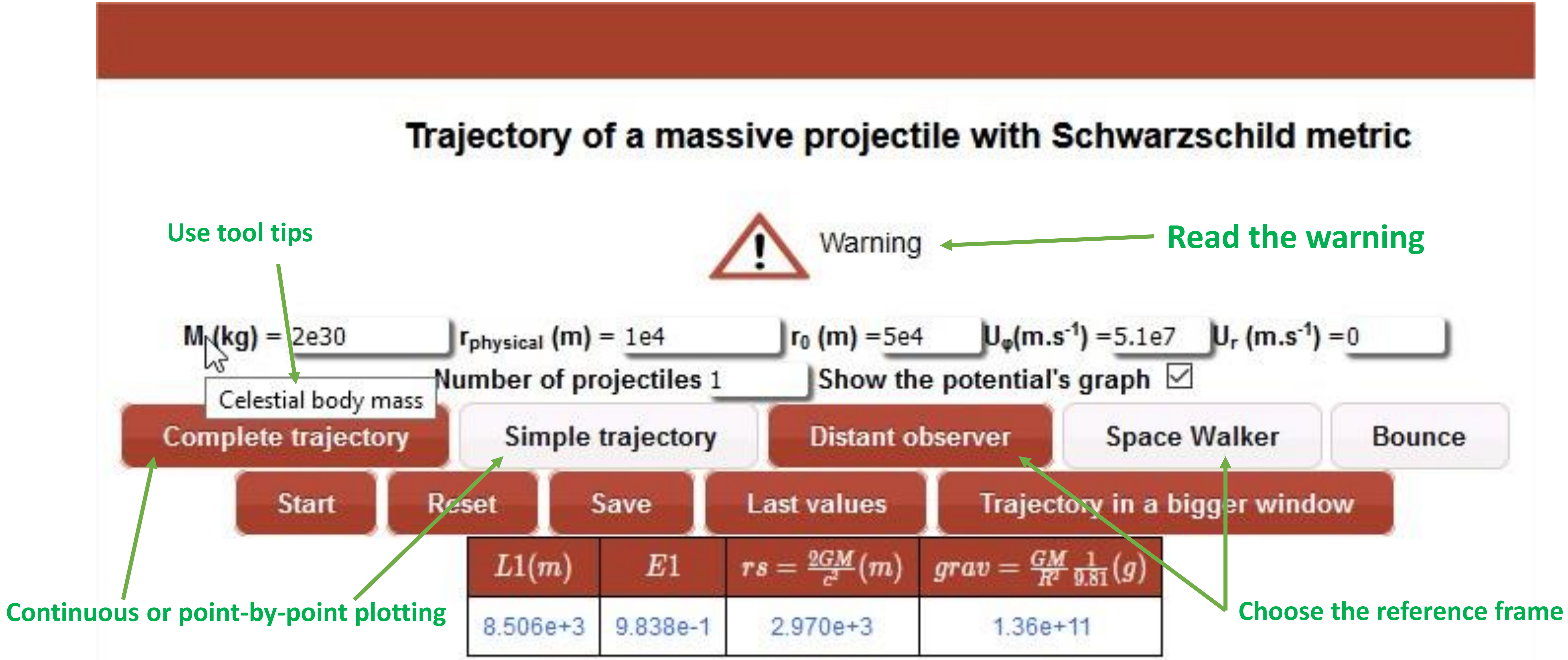
TRAJECTORIES with COSMOGRAVITY TUTORIAL

Choose the type of mass and mobile

Enter the physical parameters of the trajectory



Click on **Start** to start the simulation

Calculated values during the simulation

r(m)	Proper time	Acceleration gradient	$U_r(m.s^{-1})$	$U_\varphi(m.s^{-1})$	Distant observer time	spectral shift
4.993e+4	1.578e-4	5.952e+5	-9.044e+5	4.883e+7	1.651e-4	4.511e-2

Calculation on break

Baryonic mass and particle

Inputs :

M = 2.000e+30 kg

r_{phy} = 1.000e+4 m

Scale of the simulation

1e+4 m

reference frame

Distant observer

mobile1:

r_0 = 5.000e+4 m

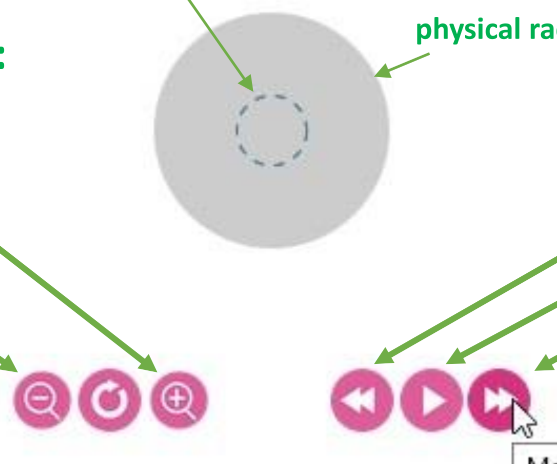
$U_\varphi(r_0)$ = 5.100e+7 $m.s^{-1}$

$U_r(r_0)$ = 0.000e+0 $m.s^{-1}$

The **Save** button saves the graphic and the **Inputs**.
The **Stop** key ends the simulation and resets the inputs to the default values ... but the **Last values** key is used to recall the previous inputs.

rs : Schwarzschild radius

physical radius



During the simulation you can :
- enlarge it (Zoom+)
- reset
- decrease it (Zoom-)

During the simulation you can :
- slow it down
- pause
- speed it up

More (warning, calculations will be accurateless)

Example 1: Small asteroid

Trajectory of a massive projectile with Schwarzschild metric

2 mobiles around the asteroid

Warning

M (kg) = 1e13 $r_{physical}$ (m) = 1000 r_0 (m) = 3e3 5e3 $U_\varphi(m.s^{-1})$ = 0.3 -0.3 U_r $(m.s^{-1})$ = -0.01 -0.5

Number of projectiles 2 Show the potential's graph ☑

Complete trajectory | Simple trajectory | Distant observer | Space Walker | Bounce

Possibility of bounce

Choose the impact absorption coefficient

Shock absorption : the bounce is limited to an impact speed of 300 m/s 0.3

Stop | Reset | Save | Last values | Trajectory in a bigger window

$L1(m)$	$L2(m)$	$E1$	$E2$	$rs = \frac{2GM}{c^2}(m)$	$grav = \frac{GM}{R^2}\frac{1}{9.81}(g)$
3.002e-6	-5.003e-6	1.000e+0	1.000e+0	1.485e-14	6.80e-5

r(m)	Proper time	Gradient	$U_r(m.s^{-1})$	$U_\varphi(m.s^{-1})$	Distant observer time	spectral shift
1.001e+3	2.060e+4	1.191e-8	-1.143e-1	2.159e-1	2.060e+4	
r(m)	Proper time	Gradient	$U_r(m.s^{-1})$	$U_\varphi(m.s^{-1})$	Distant observer time	spectral shift
6.286e+3	1.815e+4	1.051e-9	4.780e-1	-2.386e-1	1.815e+4	

Calculation finished

Example 1 : Simulation result

Calculation finished

Baryonic mass and particle

Inputs :

$M = 1.000e{+}13$ kg

$r_{plr/} = 1.000e{+}3$ m

Shock absorption = 0.3

reference frame → Space Walker

mobile1:

$r_0 = 3.000e{+}3$ m

$U_\varphi(r_0) = 3.000e{-}1\ m.s^{-1}$

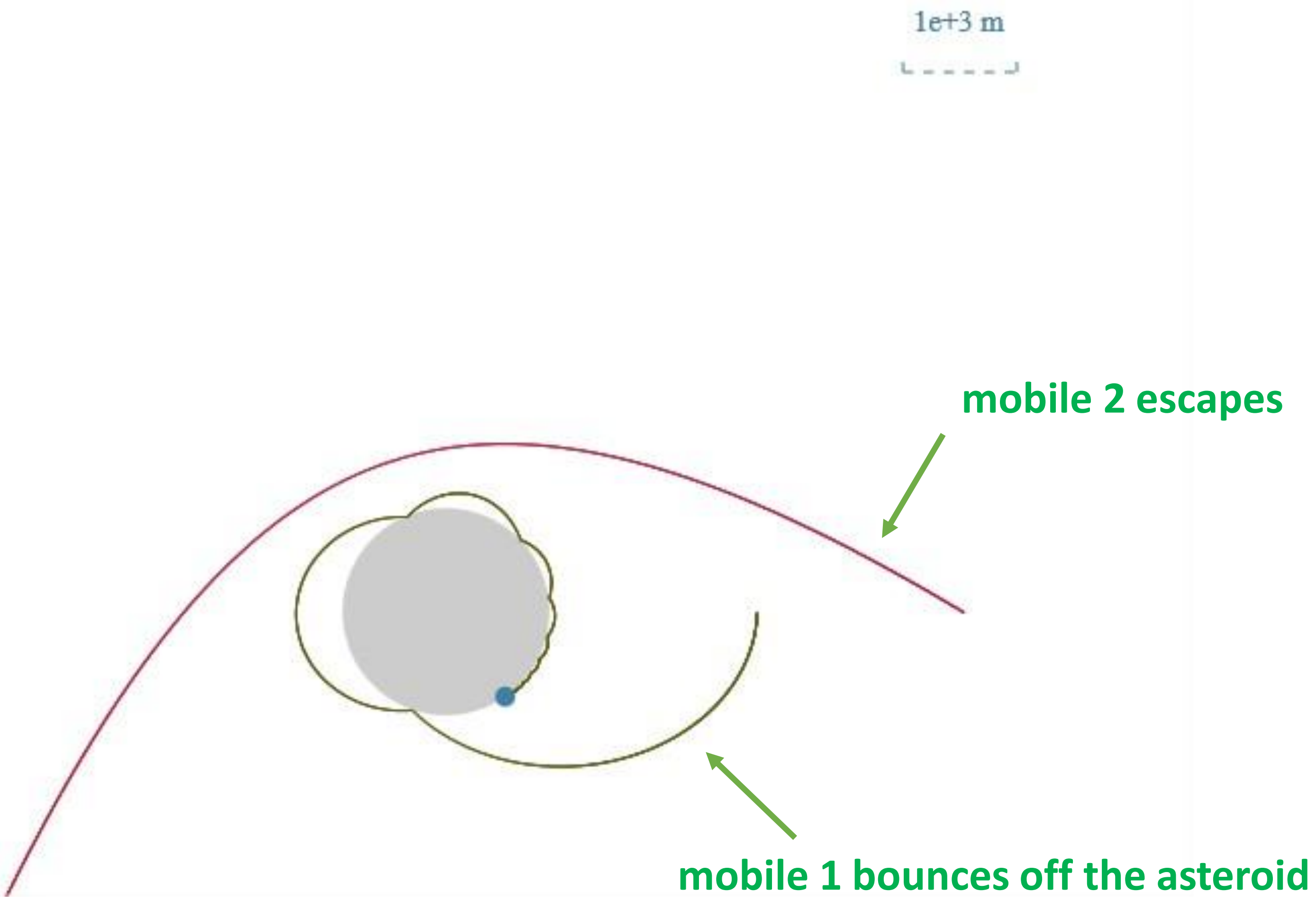
$U_r(r_0) = -1.000e{-}2\ m.s^{-1}$

mobile2:

$r_0 = 5.000e{+}3$ m

$U_\varphi(r_0) = -3.000e{-}1\ m.s^{-1}$

$U_r(r_0) = -5.000e{-}1\ m.s^{-1}$



Example 2 :
photon and massive rotating black hole

Trajectory of a photon with Kerr metric

Warning

M (kg) = 2e39 | r_0 (m) = 5e12 | J ($kg.m^2.s^{-1}$)= 8.5e59 | U_φ ($m.s^{-1}$) = 4e8 | U_r ($m.s^{-1}$) = -3.4e8 | Show the potential's graph ☑

Complete trajectory | Simple trajectory | Distant observer | Photon

Stop | Reset | Save | Last values | Trajectory in a bigger window

$L(m)$	E	$rs = \frac{2GM}{c^2}(m)$	$a = \frac{J}{cM}(m)$	$Rh+(m)$	$Rh-(m)$
5.103e+12	1.393e+0	2.970e+12	1.418e+12	1.928e+12	1.042e+12

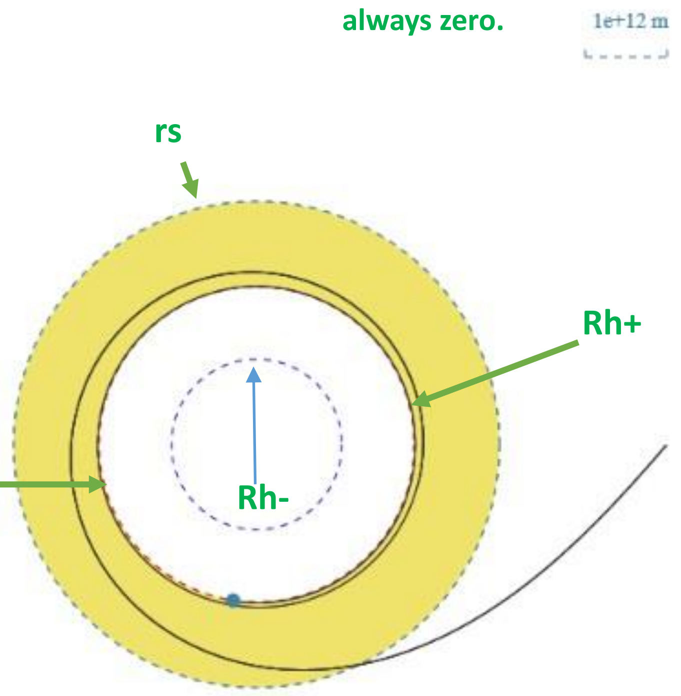
r(m)	Proper time	Acceleration gradient	$U_r(m.s^{-1})$	$U_\varphi(m.s^{-1})$	Distant observer time
1.928e+12	0.000e+0		0.000e+0	1.431e+8	2.053e+5

Calculation on break

The proper time of a photon is always zero.

Trajectory of a photon with Kerr metric

Inputs :
M = 2.000e+39 kg
r_0 = 5.000e+12 m
a = 1.418e+12 m
$U_\varphi(r_0)$ = 4.000e+8 $m.s^{-1}$
$U_r(r_0)$ = -3.400e+8 $m.s^{-1}$
Reference frame → Distant observer



In the reference frame of the distant observer, the photon wraps itself indefinitely around the event horizon Rh+

Potential graph (see Theory)