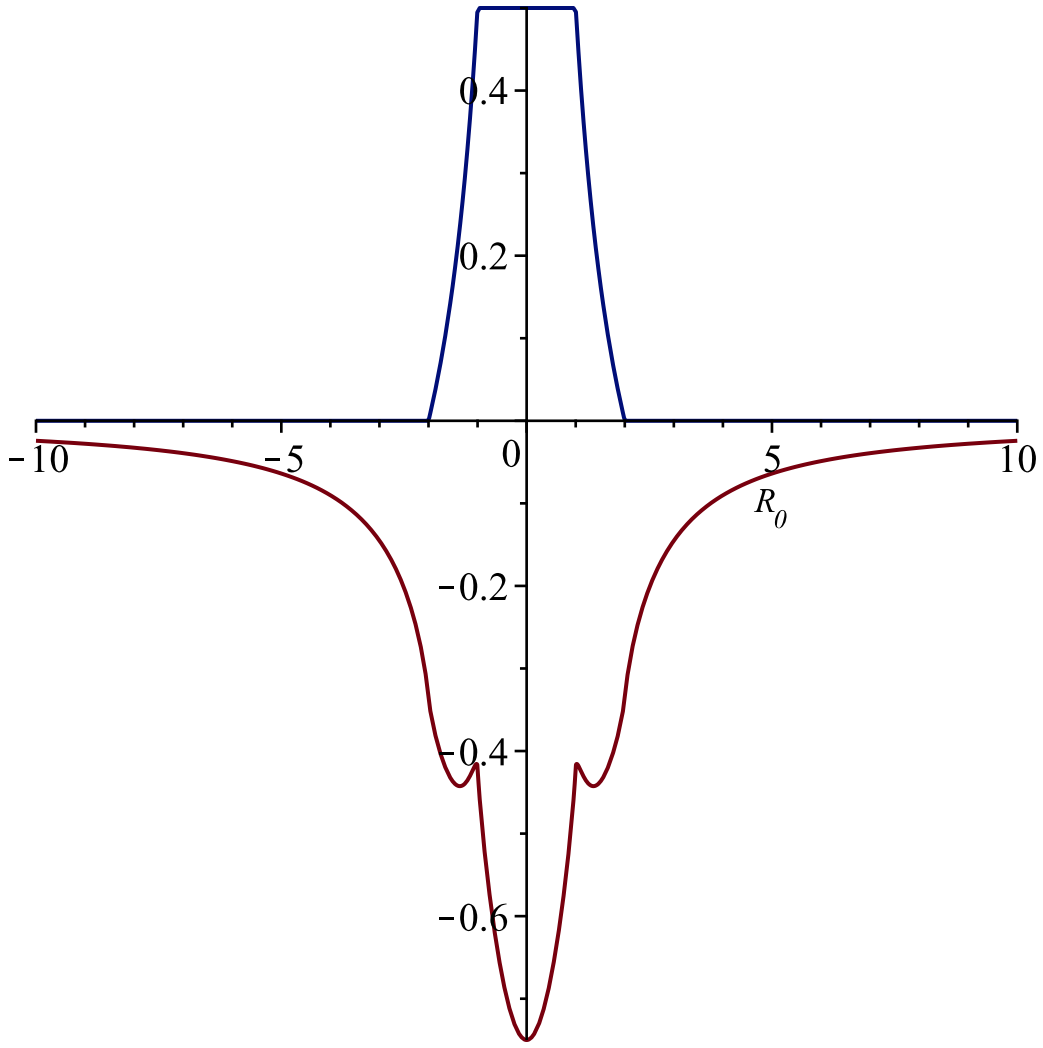
$with(plots) : plot\left(\left[\varphi_{lw}(1, 1, c, R_+, R_0) + \varphi_{lw}(-1, -2, c, R_-, R_0), \varphi_R(1, R_+, R_0) + \varphi_R(-1, R_-, R_0) \right], R_0 = -10..10 \right)$



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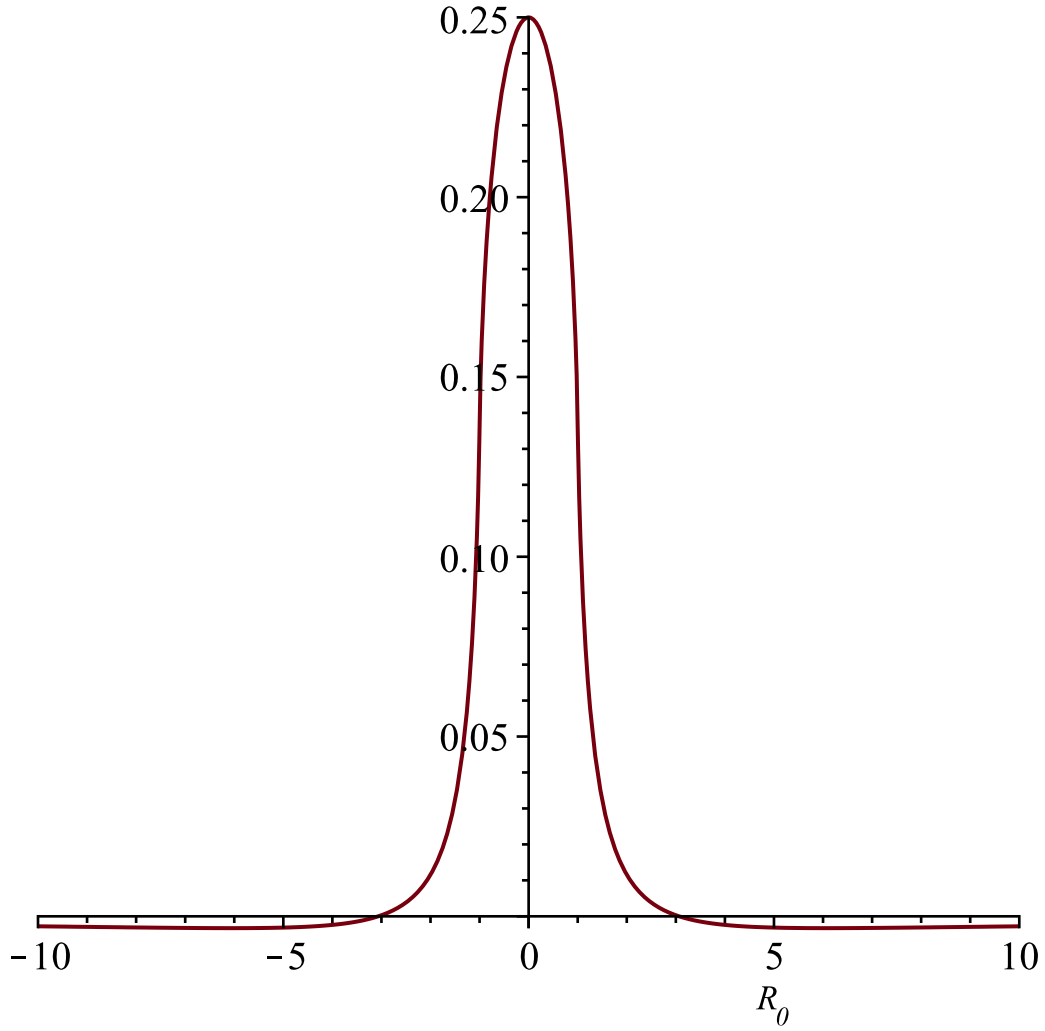
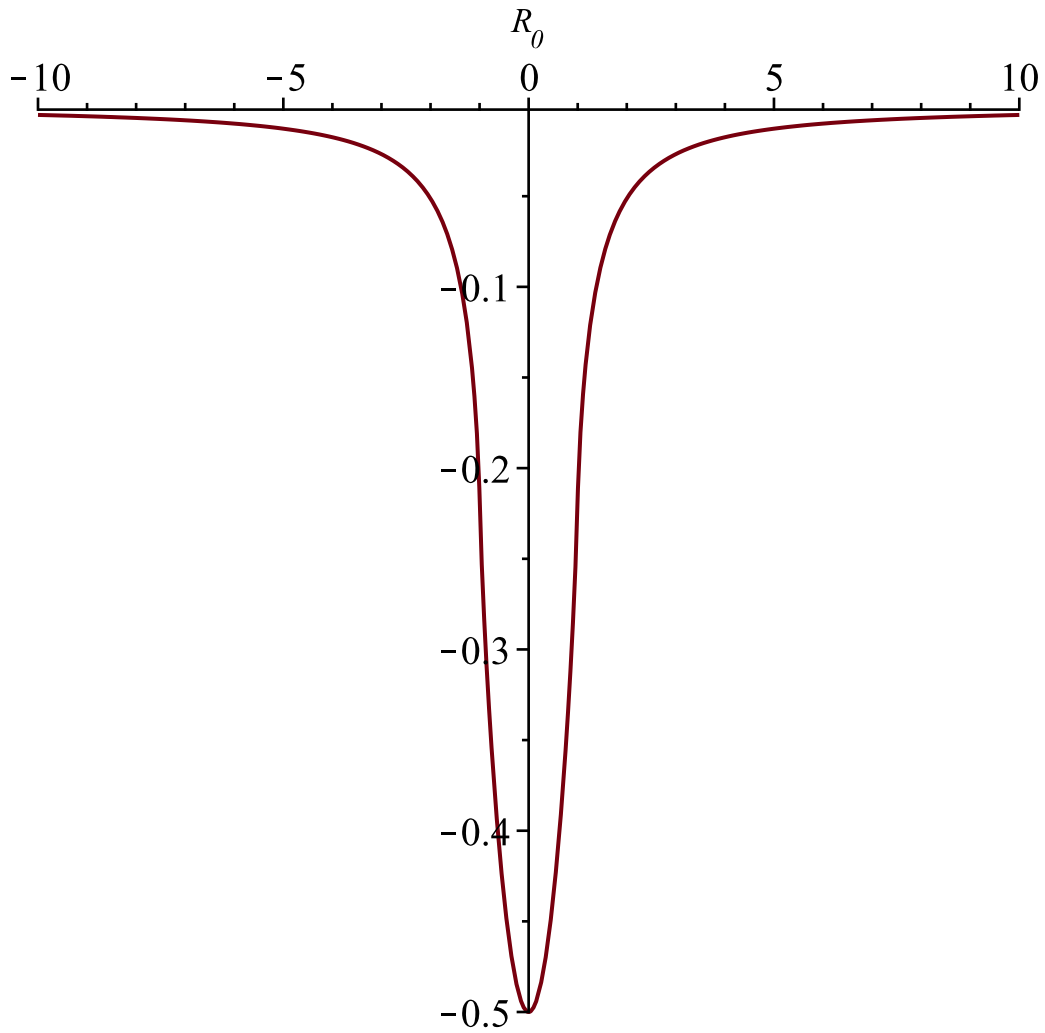
$$d\varphi_{lw}(q, v, c, R, R_0) := \varphi_{lw}(q, v, c, R, R_0) + \varphi_{lw}(-q, 0, c, R, R_0)$$

$$(q, v, c, R, R_0) \rightarrow \varphi_{lw}(q, v, c, R, R_0) + \varphi_{lw}(-q, 0, c, R, R_0) \quad \textbf{(9)}$$

$$with(plots) : plot([d\varphi_{lw}(-1, 1, c, R_+, R_0)], R_0 = -10..10)$$



$with(plots) : plot([d\varphi_{lw}(-1, -1, c, R_+, R_0)], R_0 = -10..10)$



:

$v_{0r}(r_0) := v$
$v_{0r}(r_0)$

r_0

$a_r(t, r_0, v_0, a_0) := a_0$

$(t, r_0, v_0, a_0) \rightarrow a_0$ **(10)**

$a_r(t, r_0, v_0, a_0)$

$$a_0 \tag{11}$$

$$r(t, r_0, v_0, a_0) := r_0 + v_0 \cdot t + \frac{a_0 \cdot t^2}{2}$$

$$(t, r_0, v_0, a_0) \rightarrow r_0 + v_0\, t + \frac{1}{2}\, a_0\, t^2 \tag{12}$$

$$r(t, r_0, v_0, a_0)$$

$$r_0 + v_0\, t + \frac{1}{2}\, a_0\, t^2 \tag{13}$$

$$v_r(t, r_0, v_0, a_0) := v_0 + a_0 \cdot t$$

$$(t, r_0, v_0, a_0) \rightarrow v_0 + a_0\, t \tag{14}$$

$$v_r(t, r_0, v_0, a_0)$$

$$a_0\, t + v_0 \tag{15}$$

$$evalf\left(\left[\, subs\left(q = -1, t = 0, r_0 = R\_, v_0 = 0.2, a_0 = 0.1, R_0 = 3, \theta = 0, r\left(t_{zap}, r_0, v_0, a_0\right)\right)\right]\right)$$

$$\left[2. + 0.2\, t_{zap} + 0.05000000000\, {t_{zap}}^2\right] \tag{16}$$

$$tzap(t, r_0, v_0, a_0, R_0, \theta) := solve\left(c^2\, (t - t_{zap})^2 = {R_0}^2 - 2 \cdot R_0 \cdot r(t_{zap}, r_0, v_0, a_0) \cdot \cos(\theta) + r(t_{zap}, r_0, v_0, a_0)^2, t_{zap}\right)$$

$$(t, r_0, v_0, a_0, R_0, \theta) \rightarrow solve\left(c^2\, (t - t_{zap})^2 = {R_0}^2 - 2\, R_0\, r(t_{zap}, r_0, v_0, a_0)\, \cos(\theta) + r(t_{zap}, r_0, v_0, a_0)^2, t_{zap}\right) \tag{17}$$

$$tzap(t, r_0, v_0, a_0, R_0, \theta)$$

$$evalf\left(subs\left(q = -1, t = 0, r_0 = R\_, v_0 = 0, a_0 = 0, R_0 = 3,\right.\right.$$
$$\left[\, subs(\theta = 0, tzap(t, r_0, v_0, a_0, R_0, \theta)),\right.$$
$$subs\left(\theta = \frac{\pi}{4}, tzap(t, r_0, v_0, a_0, R_0, \theta)\right),$$
$$\left.\left.subs\left(\theta = \frac{2 \cdot \pi}{4}, tzap(t, r_0, v_0, a_0, R_0, \theta)\right),\right.\right.$$

$$subs\left(\theta = \frac{3\cdot\pi}{4}, tzap\left(t, r_0, v_0, a_0, R_0, \theta\right)\right),$$
$$subs\left(\theta = \frac{4\cdot\pi}{4}, tzap\left(t, r_0, v_0, a_0, R_0, \theta\right)\right),$$
$$subs\left(\theta = \frac{5\cdot\pi}{4}, tzap\left(t, r_0, v_0, a_0, R_0, \theta\right)\right),$$
$$subs\left(\theta = \frac{6\cdot\pi}{4}, tzap\left(t, r_0, v_0, a_0, R_0, \theta\right)\right),$$
$$subs\left(\theta = \frac{7\cdot\pi}{4}, tzap\left(t, r_0, v_0, a_0, R_0, \theta\right)\right),$$
$$subs\left(\theta = \frac{8\cdot\pi}{4}, tzap\left(t, r_0, v_0, a_0, R_0, \theta\right)\right),$$

$$plot\left(subs\left(q = -1, t = -5, r_0 = R\_, v_0 = 0, a_0 = 0, R_0 = 3, tzap\left(t, r_0, v_0, a_0, R_0, \theta\right)\right), \theta = 0..\pi\right),$$

$$plot\left(subs\left(q = -1, t = -1, r_0 = R\_, v_0 = 0, a_0 = 0, R_0 = 3, tzap\left(t, r_0, v_0, a_0, R_0, \theta\right)\right), \theta = 0..\pi\right),$$

$$plot\left(subs\left(q = -1, t = 0, r_0 = R\_, v_0 = 0, a_0 = 0, R_0 = 3, tzap\left(t, r_0, v_0, a_0, R_0, \theta\right)\right), \theta = 0..\pi\right),$$

$$plot\left(subs\left(q = -1, t = 1, r_0 = R\_, v_0 = 0, a_0 = 0, R_0 = 3, tzap\left(t, r_0, v_0, a_0, R_0, \theta\right)\right), \theta = 0..\pi\right),$$

$$plot\left(subs\left(q = -1, t = 2, r_0 = R\_, v_0 = 0, a_0 = 0, R_0 = 3, tzap\left(t, r_0, v_0, a_0, R_0, \theta\right)\right), \theta = 0..\pi\right),$$

$$plot\left(subs\left(q = -1, t = 2, r_0 = R\_, v_0 = 0, a_0 = 0, \theta = \pi, tzap\left(t, r_0, v_0, a_0, R_0, \theta\right)\right), R_0 = 3..6\right),$$

$$plot\left(subs\left(q = -1, t = 10, r_0 = R\_, v_0 = 0, a_0 = 0, \theta = \pi, tzap\left(t, r_0, v_0, a_0, R_0, \theta\right)\right), R_0 = 3..6\right)$$

$$\left.\right]\right)\right)$$

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$$R_{zap}\left(t_{zap}, r_0, v_0, a_0, R_0, \theta\right) := \sqrt{R_0^{\,2} - 2\cdot R_0\cdot r\left(t_{zap}, r_0, v_0, a_0\right)\cdot\cos(\theta) + r\left(t_{zap}, r_0, v_0, a_0\right)^2}$$

$$\left(t_{zap}, r_0, v_0, a_0, R_0, \theta\right) \rightarrow \sqrt{R_0^{\,2} - 2\,R_0\,r\left(t_{zap}, r_0, v_0, a_0\right)\,\cos(\theta) + r\left(t_{zap}, r_0, v_0, a_0\right)^2} \qquad \textbf{(19)}$$

$$R_{zap}\left(t_{zap}, r_0, v_0, a_0, R_0, \theta\right)$$

$$\sqrt{R_0^2 - 2\,R_0\left(r_0 + v_0\,t_{zap} + \frac{1}{2}\,a_0\,t_{zap}^2\right)\cos(\theta) + \left(r_0 + v_0\,t_{zap} + \frac{1}{2}\,a_0\,t_{zap}^2\right)^2} \tag{20}$$

```
R__zap := proc (t__zap, r__0, v__0, a__0, R__0, theta) options
operator, arrow; sqrt(R__0^2-2*R__0*r(t__zap, r__0, v__0, a__0)*cos
(theta)+r(t__zap, r__0, v__0, a__0)^2) end proc;
```

$$\left(t_{zap}, r_0, v_0, a_0, R_0, \theta\right) \rightarrow \sqrt{R_0^2 - 2\,R_0\,r\left(t_{zap}, r_0, v_0, a_0\right)\cos(\theta) + r\left(t_{zap}, r_0, v_0, a_0\right)^2} \tag{21}$$

$$evalf\left(subs\left(q = -1,\ t_{zap} = -1,\ r_0 = R\_,\ v_0 = 0.2,\ a_0 = 0,\ R_0 = 3,\right.\right.$$
$$\left[\ subs\left(\theta = 0,\ R_{zap}\left(t_{zap}, r_0, v_0, a_0, R_0, \theta\right)\right),\right.$$
$$subs\left(\theta = \frac{\pi}{4},\ R_{zap}\left(t_{zap}, r_0, v_0, a_0, R_0, \theta\right)\right),$$
$$subs\left(\theta = \frac{2\cdot\pi}{4},\ R_{zap}\left(t_{zap}, r_0, v_0, a_0, R_0, \theta\right)\right),$$
$$subs\left(\theta = \frac{3\cdot\pi}{4},\ R_{zap}\left(t_{zap}, r_0, v_0, a_0, R_0, \theta\right)\right),$$
$$subs\left(\theta = \frac{4\cdot\pi}{4},\ R_{zap}\left(t_{zap}, r_0, v_0, a_0, R_0, \theta\right)\right),$$
$$subs\left(\theta = \frac{5\cdot\pi}{4},\ R_{zap}\left(t_{zap}, r_0, v_0, a_0, R_0, \theta\right)\right),$$
$$subs\left(\theta = \frac{6\cdot\pi}{4},\ R_{zap}\left(t_{zap}, r_0, v_0, a_0, R_0, \theta\right)\right),$$
$$subs\left(\theta = \frac{7\cdot\pi}{4},\ R_{zap}\left(t_{zap}, r_0, v_0, a_0, R_0, \theta\right)\right),$$
$$subs\left(\theta = \frac{8\cdot\pi}{4},\ R_{zap}\left(t_{zap}, r_0, v_0, a_0, R_0, \theta\right)\right)$$
$$\left.\left.\left.\right]\right)\right)$$

$$[1.200000000,\ 2.145517831,\ 3.498571137,\ 4.458335254,\ 4.800000000,\ 4.458335253,\ 3.498571135,\ 2.145517831,\ 1.200000000] \tag{22}$$

$$R_{zap}\left(tzap\left(t, r_0, v_0, a_0, R_0, \theta\right), r_0, v_0, a_0, R_0, \theta\right);$$
$$\left(R_0^2 - 2\,R_0\left(r_0 + v_0\,RootOf\left(a_0^2\_Z^4 + 4\,v_0\_Z^3\,a_0 + \left(-4\,R_0\,a_0\cos(\theta) + 4\,a_0\,r_0 + 4\,v_0^2\right.\right.\right.\right. \tag{23}$$
$$\left.\left.\left.\left. - 36\right)\_Z^2 + \left(-8\,R_0\,v_0\cos(\theta) + 8\,r_0\,v_0 + 72\,t\right)\_Z - 8\,R_0\cos(\theta)\,r_0 + 4\,R_0^2 + 4\,r_0^2\right.\right.\right.$$

$$-36\,t^2\Big) + \frac{1}{2}\,a_0\,RootOf\Big(a_0{}^2\,\_Z^4 + 4\,v_0\,\_Z^3\,a_0 + \big(-4\,R_0\,a_0\cos(\theta) + 4\,a_0\,r_0 + 4\,v_0{}^2 - 36\big)\,\_Z^2 + \big(-8\,R_0\,v_0\cos(\theta) + 8\,r_0\,v_0 + 72\,t\big)\,\_Z - 8\,R_0\cos(\theta)\,r_0 + 4\,R_0{}^2 + 4\,r_0{}^2 - 36\,t^2\Big)^2\Big)\cos(\theta) + \Big(r_0 + v_0\,RootOf\Big(a_0{}^2\,\_Z^4 + 4\,v_0\,\_Z^3\,a_0 + \big(-4\,R_0\,a_0\cos(\theta) + 4\,a_0\,r_0 + 4\,v_0{}^2 - 36\big)\,\_Z^2 + \big(-8\,R_0\,v_0\cos(\theta) + 8\,r_0\,v_0 + 72\,t\big)\,\_Z - 8\,R_0\cos(\theta)\,r_0 + 4\,R_0{}^2 + 4\,r_0{}^2 - 36\,t^2\Big) + \frac{1}{2}\,a_0\,RootOf\Big(a_0{}^2\,\_Z^4 + 4\,v_0\,\_Z^3\,a_0 + \big(-4\,R_0\,a_0\cos(\theta) + 4\,a_0\,r_0 + 4\,v_0{}^2 - 36\big)\,\_Z^2 + \big(-8\,R_0\,v_0\cos(\theta) + 8\,r_0\,v_0 + 72\,t\big)\,\_Z - 8\,R_0\cos(\theta)\,r_0 + 4\,R_0{}^2 + 4\,r_0{}^2 - 36\,t^2\Big)^2\Big)^2\Big)^{1/2}$$

$$evalf\Big(subs\Big(q=-1,\,t=-1,\,r_0=R\_,\,v_0=0.2,\,a_0=0,\,R_0=3,$$
$$\Big[subs\big(\theta=0,\,R_{zap}\big(tzap\big(t,r_0,v_0,a_0,R_0,\theta\big),r_0,v_0,a_0,R_0,\theta\big)\big),$$
$$subs\Big(\theta=\frac{\pi}{4},\,R_{zap}\big(tzap\big(t,r_0,v_0,a_0,R_0,\theta\big),r_0,v_0,a_0,R_0,\theta\big)\Big),$$
$$subs\Big(\theta=\frac{2\cdot\pi}{4},\,R_{zap}\big(tzap\big(t,r_0,v_0,a_0,R_0,\theta\big),r_0,v_0,a_0,R_0,\theta\big)\Big),$$
$$subs\Big(\theta=\frac{3\cdot\pi}{4},\,R_{zap}\big(tzap\big(t,r_0,v_0,a_0,R_0,\theta\big),r_0,v_0,a_0,R_0,\theta\big)\Big),$$
$$subs\Big(\theta=\frac{4\cdot\pi}{4},\,R_{zap}\big(tzap\big(t,r_0,v_0,a_0,R_0,\theta\big),r_0,v_0,a_0,R_0,\theta\big)\Big),$$
$$subs\Big(\theta=\frac{5\cdot\pi}{4},\,R_{zap}\big(tzap\big(t,r_0,v_0,a_0,R_0,\theta\big),r_0,v_0,a_0,R_0,\theta\big)\Big),$$
$$subs\Big(\theta=\frac{6\cdot\pi}{4},\,R_{zap}\big(tzap\big(t,r_0,v_0,a_0,R_0,\theta\big),r_0,v_0,a_0,R_0,\theta\big)\Big),$$
$$subs\Big(\theta=\frac{7\cdot\pi}{4},\,R_{zap}\big(tzap\big(t,r_0,v_0,a_0,R_0,\theta\big),r_0,v_0,a_0,R_0,\theta\big)\Big),$$
$$subs\Big(\theta=\frac{8\cdot\pi}{4},\,R_{zap}\big(tzap\big(t,r_0,v_0,a_0,R_0,\theta\big),r_0,v_0,a_0,R_0,\theta\big)\Big),$$

$$plot\Big(subs\big(q=-1,\,t=-5,\,r_0=R\_,\,v_0=1,\,a_0=0,\,R_0=3,\,R_{zap}\big(tzap\big(t,r_0,v_0,a_0,R_0,\theta\big),r_0,v_0,a_0,R_0,\theta\big)\big),\,\theta=0..\pi\Big),$$
$$plot\Big(subs\big(q=-1,\,t=-1,\,r_0=R\_,\,v_0=1,\,a_0=0,\,R_0=3,\,R_{zap}\big(tzap\big(t,r_0,v_0,a_0,R_0,\theta\big),r_0,v_0,a_0,R_0,\theta\big)\big),\,\theta=0..\pi\Big),$$

$$
\begin{aligned}
&plot\Big(subs\big(q=-1,\ t=0,\ r_0=R\_,\ v_0=1,\ a_0=0,\ R_0=3,\ R_{zap}\big(tzap\big(t,r_0,v_0,a_0,R_0,\theta\big),r_0,v_0,a_0,R_0,\theta\big)\big),\ \theta=0\,..\pi\Big),\\
&plot\Big(subs\big(q=-1,\ t=1,\ r_0=R\_,\ v_0=1,\ a_0=0,\ R_0=3,\ R_{zap}\big(tzap\big(t,r_0,v_0,a_0,R_0,\theta\big),r_0,v_0,a_0,R_0,\theta\big)\big),\ \theta=0\,..\pi\Big),\\
&plot\Big(subs\big(q=-1,\ t=2,\ r_0=R\_,\ v_0=1,\ a_0=0,\ R_0=3,\ R_{zap}\big(tzap\big(t,r_0,v_0,a_0,R_0,\theta\big),r_0,v_0,a_0,R_0,\theta\big)\big),\ \theta=0\,..\pi\Big),\\
&plot\Big(subs\big(q=-1,\ t=5,\ r_0=R\_,\ v_0=1,\ a_0=0,\ R_0=3,\ R_{zap}\big(tzap\big(t,r_0,v_0,a_0,R_0,\theta\big),r_0,v_0,a_0,R_0,\theta\big)\big),\ \theta=0\,..\pi\Big),\\
&plot\Big(subs\big(q=-1,\ t=10,\ r_0=R\_,\ v_0=1,\ a_0=0,\ R_0=3,\ R_{zap}\big(tzap\big(t,r_0,v_0,a_0,R_0,\theta\big),r_0,v_0,a_0,R_0,\theta\big)\big),\ \theta=0\,..\pi\Big),\\
&plot\Big(subs\big(q=-1,\ t=-1,\ r_0=R\_,\ v_0=1,\ a_0=0,\ \theta=0,\ R_{zap}\big(tzap\big(t,r_0,v_0,a_0,R_0,\theta\big),r_0,v_0,a_0,R_0,\theta\big)\big),\ R_0=3\,..9\Big),\\
&plot\Big(subs\big(q=-1,\ t=10,\ r_0=R\_,\ v_0=1,\ a_0=0,\ \theta=\pi,\ R_{zap}\big(tzap\big(t,r_0,v_0,a_0,R_0,\theta\big),r_0,v_0,a_0,R_0,\theta\big)\big),\ R_0=3\,..9\Big)\\
&\Big]\Big)\Big)
\end{aligned}
$$

,

$$
K_{zap}\big(t_{zap},r_0,v_0,a_0,R_0,\theta\big) := R_{zap}\big(t_{zap},r_0,v_0,a_0,R_0,\theta\big) - \frac{v_r\big(t_{zap},r_0,v_0,a_0\big)}{c}\cdot\big(R_0\cdot\cos(\theta) - r\big(t_{zap},r_0,v_0,a_0\big)\big)
$$

$$
\big(t_{zap},r_0,v_0,a_0,R_0,\theta\big)\rightarrow R_{zap}\big(t_{zap},r_0,v_0,a_0,R_0,\theta\big) - \frac{v_r\big(t_{zap},r_0,v_0,a_0\big)\ \big(R_0\cos(\theta) - r\big(t_{zap},r_0,v_0,a_0\big)\big)}{c} \tag{25}
$$

$$
K_{zap}\big(t_{zap},r_0,v_0,a_0,R_0,\theta\big)
$$

$$
\sqrt{R_0^{\,2} - 2\,R_0\left(r_0 + v_0\,t_{zap} + \frac{1}{2}\,a_0\,t_{zap}^{\,2}\right)\cos(\theta) + \left(r_0 + v_0\,t_{zap} + \frac{1}{2}\,a_0\,t_{zap}^{\,2}\right)^2} - \frac{1}{3}\,\left(a_0\,t_{zap} + v_0\right)\left(R_0\cos(\theta) - r_0 - v_0\,t_{zap} - \frac{1}{2}\,a_0\,t_{zap}^{\,2}\right) \tag{26}
$$

$$K_{zap}\left(tzap\left(t, r_0, v_0, a_0, R_0, \theta\right), r_0, v_0, a_0, R_0, \theta\right);$$

$$\left(R_0^{\,2} - 2\,R_0\left(r_0 + v_0\,RootOf\left(a_0^{\,2}\_Z^4 + 4\,v_0\,\_Z^3\,a_0 + \left(-4\,R_0\,a_0\cos(\theta) + 4\,a_0\,r_0 + 4\,v_0^{\,2} - 36\right)\_Z^2 + \left(-8\,R_0\,v_0\cos(\theta) + 8\,r_0\,v_0 + 72\,t\right)\_Z - 8\,R_0\cos(\theta)\,r_0 + 4\,R_0^{\,2} + 4\,r_0^{\,2} - 36\,t^2\right) + \frac{1}{2}\,a_0\,RootOf\left(a_0^{\,2}\_Z^4 + 4\,v_0\,\_Z^3\,a_0 + \left(-4\,R_0\,a_0\cos(\theta) + 4\,a_0\,r_0 + 4\,v_0^{\,2} - 36\right)\_Z^2 + \left(-8\,R_0\,v_0\cos(\theta) + 8\,r_0\,v_0 + 72\,t\right)\_Z - 8\,R_0\cos(\theta)\,r_0 + 4\,R_0^{\,2} + 4\,r_0^{\,2} - 36\,t^2\right)^2\right)\cos(\theta) + \left(r_0 + v_0\,RootOf\left(a_0^{\,2}\_Z^4 + 4\,v_0\,\_Z^3\,a_0 + \left(-4\,R_0\,a_0\cos(\theta) + 4\,a_0\,r_0 + 4\,v_0^{\,2} - 36\right)\_Z^2 + \left(-8\,R_0\,v_0\cos(\theta) + 8\,r_0\,v_0 + 72\,t\right)\_Z - 8\,R_0\cos(\theta)\,r_0 + 4\,R_0^{\,2} + 4\,r_0^{\,2} - 36\,t^2\right) + \frac{1}{2}\,a_0\,RootOf\left(a_0^{\,2}\_Z^4 + 4\,v_0\,\_Z^3\,a_0 + \left(-4\,R_0\,a_0\cos(\theta) + 4\,a_0\,r_0 + 4\,v_0^{\,2} - 36\right)\_Z^2 + \left(-8\,R_0\,v_0\cos(\theta) + 8\,r_0\,v_0 + 72\,t\right)\_Z - 8\,R_0\cos(\theta)\,r_0 + 4\,R_0^{\,2} + 4\,r_0^{\,2} - 36\,t^2\right)^2\right)^2\right)^{1/2} - \frac{1}{3}\left(v_0 + a_0\,RootOf\left(a_0^{\,2}\_Z^4 + 4\,v_0\,\_Z^3\,a_0 + \left(-4\,R_0\,a_0\cos(\theta) + 4\,a_0\,r_0 + 4\,v_0^{\,2} - 36\right)\_Z^2 + \left(-8\,R_0\,v_0\cos(\theta) + 8\,r_0\,v_0 + 72\,t\right)\_Z - 8\,R_0\cos(\theta)\,r_0 + 4\,R_0^{\,2} + 4\,r_0^{\,2} - 36\,t^2\right)\right)\left(R_0\cos(\theta) - r_0 - v_0\,RootOf\left(a_0^{\,2}\_Z^4 + 4\,v_0\,\_Z^3\,a_0 + \left(-4\,R_0\,a_0\cos(\theta) + 4\,a_0\,r_0 + 4\,v_0^{\,2} - 36\right)\_Z^2 + \left(-8\,R_0\,v_0\cos(\theta) + 8\,r_0\,v_0 + 72\,t\right)\_Z - 8\,R_0\cos(\theta)\,r_0 + 4\,R_0^{\,2} + 4\,r_0^{\,2} - 36\,t^2\right) - \frac{1}{2}\,a_0\,RootOf\left(a_0^{\,2}\_Z^4 + 4\,v_0\,\_Z^3\,a_0 + \left(-4\,R_0\,a_0\cos(\theta) + 4\,a_0\,r_0 + 4\,v_0^{\,2} - 36\right)\_Z^2 + \left(-8\,R_0\,v_0\cos(\theta) + 8\,r_0\,v_0 + 72\,t\right)\_Z - 8\,R_0\cos(\theta)\,r_0 + 4\,R_0^{\,2} + 4\,r_0^{\,2} - 36\,t^2\right)^2\right) \tag{27}$$

$$evalf\left(subs\left(q = -1,\, t = 1,\, r_0 = R\_,\, v_0 = 0.2,\, a_0 = 0,\, R_0 = 3,\right.\right.$$
$$\left[subs\left(\theta = 0, K_{zap}\left(tzap\left(t, r_0, v_0, a_0, R_0, \theta\right), r_0, v_0, a_0, R_0, \theta\right)\right),\right.$$
$$subs\left(\theta = \frac{\pi}{4}, K_{zap}\left(tzap\left(t, r_0, v_0, a_0, R_0, \theta\right), r_0, v_0, a_0, R_0, \theta\right)\right),$$
$$subs\left(\theta = \frac{2\cdot\pi}{4}, K_{zap}\left(tzap\left(t, r_0, v_0, a_0, R_0, \theta\right), r_0, v_0, a_0, R_0, \theta\right)\right),$$
$$\left.\left.subs\left(\theta = \frac{3\cdot\pi}{4}, K_{zap}\left(tzap\left(t, r_0, v_0, a_0, R_0, \theta\right), r_0, v_0, a_0, R_0, \theta\right)\right),\right.\right.$$

$$subs\left(\theta=\frac{4\cdot\pi}{4}, K_{zap}\left(tzap\left(t, r_0, v_0, a_0, R_0, \theta\right), r_0, v_0, a_0, R_0, \theta\right)\right),$$
$$subs\left(\theta=\frac{5\cdot\pi}{4}, K_{zap}\left(tzap\left(t, r_0, v_0, a_0, R_0, \theta\right), r_0, v_0, a_0, R_0, \theta\right)\right),$$
$$subs\left(\theta=\frac{6\cdot\pi}{4}, K_{zap}\left(tzap\left(t, r_0, v_0, a_0, R_0, \theta\right), r_0, v_0, a_0, R_0, \theta\right)\right),$$
$$subs\left(\theta=\frac{7\cdot\pi}{4}, K_{zap}\left(tzap\left(t, r_0, v_0, a_0, R_0, \theta\right), r_0, v_0, a_0, R_0, \theta\right)\right),$$
$$subs\left(\theta=\frac{8\cdot\pi}{4}, K_{zap}\left(tzap\left(t, r_0, v_0, a_0, R_0, \theta\right), r_0, v_0, a_0, R_0, \theta\right)\right),$$

$$plot\left(subs\left(q=-1, t=-5, r_0=R\_, v_0=1, a_0=0, R_0=3, K_{zap}\left(tzap\left(t, r_0, v_0, a_0, R_0, \theta\right), r_0, v_0, a_0, R_0, \theta\right)\right), \theta=0..\pi\right),$$
$$plot\left(subs\left(q=-1, t=-1, r_0=R\_, v_0=1, a_0=0, R_0=3, K_{zap}\left(tzap\left(t, r_0, v_0, a_0, R_0, \theta\right), r_0, v_0, a_0, R_0, \theta\right)\right), \theta=0..\pi\right),$$
$$plot\left(subs\left(q=-1, t=0, r_0=R\_, v_0=1, a_0=0, R_0=3, K_{zap}\left(tzap\left(t, r_0, v_0, a_0, R_0, \theta\right), r_0, v_0, a_0, R_0, \theta\right)\right), \theta=0..\pi\right),$$
$$plot\left(subs\left(q=-1, t=1, r_0=R\_, v_0=1, a_0=0, R_0=3, K_{zap}\left(tzap\left(t, r_0, v_0, a_0, R_0, \theta\right), r_0, v_0, a_0, R_0, \theta\right)\right), \theta=0..\pi\right),$$
$$plot\left(subs\left(q=-1, t=2, r_0=R\_, v_0=1, a_0=0, R_0=3, K_{zap}\left(tzap\left(t, r_0, v_0, a_0, R_0, \theta\right), r_0, v_0, a_0, R_0, \theta\right)\right), \theta=0..\pi\right),$$
$$plot\left(subs\left(q=-1, t=5, r_0=R\_, v_0=1, a_0=0, R_0=3, K_{zap}\left(tzap\left(t, r_0, v_0, a_0, R_0, \theta\right), r_0, v_0, a_0, R_0, \theta\right)\right), \theta=0..\pi\right),$$
$$plot\left(subs\left(q=-1, t=10, r_0=R\_, v_0=1, a_0=0, R_0=3, K_{zap}\left(tzap\left(t, r_0, v_0, a_0, R_0, \theta\right), r_0, v_0, a_0, R_0, \theta\right)\right), \theta=0..\pi\right)$$

$$\left.\left.\right]\right)\right)$$

$$t\_cur\left(t_{zap}, r_0, v_0, a_0, R_0, \theta\right) := solve\left(c^2\left(t-t_{zap}\right)^2 = {R_0}^2 - 2\cdot R_0\cdot r\left(t_{zap}, r_0, v_0, a_0\right)\cdot\cos(\theta) + r\left(t_{zap}, r_0, v_0, a_0\right)^2, t\right)$$

$$\left(t_{zap}, r_0, v_0, a_0, R_0, \theta\right) \rightarrow solve\left(c^2\left(t-t_{zap}\right)^2 = {R_0}^2 - 2\,R_0\,r\left(t_{zap}, r_0, v_0, a_0\right)\cos(\theta) + r\left(t_{zap}, r_0, v_0,\right.\right. \quad \textbf{(29)}$$

$a_0)^2, t)$

$t\_cur(t_{zap}, r_0, v_0, a_0, R_0, \theta)$

t_{zap}

$$+\frac{1}{6}\left(a_0^{\,2}\,t_{zap}^{\,4}-4\,R_0\cos(\theta)\,a_0\,t_{zap}^{\,2}+4\,v_0\,t_{zap}^{\,3}\,a_0-8\,R_0\cos(\theta)\,v_0\,t_{zap}\right.$$

$$\left.+4\,r_0\,a_0\,t_{zap}^{\,2}+4\,v_0^{\,2}\,t_{zap}^{\,2}-8\,R_0\cos(\theta)\,r_0+8\,r_0\,v_0\,t_{zap}+4\,R_0^{\,2}+4\,r_0^{\,2}\right)^{1/2}, t_{zap}$$

$$-\frac{1}{6}\left(a_0^{\,2}\,t_{zap}^{\,4}-4\,R_0\cos(\theta)\,a_0\,t_{zap}^{\,2}+4\,v_0\,t_{zap}^{\,3}\,a_0-8\,R_0\cos(\theta)\,v_0\,t_{zap}\right.$$

$$\left.+4\,r_0\,a_0\,t_{zap}^{\,2}+4\,v_0^{\,2}\,t_{zap}^{\,2}-8\,R_0\cos(\theta)\,r_0+8\,r_0\,v_0\,t_{zap}+4\,R_0^{\,2}+4\,r_0^{\,2}\right)^{1/2}$$

(30)

$evalf\left(subs\left(\theta=\pi, R_0=10, t_{zap}=0, r_0=R\_, v_0=1, a_0=1, \left[t\_cur\left(t_{zap}, r_0, v_0, a_0, R_0, \theta\right), t\_cur\left(t_{zap}, r\left(t_{zap}, r_0, v_0, a_0\right), v_0, a_0, R_0, \theta\right)\right]\right)\right)$

$$[4.000000001,\ -4.000000001,\ 4.000000000,\ -4.000000000]$$

(31)

$evalf\left(subs\left(\theta=\pi, R_0=10, t_{zap}=0, r_0=R\_, v_0=1, a_0=1, t\_cur\left(t_{zap}, r_0, v_0, a_0, R_0, \theta\right)[1]\right)\right)$

$$4.000000001$$

(32)

r ,

R_0

$$\varphi\left(q, t, r_0, v_0, a_0, R_0\right) := \int_0^{\pi} \frac{2\cdot\pi\cdot\, r\left(t, r_0, v_0, a_0\right)^2\cdot\sin(\theta)\cdot\sigma\left(q, r_0\right)}{K_{zap}\left(tzap\left(t, r_0, v_0, a_0, R_0, \theta\right), r_0, v_0, a_0, R_0, \theta\right)}\, d\theta;$$

$$\left(q, t, r_0, v_0, a_0, R_0\right) \to \int_0^{\pi} \frac{2\,\pi\, r\left(t, r_0, v_0, a_0\right)^2\sin(\theta)\,\sigma\left(q, r_0\right)}{K_{zap}\left(tzap\left(t, r_0, v_0, a_0, R_0, \theta\right), r_0, v_0, a_0, R_0, \theta\right)}\, d\theta$$

(33)

$evalf\left(subs\left(q=1, t=5, r_0=1, R_0=2, v_0=0, a_0=0.0\ , \varphi\left(q, t, r_0, v_0, a_0, R_0\right)\right)\right)$

$$0.5000000000$$

(34)

r 0

$$A_{R_0}\left(q, t, r_0, v_0, a_0, R_0\right) := \int_0^{\pi} \frac{2\cdot\pi\cdot\, r\left(t, r_0, v_0, a_0\right)^2\cdot\sin(\theta)\cdot\sigma\left(q, r_0\right)\cdot\left(v_r\left(t_{zap}, r_0, v_0, a_0\right)\cdot\cos(\theta)\right)}{K_{zap}\left(tzap\left(t, r_0, v_0, a_0, R_0, \theta\right), r_0, v_0, a_0, R_0, \theta\right)}\, d\theta;$$

$$\left(q, t, r_0, v_0, a_0, R_0\right) \rightarrow \int_0^{\pi} \frac{2\,\pi\, r\left(t, r_0, v_0, a_0\right)^2 \sin(\theta)\ \sigma\left(q, r_0\right)\ v_r\left(t_{zap}, r_0, v_0, a_0\right)\cos(\theta)}{K_{zap}\left(tzap\left(t, r_0, v_0, a_0, R_0, \theta\right), r_0, v_0, a_0, R_0, \theta\right)}\ d\theta \tag{35}$$

- - (
) -

$$cos\_\alpha_{zap}\left(t_{zap}, r_0, v_0, a_0, R_0, \theta\right) := \frac{R_0 - r\left(t_{zap}, r_0, v_0, a_0\right)\cdot\cos(\theta)}{R_{zap}\left(t_{zap}, r_0, v_0, a_0, R_0, \theta\right)}$$

$$\left(t_{zap}, r_0, v_0, a_0, R_0, \theta\right) \rightarrow \frac{R_0 - r\left(t_{zap}, r_0, v_0, a_0\right)\cos(\theta)}{R_{zap}\left(t_{zap}, r_0, v_0, a_0, R_0, \theta\right)} \tag{36}$$

- (
)

$$aR_{zap}\left(t_{zap}, r_0, v_0, a_0\right) := a_r\left(t_{zap}, r_0, v_0, a_0\right)\cdot\left(R_0\cdot\cos(\theta) - r\left(t_{zap}, r_0, v_0, a_0\right)\right)$$

$$\left(t_{zap}, r_0, v_0, a_0\right) \rightarrow a_r\left(t_{zap}, r_0, v_0, a_0\right)\ \left(R_0\cos(\theta) - r\left(t_{zap}, r_0, v_0, a_0\right)\right) \tag{37}$$

-

$$E\_minus\_grad\_\varphi_{R_0}\left(q, t_{zap}, r_0, v_0, a_0, R_0, \theta\right) := \frac{\sigma\left(q, r_0\right)}{K_{zap}\left(t_{zap}, r_0, v_0, a_0, R_0, \theta\right)^2}$$
$$\cdot\left(\frac{R_{zap}\left(t_{zap}, r_0, v_0, a_0, R_0, \theta\right)\cdot cos\_\alpha_{zap}\left(t_{zap}, r_0, v_0, a_0, R_0, \theta\right)}{K_{zap}\left(t_{zap}, r_0, v_0, a_0, R_0, \theta\right)}\left(1 + \frac{aR_{zap}\left(t_{zap}, r_0, v_0, a_0\right)}{c^2}\right.\right.$$
$$\left.\left. - \frac{v_r\left(t_{zap}, r_0, v_0, a_0\right)^2}{c^2}\right) - \frac{v_r\left(t_{zap}, r_0, v_0, a_0\right)\cdot\cos(\theta)}{c}\right)$$

$$\left(q, t_{zap}, r_0, v_0, a_0, R_0, \theta\right) \rightarrow \frac{1}{K_{zap}\left(t_{zap}, r_0, v_0, a_0, R_0, \theta\right)^2}\left(\sigma\left(q,\right.\right. \tag{38}$$
$$\left.r_0\right)\left(\frac{1}{K_{zap}\left(t_{zap}, r_0, v_0, a_0, R_0, \theta\right)}\left(R_{zap}\left(t_{zap}, r_0, v_0, a_0, R_0, \theta\right)\ cos\_alpha_{zap}\left(t_{zap}, r_0, v_0, a_0, R_0,\right.\right.\right.$$
$$\left.\left.\left.\theta\right)\left(1 + \frac{aR_{zap}\left(t_{zap}, r_0, v_0, a_0\right)}{c^2} - \frac{v_r\left(t_{zap}, r_0, v_0, a_0\right)^2}{c^2}\right)\right) - \frac{v_r\left(t_{zap}, r_0, v_0, a_0\right)\cos(\theta)}{c}\right)\right)$$

$$E\_minus\_grad\_\varphi\_integral_{R_0}(q, t, r_0, v_0, a_0, R_0) := \int_0^{\pi} 2\cdot\pi\cdot r(t, r_0, v_0, a_0)^2\cdot\sin(\theta)$$
$$\cdot E\_minus\_grad\_\varphi_{R_0}(q, tzap(t, r_0, v_0, a_0, R_0, \theta), r_0, v_0, a_0, R_0, \theta)\ d\theta$$

$$(q, t, r_0, v_0, a_0, R_0) \to \int_0^{\pi} 2\,\pi\, r(t, r_0, v_0, a_0)^2 \sin(\theta)\ E\_minus\_grad\_varphi_{R_0}(q, tzap(t, r_0, v_0, a_0, R_0, \theta), r_0, v_0, a_0, R_0, \theta)\ d\theta \quad \textbf{(39)}$$

$$E\_minus\_1\_c\_dA\_dt_{R_0}(q, t_{zap}, r_0, v_0, a_0, R_0, \theta) := \frac{\cos(\theta)\cdot\sigma(q, r_0)}{K_{zap}(t_{zap}, r_0, v_0, a_0, R_0, \theta)^2}\cdot\left(\frac{v_r(t_{zap}, r_0, v_0, a_0)}{c^2}\right.$$
$$\cdot\left(\frac{R_{zap}(t_{zap}, r_0, v_0, a_0, R_0, \theta)}{K_{zap}(t_{zap}, r_0, v_0, a_0, R_0, \theta)}\cdot\left(\frac{v_r(t_{zap}, r_0, v_0, a_0)^2}{c} - \frac{aR_{zap}(t_{zap}, r_0, v_0, a_0)}{c} - c\right) + c\right)$$
$$\left. - \frac{a_r(t_{zap}, r_0, v_0, a_0)\cdot R_{zap}(t_{zap}, r_0, v_0, a_0, R_0, \theta)}{c^2}\right)$$

$$(q, t_{zap}, r_0, v_0, a_0, R_0, \theta) \to \frac{1}{K_{zap}(t_{zap}, r_0, v_0, a_0, R_0, \theta)^2}\left(\cos(\theta)\ \sigma(q, r_0)\left(\frac{1}{c^2}\left(v_r(t_{zap}, r_0, v_0, a_0)\left(\frac{R_{zap}(t_{zap}, r_0, v_0, a_0, R_0, \theta)\left(\frac{v_r(t_{zap}, r_0, v_0, a_0)^2}{c} - \frac{aR_{zap}(t_{zap}, r_0, v_0, a_0)}{c} - c\right)}{K_{zap}(t_{zap}, r_0, v_0, a_0, R_0, \theta)} + c\right)\right)\right.\right. \quad \textbf{(40)}$$
$$\left.\left. - \frac{a_r(t_{zap}, r_0, v_0, a_0)\ R_{zap}(t_{zap}, r_0, v_0, a_0, R_0, \theta)}{c^2}\right)\right)$$

$$E\_minus\_1\_c\_dA\_dt\_integral_{R_0}(q, t, r_0, v_0, a_0, R_0) := \int_0^{\pi} 2\cdot\pi\cdot r(t, r_0, v_0, a_0)^2\cdot\sin(\theta)$$
$$\cdot E\_minus\_1\_c\_dA\_dt_{R_0}(q, tzap(t, r_0, v_0, a_0, R_0, \theta), r_0, v_0, a_0, R_0, \theta)\ d\theta$$

$$(q, t, r_0, v_0, a_0, R_0) \to \int_0^{\pi} 2\,\pi\, r(t, r_0, v_0, a_0)^2 \sin(\theta)\ E\_minus\_1\_c\_dA\_dt_{R_0}(q, tzap(t, r_0, v_0, a_0, R_0, \theta), r_0, v_0, a_0, R_0, \theta)\ d\theta \quad \textbf{(41)}$$

$$tcur := subs\left(t_{zap}=0,\ r_0=R\_,\ R_0=10,\ evalf\left(\max\left(t\_cur\left(t_{zap},\ r\left(t_{zap},\ r_0,\ v_0,\ a_0\right),\ v_0,\ a_0,\ R_0,\ \pi\right)\right)\right)\right)$$

$$\max(-4.000000000,\ 4.000000000) \tag{42}$$

$$tcur$$

$$4.000000000 \tag{43}$$

$$ftcur\left(R_0\right) := subs\left(t_{zap}=0,\ r_0=R\_,\ evalf\left(\max\left(t\_cur\left(t_{zap},\ r\left(t_{zap},\ r_0,\ v_0,\ a_0\right),\ v_0,\ a_0,\ R_0,\ \pi\right)\right)\right)\right)$$

$$R_0 \rightarrow subs\left(t_{zap}=0,\ r_0=R\_,\ evalf\left(\max\left(t\_cur\left(t_{zap},\ r\left(t_{zap},\ r_0,\ v_0,\ a_0\right),\ v_0,\ a_0,\ R_0,\ \pi\right)\right)\right)\right) \tag{44}$$

$$evalf\left(\left[subs\left(q=-1,\ r=R\_,\ v=1,\ c=3,\ R_0=3,\ \varphi_{lw}\left(q,\ v,\ c,\ r,\ R_0\right)\right),\ subs\left(q=-1,\ t=tcur,\ r_0=R\_,\ v_0=1,\ a_0=0,\ R_0=3,\ \varphi\left(q,\ t,\ r_0,\ v_0,\ a_0,\ R_0\right)\right)\right]\right)$$

$$[-0.3172022481,\ -1.514125065] \tag{45}$$

$$evalf\left(\left[subs\left(q=-1,\ t_{zap}=0.1,\ r_0=R\_,\ v_0=1,\ a_0=0,\ R_0=3,\ \theta=0,\ E\_minus\_grad\_\varphi_{R_0}\left(q,\ t_{zap},\ r_0,\ v_0,\ a_0,\ R_0,\ \theta\right)\right)\right]\right)$$

$$[-0.05526213297] \tag{46}$$

$$evalf\left(\left[subs\left(q=-1,\ t_{zap}=0.1,\ r_0=R\_,\ v_0=1,\ a_0=0,\ R_0=3,\ \theta=0,\ E\_minus\_1\_c\_dA\_dt_{R_0}\left(q,\ t_{zap},\ r_0,\ v_0,\ a_0,\ R_0,\ \theta\right)\right)\right]\right)$$

$$[0.006140236998] \tag{47}$$

$$evalf\left(\left[subs\left(q=-1,\ t=tcur,\ r_0=R\_,\ v_0=1,\ a_0=0,\ R_0=2,\ \theta=1,\ tzap\left(t,\ r_0,\ v_0,\ a_0,\ R_0,\ \theta\right)\right)\right]\right)$$

$$[2.676568128] \tag{48}$$

$$evalf\left(\left[subs\left(q=-1,\ t=tcur,\ r_0=R\_,\ v_0=1,\ a_0=0,\ R_0=3,\ \theta=0,\ E\_minus\_1\_c\_dA\_dt_{R_0}\left(q,\ tzap\left(t,\ r_0,\ v_0,\ a_0,\ R_0,\ \theta\right),\ r_0,\ v_0,\ a_0,\ R_0,\ \theta\right)\right)\right]\right)$$

$$[-0.0002456094800] \tag{49}$$

$$evalf\left(\left[subs\left(q=-1,\ t=tcur,\ r_0=R\_,\ v_0=1,\ a_0=0,\ R_0=4,\ \theta=0,\ E\_minus\_grad\_\varphi_{R_0}\left(q,\ tzap\left(t,\ r_0,\ v_0,\ a_0,\ R_0,\ \theta\right),\ r_0,\ v_0,\ a_0,\ R_0,\ \theta\right)\right)\right]\right)$$

$$[0.004973591964] \tag{50}$$

$$evalf\left(\left[\, subs\left(q=-1,\, t=tcur,\, r_0=R_-,\, v_0=1,\, a_0=0,\, R_0=4,\, \theta=0,\, E\_minus\_1\_c\_dA\_dt_{R_0}\left(q,\, tzap\left(t,\, r_0,\, v_0,\, a_0,\, R_0,\, \theta\right),\, r_0,\, v_0,\, a_0,\, R_0,\, \theta\right)\right)\right]\right)$$

$$[-0.0005526213299] \quad \textbf{(51)}$$

$$evalf\left(\left[\, subs\left(q=-1,\, t=subs\left(R_0=3,\, ftcur\left(R_0\right)\right),\, r_0=R_-,\, v_0=1,\, a_0=0,\, R_0=3,\, E\_minus\_grad\_\varphi\_integral_{R_0}\left(q,\, t,\, r_0,\, v_0,\, a_0,\, R_0\right)\right),\, subs\left(q=+1,\, t=subs\left(R_0=3,\, ftcur\left(R_0\right)\right),\, r_0=R_+,\, v_0=0.1,\, a_0=0,\, R_0=3,\, E\_minus\_grad\_\varphi\_integral_{R_0}\left(q,\, t,\, r_0,\, v_0,\, a_0,\, R_0\right)\right)\right]\right)$$

$$[0.01662065319,\, 0.1512906181] \quad \textbf{(52)}$$

$$evalf\left(\left[\, subs\left(q=-1,\, t=subs\left(R_0=3,\, ftcur\left(R_0\right)\right),\, r_0=R_-,\, v_0=1,\, a_0=0,\, R_0=3,\, E\_minus\_1\_c\_dA\_dt\_integral_{R_0}\left(q,\, t,\, r_0,\, v_0,\, a_0,\, R_0\right)\right),\, subs\left(q=+1,\, t=subs\left(R_0=3,\, ftcur\left(R_0\right)\right),\, r_0=R_+,\, v_0=0.1,\, a_0=0,\, R_0=3,\, E\_minus\_1\_c\_dA\_dt\_integral_{R_0}\left(q,\, t,\, r_0,\, v_0,\, a_0,\, R_0\right)\right)\right]\right)$$

$$[-0.01662065319,\, -0.00005605017475] \quad \textbf{(53)}$$

$$subs\left(R_0=3,\, ftcur\left(R_0\right)\right)$$

$$\max(-1.666666666,\, 1.666666666) \quad \textbf{(54)}$$

$$subs\left(R_0=5,\, ftcur\left(R_0\right)\right)$$

$$\max(-2.333333333,\, 2.333333333) \quad \textbf{(55)}$$

$$evalf\left(\left[\, subs\left(q=-1,\, t=subs\left(R_0=3,\, ftcur\left(R_0\right)\right),\, r_0=R_-,\, v_0=1,\, a_0=0,\, R_0=3,\, E\_minus\_grad\_\varphi\_integral_{R_0}\left(q,\, t,\, r_0,\, v_0,\, a_0,\, R_0\right)\right),\right.$$

$$subs\left(q=+1,\, t=subs\left(R_0=3,\, ftcur\left(R_0\right)\right),\, r_0=R_+,\, v_0=0.1,\, a_0=0,\, R_0=3,\, E\_minus\_grad\_\varphi\_integral_{R_0}\left(q,\, t,\, r_0,\, v_0,\, a_0,\, R_0\right)\right),$$

$$subs\left(q=-1,\, t=subs\left(R_0=3,\, ftcur\left(R_0\right)\right),\, r_0=R_-,\, v_0=1,\, a_0=0,\, R_0=3,\, E\_minus\_1\_c\_dA\_dt\_integral_{R_0}\left(q,\, t,\, r_0,\, v_0,\, a_0,\, R_0\right)\right),$$

$$\left.subs\left(q=1,\, t=subs\left(R_0=3,\, ftcur\left(R_0\right)\right),\, r_0=R_+,\, v_0=0.1,\, a_0=0,\, R_0=3,\, E\_minus\_1\_c\_dA\_dt\_integral_{R_0}\left(q,\, t,\, r_0,\, v_0,\, a_0,\, R_0\right)\right)\right)$$

$$\left]\right)$$

$$[0.01662065319,\ 0.1512906181,\ -0.01662065319,\ -0.00005605017475] \quad \textbf{(56)}$$

$$evalf\left(\left[\begin{array}{l} subs\left(q=-1,\ t=1.1\cdot subs\left(R_0=3,\ ftcur\left(R_0\right)\right),\ r_0=R_-,\ v_0=1,\ a_0=0,\ R_0=3,\right. \\ \quad \left. E\_minus\_grad\_\varphi\_integral_{R_0}\left(q,\ t,\ r_0,\ v_0,\ a_0,\ R_0\right)\right), \\ \\ subs\left(q=+1,\ t=1.1\cdot subs\left(R_0=3,\ ftcur\left(R_0\right)\right),\ r_0=R_+,\ v_0=0.1,\ a_0=0,\ R_0=3,\right. \\ \quad \left. E\_minus\_grad\_\varphi\_integral_{R_0}\left(q,\ t,\ r_0,\ v_0,\ a_0,\ R_0\right)\right), \\ subs\left(q=-1,\ t=1.1\cdot subs\left(R_0=3,\ ftcur\left(R_0\right)\right),\ r_0=R_-,\ v_0=1,\ a_0=0,\ R_0=3,\right. \\ \quad \left. E\_minus\_1\_c\_dA\_dt\_integral_{R_0}\left(q,\ t,\ r_0,\ v_0,\ a_0,\ R_0\right)\right), \\ subs\left(q=1,\ t=1.1\cdot subs\left(R_0=3,\ ftcur\left(R_0\right)\right),\ r_0=R_+,\ v_0=0.1,\ a_0=0,\ R_0=3,\right. \\ \quad \left. E\_minus\_1\_c\_dA\_dt\_integral_{R_0}\left(q,\ t,\ r_0,\ v_0,\ a_0,\ R_0\right)\right) \end{array}\right]\right)$$

$$[0.01576912403,\ 0.1556440828,\ -0.01576912403,\ -0.00005766304713] \quad \textbf{(57)}$$

$$evalf\left(\left[\begin{array}{l} subs\left(q=-1,\ t=1.5\cdot subs\left(R_0=3,\ ftcur\left(R_0\right)\right),\ r_0=R_-,\ v_0=1,\ a_0=0,\ R_0=3,\right. \\ \quad \left. E\_minus\_grad\_\varphi\_integral_{R_0}\left(q,\ t,\ r_0,\ v_0,\ a_0,\ R_0\right)\right), \\ \\ subs\left(q=+1,\ t=1.5\cdot subs\left(R_0=3,\ ftcur\left(R_0\right)\right),\ r_0=R_+,\ v_0=0.1,\ a_0=0,\ R_0=3,\right. \\ \quad \left. E\_minus\_grad\_\varphi\_integral_{R_0}\left(q,\ t,\ r_0,\ v_0,\ a_0,\ R_0\right)\right), \\ subs\left(q=-1,\ t=1.5\cdot subs\left(R_0=3,\ ftcur\left(R_0\right)\right),\ r_0=R_-,\ v_0=1,\ a_0=0,\ R_0=3,\right. \\ \quad \left. E\_minus\_1\_c\_dA\_dt\_integral_{R_0}\left(q,\ t,\ r_0,\ v_0,\ a_0,\ R_0\right)\right), \\ subs\left(q=1,\ t=1.5\cdot subs\left(R_0=3,\ ftcur\left(R_0\right)\right),\ r_0=R_+,\ v_0=0.1,\ a_0=0,\ R_0=3,\right. \end{array}\right]\right)$$

$$E\_minus\_1\_c\_dA\_dt\_integral_{R_0}(q, t, r_0, v_0, a_0, R_0)\Big)$$

$$\Big]$$
$$\Big)$$

$$[0.01311807133,\ 0.1736754544,\ -0.01311807133,\ -0.00006434331287] \quad \textbf{(58)}$$

$$evalf\Big($$
$$\Big[$$
$$subs\Big(q = -1,\ t = 1.66667,\ r_0 = R\_,\ v_0 = 1,\ a_0 = 0,\ R_0 = 3,\ E\_minus\_grad\_\varphi\_integral_{R_0}(q, t, r_0, v_0, a_0, R_0)\Big),$$

$$subs\Big(q = +1,\ t = 1.66667,\ r_0 = R_+,\ v_0 = 0.1,\ a_0 = 0,\ R_0 = 3,\ E\_minus\_grad\_\varphi\_integral_{R_0}(q, t, r_0, v_0, a_0, R_0)\Big),$$
$$subs\Big(q = -1,\ t = 1.66667,\ r_0 = R\_,\ v_0 = 1,\ a_0 = 0,\ R_0 = 3,\ E\_minus\_1\_c\_dA\_dt\_integral_{R_0}(q, t, r_0, v_0, a_0, R_0)\Big),$$
$$subs\Big(q = 1,\ t = 1.66667,\ r_0 = R_+,\ v_0 = 0.1,\ a_0 = 0,\ R_0 = 3,\ E\_minus\_1\_c\_dA\_dt\_integral_{R_0}(q, t, r_0, v_0, a_0, R_0)\Big)$$

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$$\Big)$$

$$[0.01662063518,\ 0.1512907045,\ -0.01662063518,\ -0.00005605020679] \quad \textbf{(59)}$$

$$evalf\Big($$
$$\Big[$$
$$subs\Big(q = -1,\ t = 2.66667,\ r_0 = R\_,\ v_0 = 1,\ a_0 = 0,\ R_0 = 3,\ E\_minus\_grad\_\varphi\_integral_{R_0}(q, t, r_0, v_0, a_0, R_0)\Big),$$

$$subs\Big(q = +1,\ t = 2.66667,\ r_0 = R_+,\ v_0 = 0.1,\ a_0 = 0,\ R_0 = 3,\ E\_minus\_grad\_\varphi\_integral_{R_0}(q, t, r_0, v_0, a_0, R_0)\Big),$$
$$subs\Big(q = -1,\ t = 2.66667,\ r_0 = R\_,\ v_0 = 1,\ a_0 = 0,\ R_0 = 3,\ E\_minus\_1\_c\_dA\_dt\_integral_{R_0}(q, t, r_0, v_0, a_0, R_0)\Big),$$
$$subs\Big(q = 1,\ t = 2.66667,\ r_0 = R_+,\ v_0 = 0.1,\ a_0 = 0,\ R_0 = 3,\ E\_minus\_1\_c\_dA\_dt\_integral_{R_0}(q, t, r_0, v_0, a_0, R_0)\Big)$$

$$\left]\right)$$

$$[0.01259461396,\ 0.1783377694,\ -0.01259461396,\ -0.00006607060815] \quad \textbf{(60)}$$

$$evalf\left(\left[subs\left(q=-1,\ t=2.66667,\ r_0=R_-,\ v_0=1,\ a_0=0,\ R_0=5,\ E\_minus\_grad\_\varphi\_integral_{R_0}\left(q,\ t,\ r_0,\ v_0,\ a_0,\ R_0\right)\right),\right.\right.$$

$$subs\left(q=+1,\ t=2.66667,\ r_0=R_+,\ v_0=0.1,\ a_0=0,\ R_0=5,\ E\_minus\_grad\_\varphi\_integral_{R_0}\left(q,\ t,\ r_0,\ v_0,\ a_0,\ R_0\right)\right),$$

$$subs\left(q=-1,\ t=2.66667,\ r_0=R_-,\ v_0=1,\ a_0=0,\ R_0=5,\ E\_minus\_1\_c\_dA\_dt\_integral_{R_0}\left(q,\ t,\ r_0,\ v_0,\ a_0,\ R_0\right)\right),$$

$$\left.\left.subs\left(q=1,\ t=2.66667,\ r_0=R_+,\ v_0=0.1,\ a_0=0,\ R_0=5,\ E\_minus\_1\_c\_dA\_dt\_integral_{R_0}\left(q,\ t,\ r_0,\ v_0,\ a_0,\ R_0\right)\right)\right]\right)$$

$$[-0.2264284024,\ 0.06420159698,\ 0.008650313562,\ -0.00002378541887] \quad \textbf{(61)}$$

$$plot\left(evalf\left(\left[subs\left(q=-1,\ r_0=R_-,\ v_0=1,\ a_0=0,\ R_0=3,\ E\_minus\_grad\_\varphi\_integral_{R_0}\left(q,\ t,\ r_0,\ v_0,\ a_0,\ R_0\right)\right),\right.\right.\right.$$

$$subs\left(q=+\ `1\_\_`,\ r_0=R_+,\ v_0=0.1,\ a_0=0,\ R_0=3,\ E\_minus\_grad\_\varphi\_integral_{R_0}\left(q,\ t,\ r_0,\ v_0,\ a_0,\ R_0\right)\right),$$

$$subs\left(q=-\ `1\_\_`,\ r_0=R_-,\ v_0=1,\ a_0=0,\ R_0=3,\ E\_minus\_1\_c\_dA\_dt\_integral_{R_0}\left(q,\ t,\ r_0,\ v_0,\ a_0,\ R_0\right)\right),$$

$$\left.\left.\left.subs\left(q=+1,\ r_0=R_+,\ v_0=0.1,\ a_0=0,\ R_0=3,\ E\_minus\_1\_c\_dA\_dt\_integral_{R_0}\left(q,\ t,\ r_0,\ v_0,\ a_0,\ R_0\right)\right)\right]\right),\ t=subs\left(R_0=3,\ ftcur\left(R_0\right)\right)..2\cdot subs\left(R_0=3,\ ftcur\left(R_0\right)\right)\right)$$

$$evalf\left(\left[\ subs\left(q=-1,\ t=subs\left(R_0=3,\ ftcur\left(R_0\right)\right),\ r_0=R\_,\ v_0=0,\ a_0=0.1,\ R_0=3,\ E\_minus\_grad\_\varphi\_integral_{R_0}\left(q,\ t,\ r_0,\ v_0,\ a_0,\ R_0\right)\right),\ subs\left(q=+1,\ t=subs\left(R_0=3,\ ftcur\left(R_0\right)\right),\ r_0=R_+,\ v_0=0,\ a_0=0.1,\ R_0=3,\ E\_minus\_grad\_\varphi\_integral_{R_0}\left(q,\ t,\ r_0,\ v_0,\ a_0,\ R_0\right)\right)\right]\right)$$

$$evalf\left(\left[\ subs\left(q=-1,\ t=subs\left(R_0=3,\ ftcur\left(R_0\right)\right),\ r_0=R\_,\ v_0=0,\ a_0=0.1,\ R_0=3,\ E\_minus\_1\_c\_dA\_dt\_integral_{R_0}\left(q,\ t,\ r_0,\ v_0,\ a_0,\ R_0\right)\right),\ subs\left(q=+1,\ t=subs\left(R_0=3,\ ftcur\left(R_0\right)\right),\ r_0=R_+,\ v_0=0,\ a_0=0.1,\ R_0=3,\ E\_minus\_1\_c\_dA\_dt\_integral_{R_0}\left(q,\ t,\ r_0,\ v_0,\ a_0,\ R_0\right)\right)\right]\right)$$

$$evalf\left(\left[subs\left(q=-1,\ r=R\_,\ v=1,\ c=3,\ R_0=3,\ \varphi_{lw}\left(q,\ v,\ c,\ r,\ R_0\right)\right),\ subs\left(q=-1,\ t=tcur,\ r_0=R\_,\ v_0=1,\ a_0=0,\ R_0=3,\ \varphi\left(q,\ t,\ r_0,\ v_0,\ a_0,\ R_0\right)\right)\right]\right)$$

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$$plot\left(evalf\left(\left[\ subs\left(q=-1,\ t=tcur,\ r_0=R\_,\ v_0=1,\ a_0=0,\ E\_minus\_grad\_\varphi\_integral_{R_0}\left(q,\ t,\ r_0,\ v_0,\ a_0,\ R_0\right)\right),\ subs\left(q=+1,\ t=tcur,\ r_0=R_+,\ v_0=0.1,\ a_0=0,\ E\_minus\_grad\_\varphi\_integral_{R_0}\left(q,\ t,\ r_0,\ v_0,\ a_0,\ R_0\right)\right)\right]\right),\ R_0=3..10\right)$$

$$plot\left(evalf\left(\left[\ subs\left(q=-1,\ t=tcur,\ r_0=R\_,\ v_0=1,\ a_0=0,\ E\_minus\_1\_c\_dA\_dt\_integral_{R_0}\left(q,\ t,\ r_0,\ v_0,\ a_0,\ R_0\right)\right),\ subs\left(q=+1,\ t=tcur,\ r_0=R_+,\ v_0=0.1,\ a_0=0,\ E\_minus\_1\_c\_dA\_dt\_integral_{R_0}\left(q,\ t,\ r_0,\ v_0,\ a_0,\ R_0\right)\right)\right]\right),\ R_0=3..10\right)$$

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$$with(plots) : plot\left(evalf\left(subs\left(q=1,\ t=0,\ r_{0e}=R\_,\ r_{0p}=R_+,\ v_{0p}=\frac{1}{2},\ v_{0e}=1,\ a_0=0,\ \left[\ \varphi_{lw}\left(q,\ v_{0p},\ c,\ r_{0p},\ R_0\right)+\varphi_{lw}\left(-q,\ v_{0e},\ c,\ r_{0e},\ R_0\right),\ \varphi\left(q,\ t,\ r_{0p},\ v_{0p},\ a_0,\ R_0\right)+\varphi\left(-q,\ t,\ r_{0e},\ v_{0e},\ a_0,\ R_0\right)\right]\right)\right),\ R_0=-5..5,\ style=point,\ numpoints=10\right)$$

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$$with(plots):plot\left(evalf\left(subs\left(q=1, t=tcur, r_{0e}=R\_, r_{0p}=R_{+}, v_{0p}=1, v_{0e}=-2, a_0=0, \left[\varphi_{lw}\left(q, v_{0p}, c, r_{0p}, R_0\right)+\varphi_{lw}\left(-q, v_{0e}, c, r_{0e}, R_0\right), \varphi\left(q, t, r_{0p}, v_{0p}, a_0, R_0\right)+\varphi\left(-q, t, r_{0e}, v_{0e}, a_0, R_0\right)\right]\right)\right), R_0=-5..5, style=point, numpoints=10\right)$$