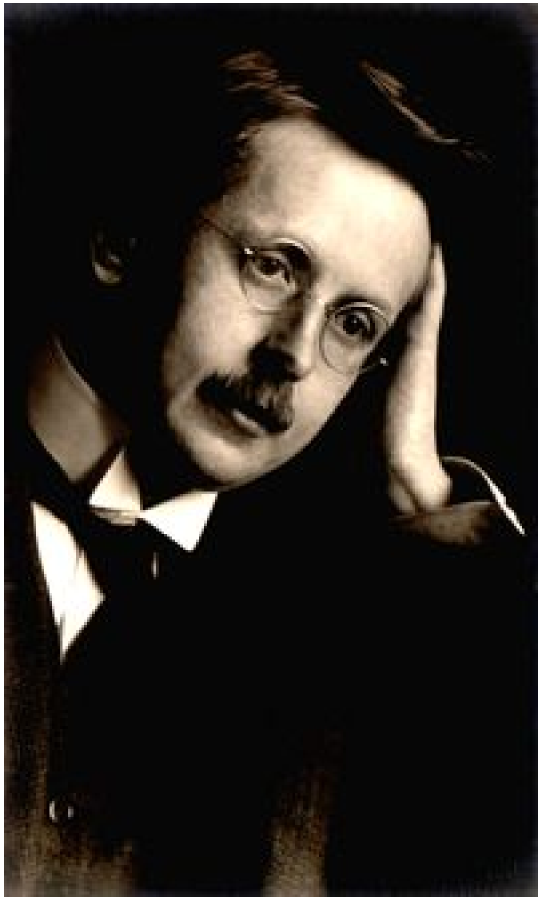
„Beyond the event horizon” Weyl’s forgotten cosmology

György Szondy

Logic, Relativity and Beyond
3rd International Conference
August 23-27, 2017, Budapest

Hermann Weyl (1885-1955)

- German mathematician, theoretical physicist and philosopher
- He was one of the first trying to combine general relativity with electromagnetism
- He was the one who introduced frames into general relativity in 1929.
- He said: *„You can not apply mathematics as long as words still becloud reality”*



Well known Problems of General Relativity

- Nonlinearity

  „General relativity describes the gravitational field by curved space-time; the field equations governing this curvature are nonlinear and therefore difficult to solve in a closed form."

- Local frames instead of coordinate system
  - Spacetime = frame field defined on a Lorentzian manifold
- No quantum theory

Real problem with General Relativity

- We belive in it
- We know it's mathematics
- But – in general – we still don't understadn it's **physical meaning**

  - *In 1957 at Chapel Hill "Conference on The Role of Gravitation in Physics" –* ***John Archibald Wheeler*** *spoke on the need to better understand the physical meaning of general relativity.*
    (Peebles, 2016)
  - Wheeler started teaching relativity 4 years earlier in 1953.

On the Theory of Gravitation By Hermann Weyl (1917)

Contents:

- Appendix to General Relativity
- Theory of the static, axial symmetric field
  - **Point-mass** with and **without electric charge**.

Motivation:

- To understand better the geometry of Schwarzschild solution

About the Schwarzschild solution

- …uses standard coordinates

- The form of the line element:

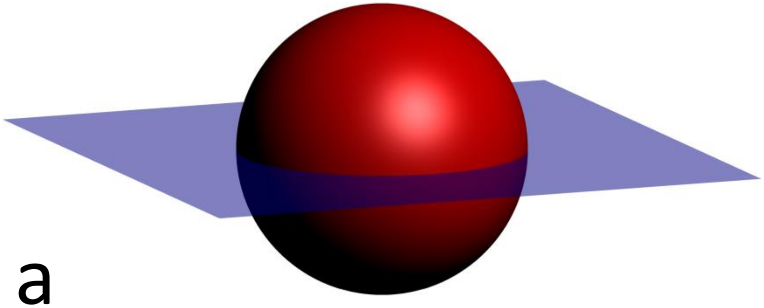
$$ds^2 = A(r)dt^2 - B(r)dr^2 - \boxed{r^2(d\theta^2 + \sin^2\theta d\varphi^2)}$$

- The metric:

$$ds^2 = (1-\frac{r_s}{r})dt^2 - \left(1-\frac{r_s}{r}\right)^{-1} dr^2 - r^2(d\theta^2 + \sin^2\theta d\varphi^2)$$

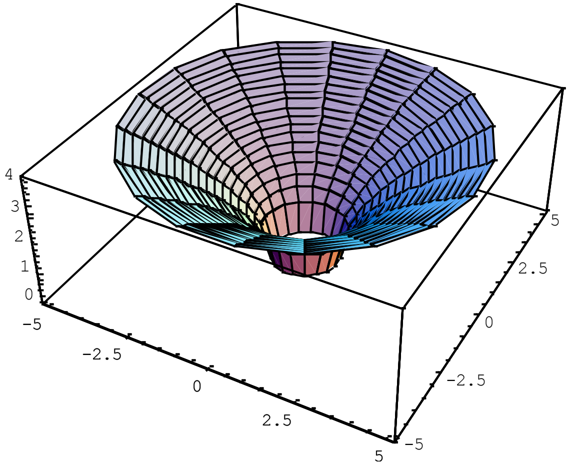
To understand better the geometry of Schwarzschild solution

Geometry of the plane surface through the equator (φ=0)



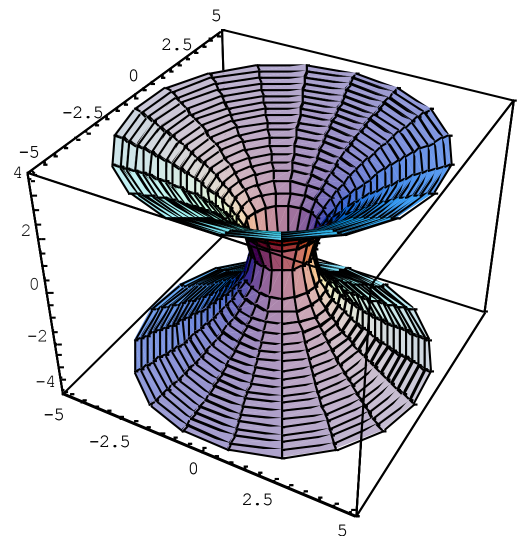
Line-element characterizes a geometry , which is valid for the following rotation ellipsoid in Euclidean space

$$z = \sqrt{8a(r - r_s)}$$



Natural analytic continuation

Rotation ellipsoid $z = \sqrt{8a(r - r_s)}$ ⇨ $z = \pm\sqrt{8a(r - r_s)}$



- The projection covers
  - the outer part of the sphere ($r>r_s$) twice
  - the inner part ($r<r_s$) not at all

To make it obvious: Change the coordinate system

Schwarschild solution in standard coordinates

$$ds^2 = (1-\frac{r_s}{r})dt^2 - \left(1-\frac{r_s}{r}\right)^{-1} dr^2 - r^2(d\theta^2 + \sin^2\theta d\varphi^2)$$

Coordinate transformation

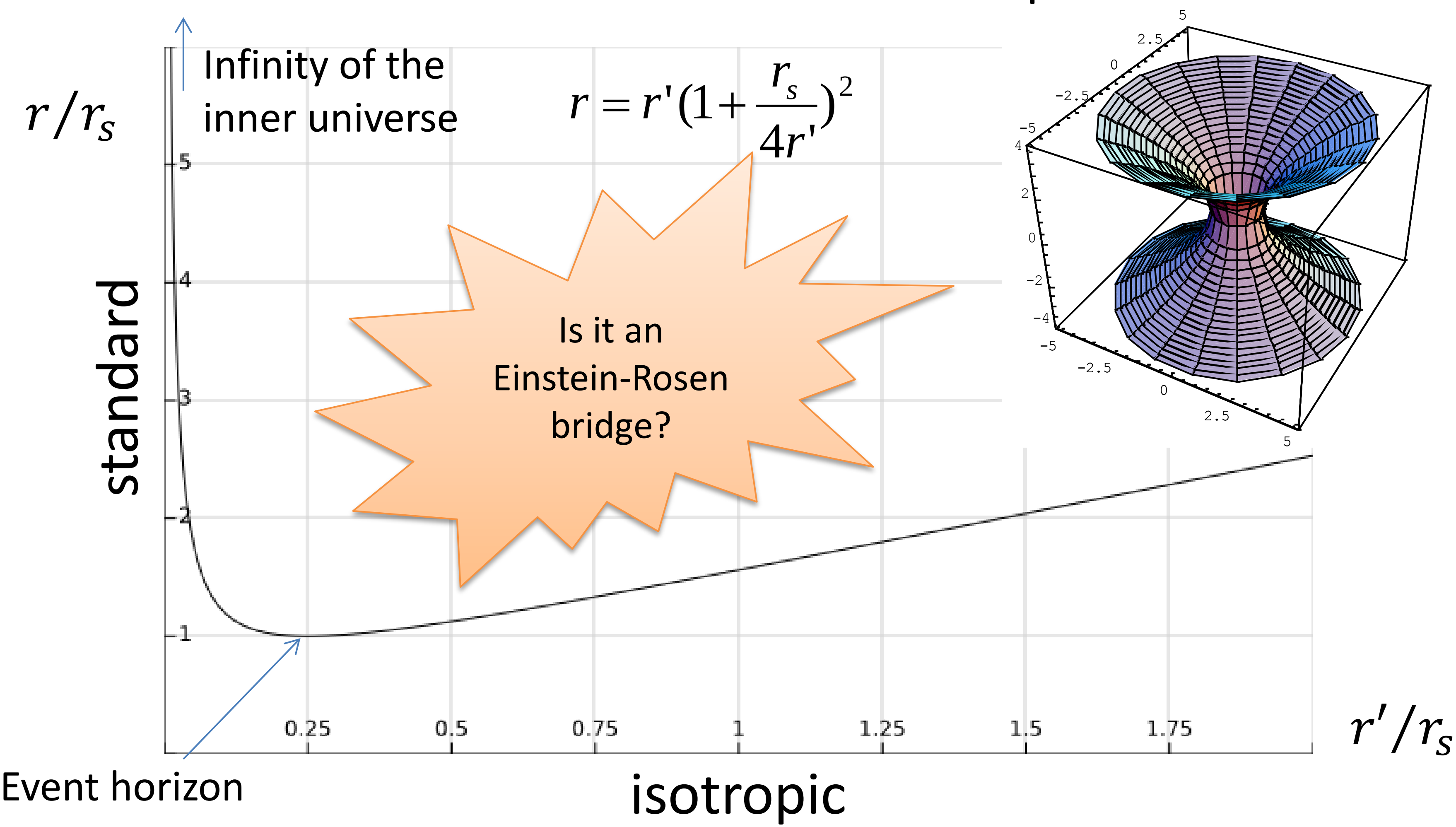
$$r = r'(1+\frac{r_s}{4r'})^2$$

Schwarschild solution in isotropic coordinates

$$ds^2 = \left(\frac{1-\frac{r_g}{4r'}}{1+\frac{r_g}{4r'}}\right)^2 dt^2 + \left(1+\frac{r_g}{4r'}\right)^4 (dr'^2 + r'^2 d\theta^2 + r'^2 \sin^2\theta d\varphi^2)$$

The coordinate transformation

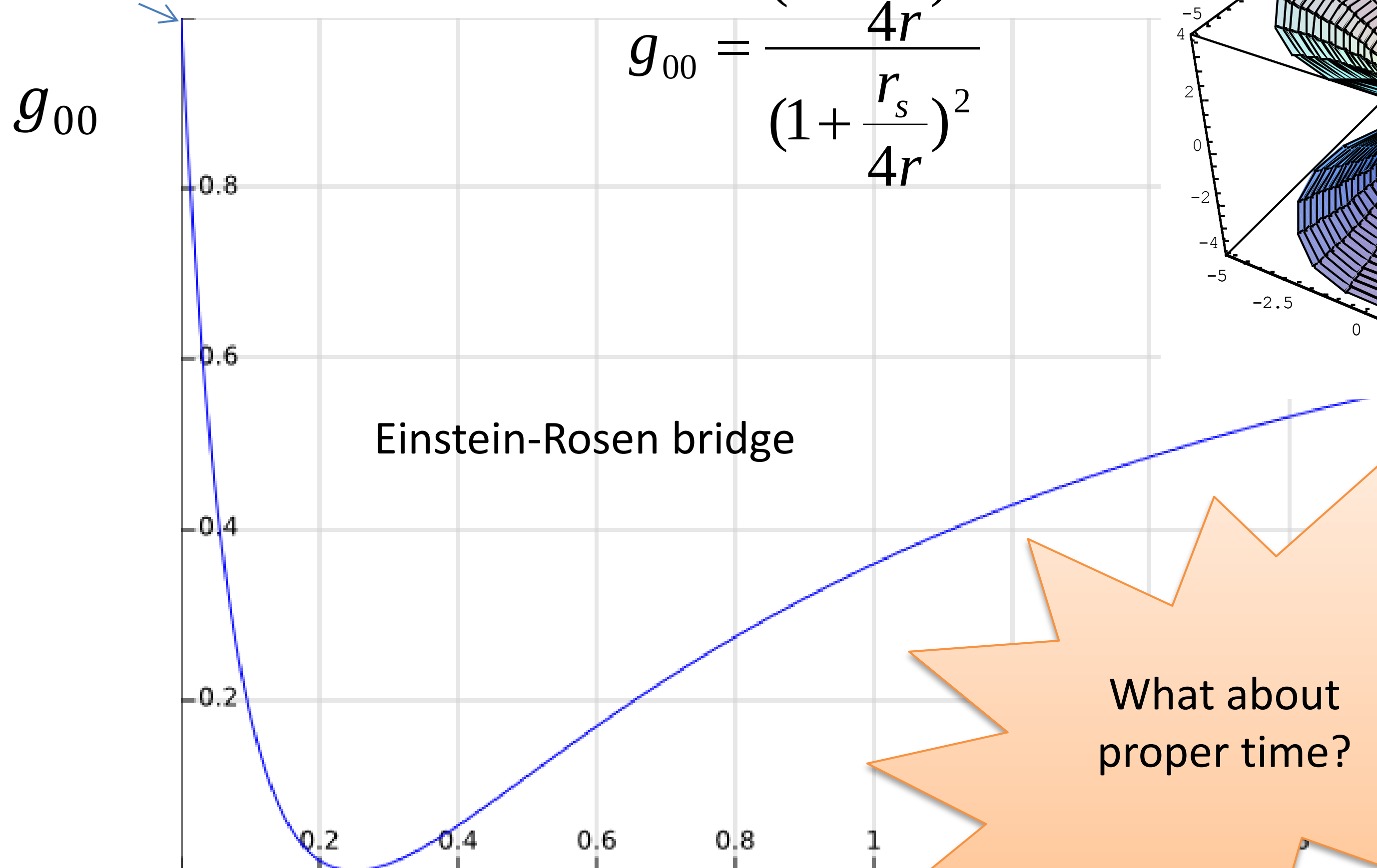
To understand Schwarzschild metric in isotropic coordinates

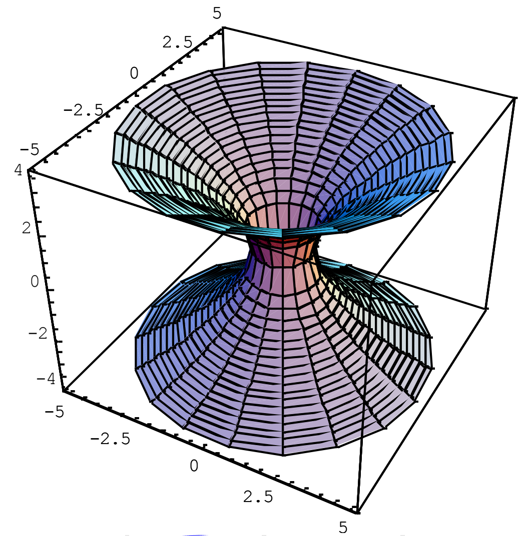


g_{00} in isotropic coordinates

Infinity of the inner universe

$$g_{00} = \frac{(1-\frac{r_s}{4r})^2}{(1+\frac{r_s}{4r})^2}$$





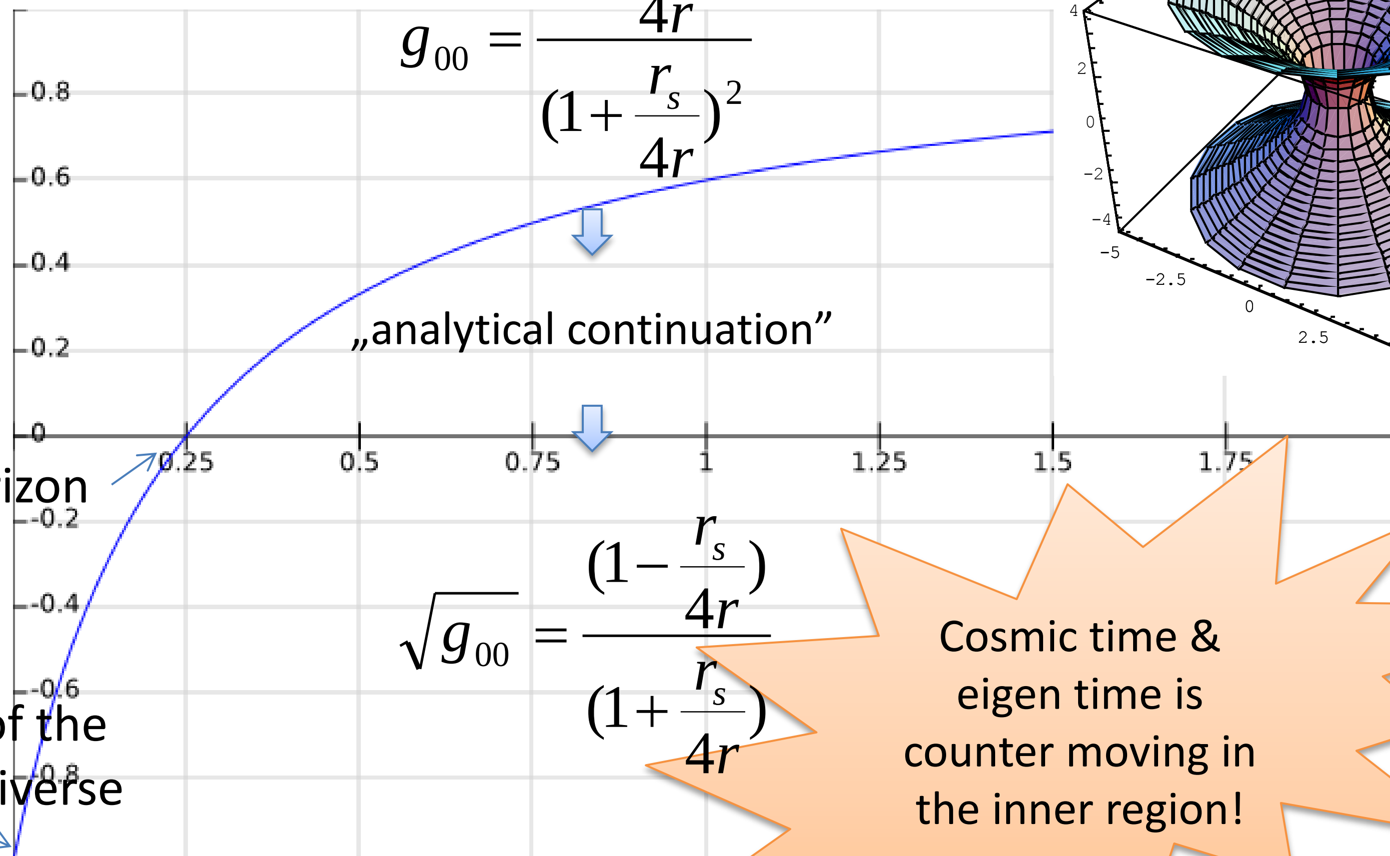
Einstein-Rosen bridge

What about proper time?

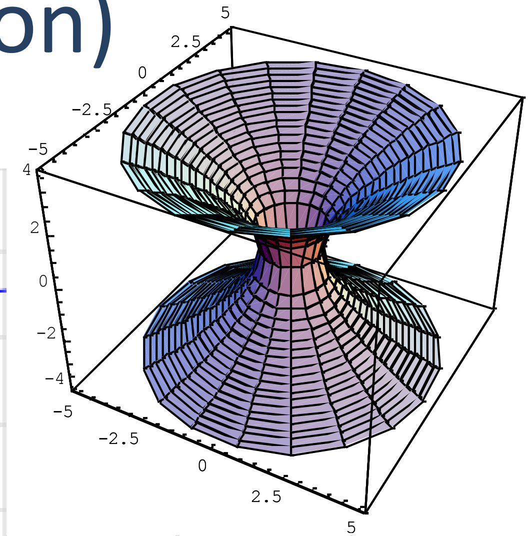
Event horizon

Time in isotropic coordinates (Weil's final conclusion)

$$g_{00} = \frac{(1-\frac{r_s}{4r})^2}{(1+\frac{r_s}{4r})^2}$$



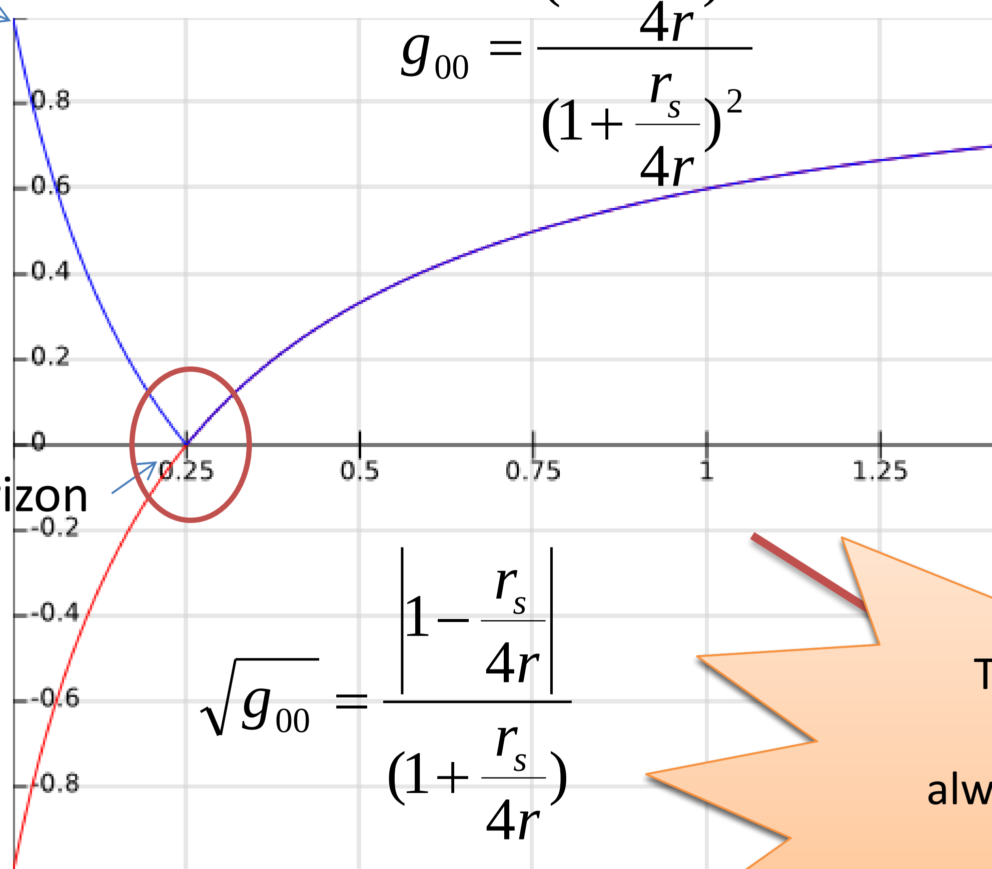
$$\sqrt{g_{00}} = \frac{(1-\frac{r_s}{4r})}{(1+\frac{r_s}{4r})}$$



Cosmic time & eigen time is counter moving in the inner region!

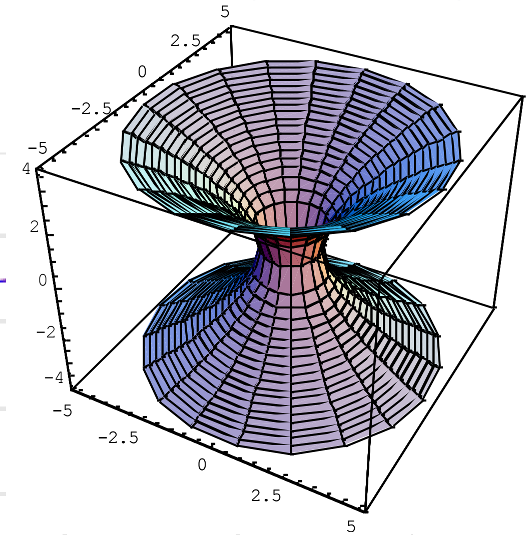
Time in isotropic coordinates (Real)

Infinity of the inner universe



$\sqrt{g_{00}}$

$$g_{00} = \frac{(1-\frac{r_s}{4r})^2}{(1+\frac{r_s}{4r})^2}$$



Event horizon

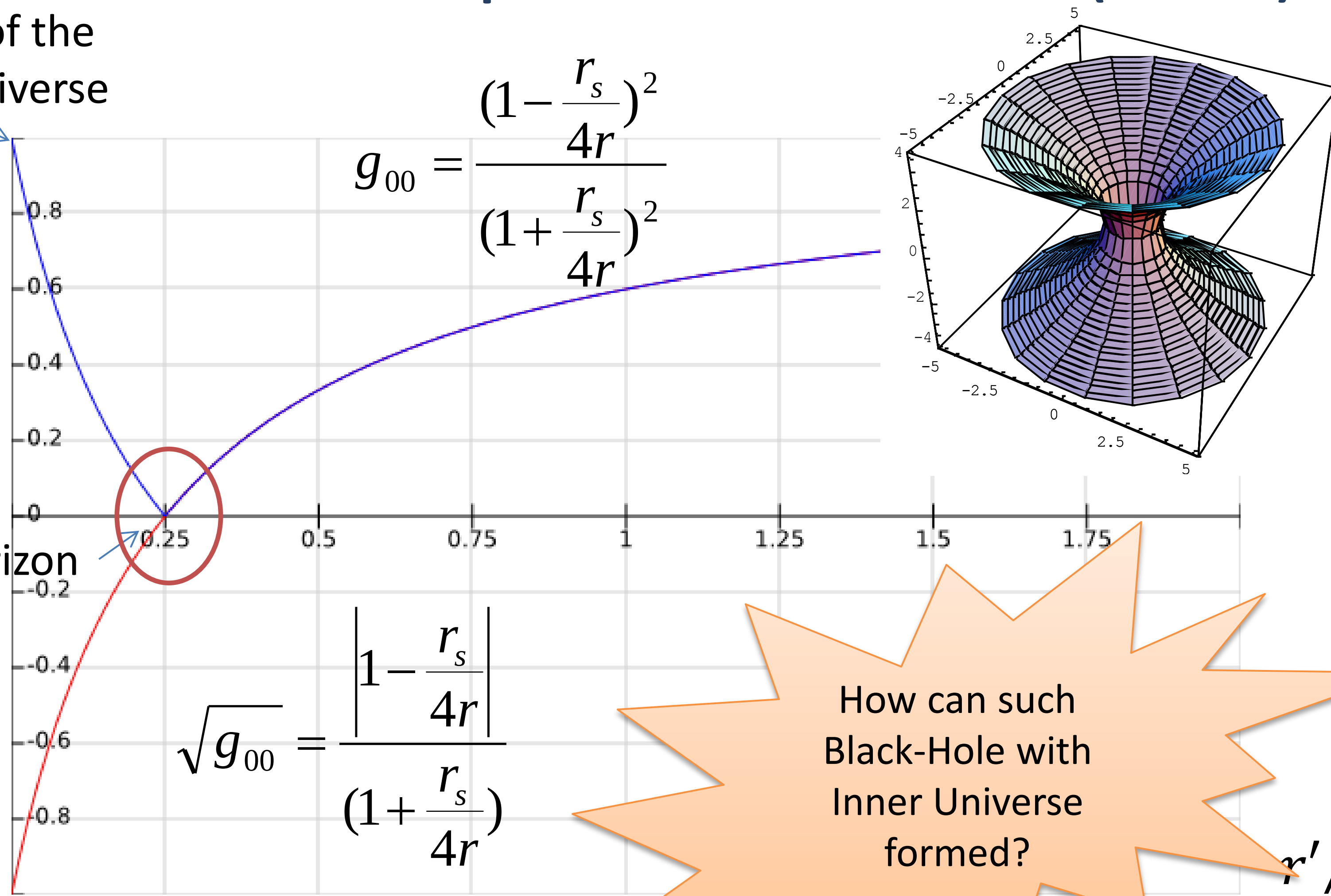
$$\sqrt{g_{00}} = \frac{\left|1-\frac{r_s}{4r}\right|}{(1+\frac{r_s}{4r})}$$

Time is like distance: always positive!

r'/r_s

Time in isotropic coordinates (Real)

Infinity of the inner universe



Event horizon

$\sqrt{g_{00}}$

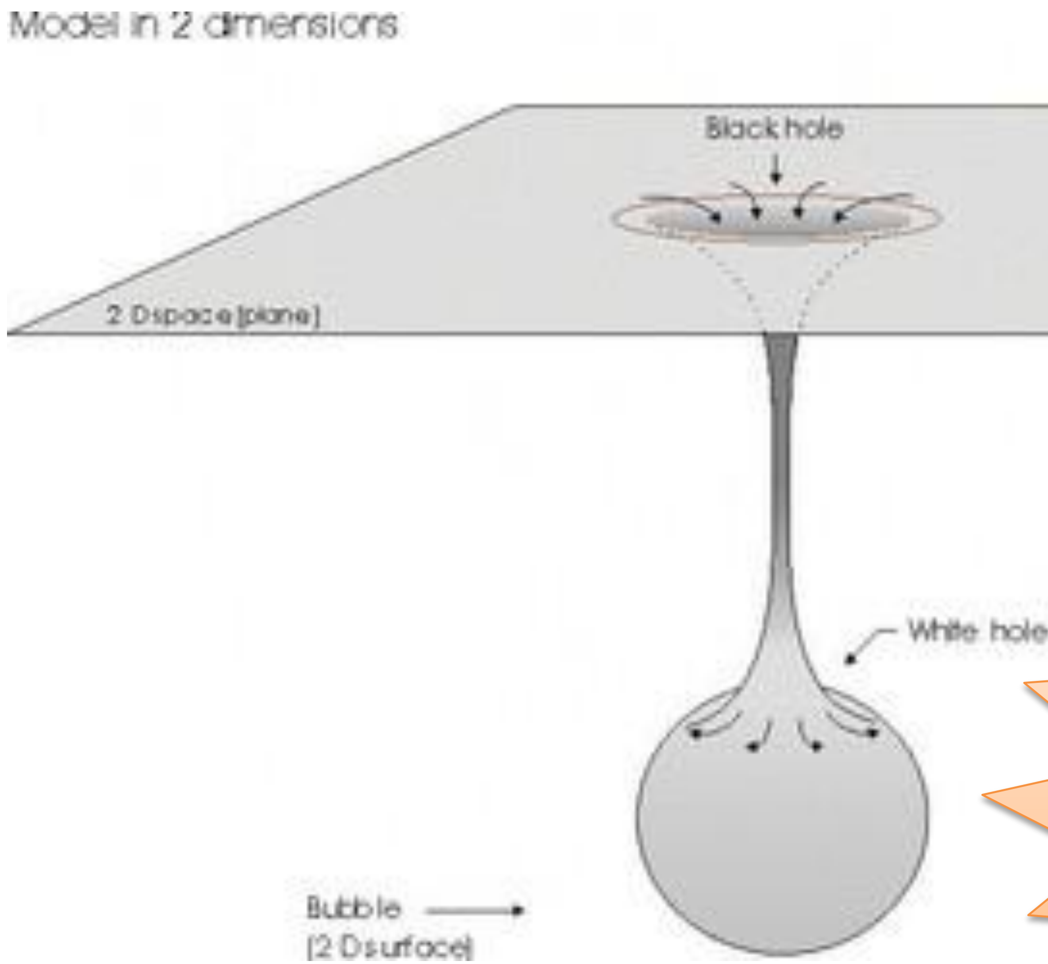
$$g_{00} = \frac{(1-\frac{r_s}{4r})^2}{(1+\frac{r_s}{4r})^2}$$

$$\sqrt{g_{00}} = \frac{\left|1-\frac{r_s}{4r}\right|}{(1+\frac{r_s}{4r})}$$

r'/r_s

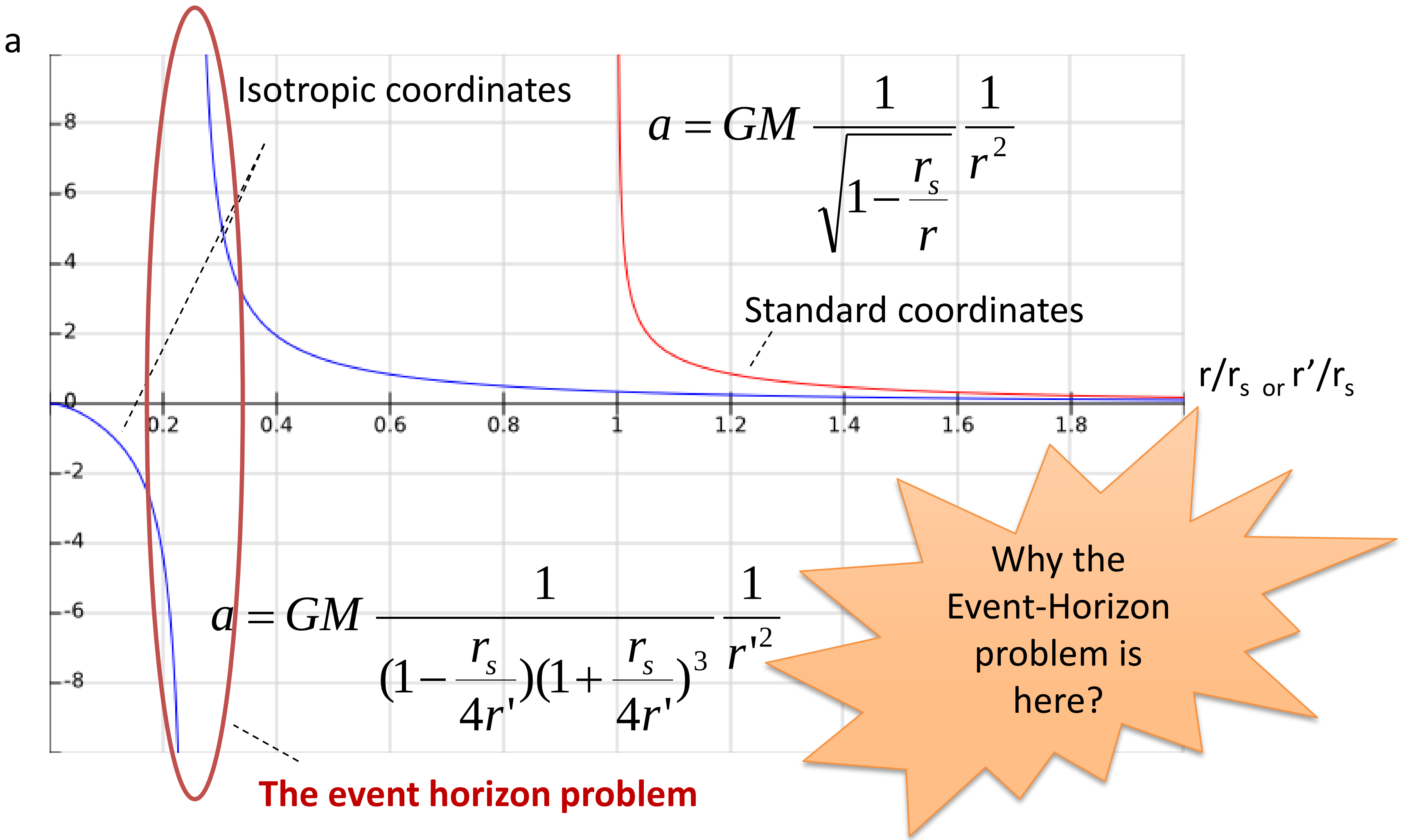
How can such Black-Hole with Inner Universe formed?

Evolution of Black-Hole (Lee Smolin – Loop Quantum Gravity)



What is the Acceleration of point particles?

Gravitational accelertion

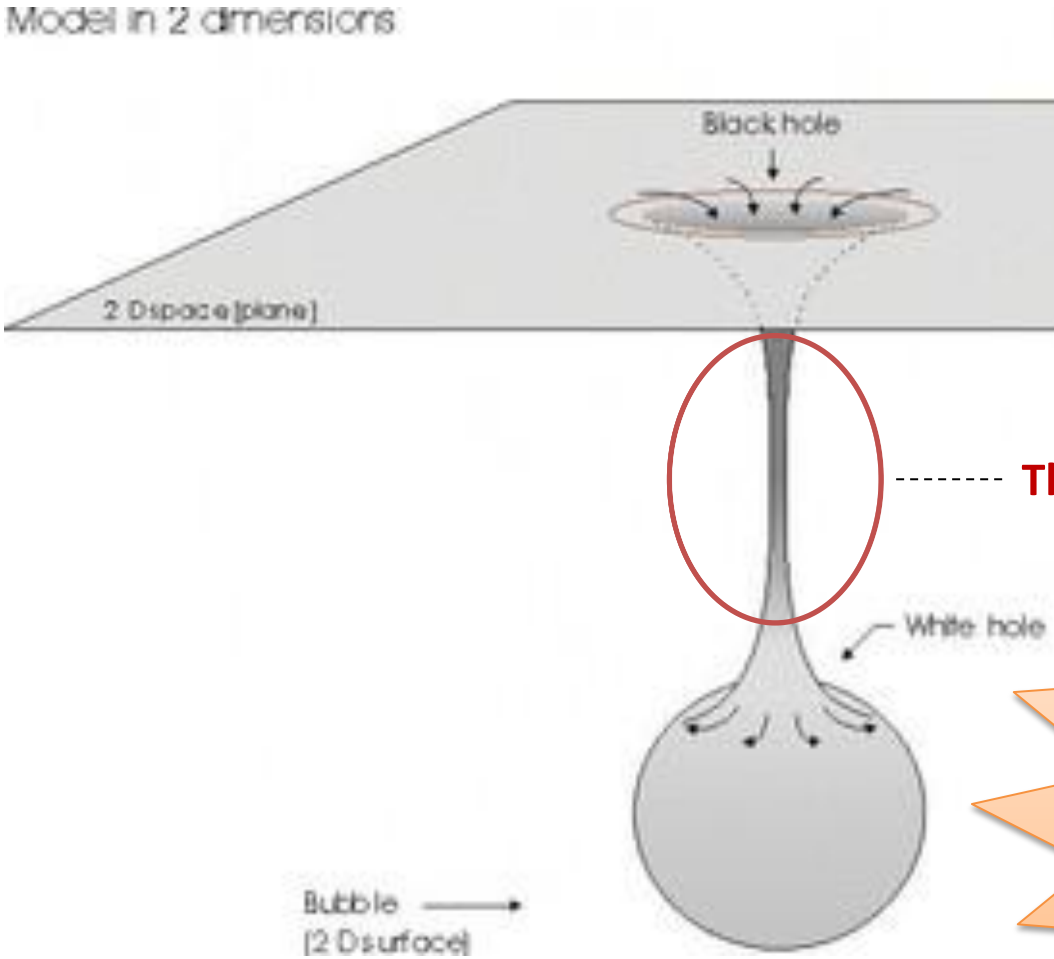


The event horizon problem

"Einstein equivalence principle„

- *The outcome of any* ***local*** *non-gravitational experiment in a freely falling laboratory is independent of the velocity of the laboratory and its location in spacetime.*
- *„Here "local" has a very special meaning: [...] it must [...] be* ***small*** *compared to* ***variations*** *in the* ***gravitational*** *field"*
- *EEP can not be applied near the event-horizon!*

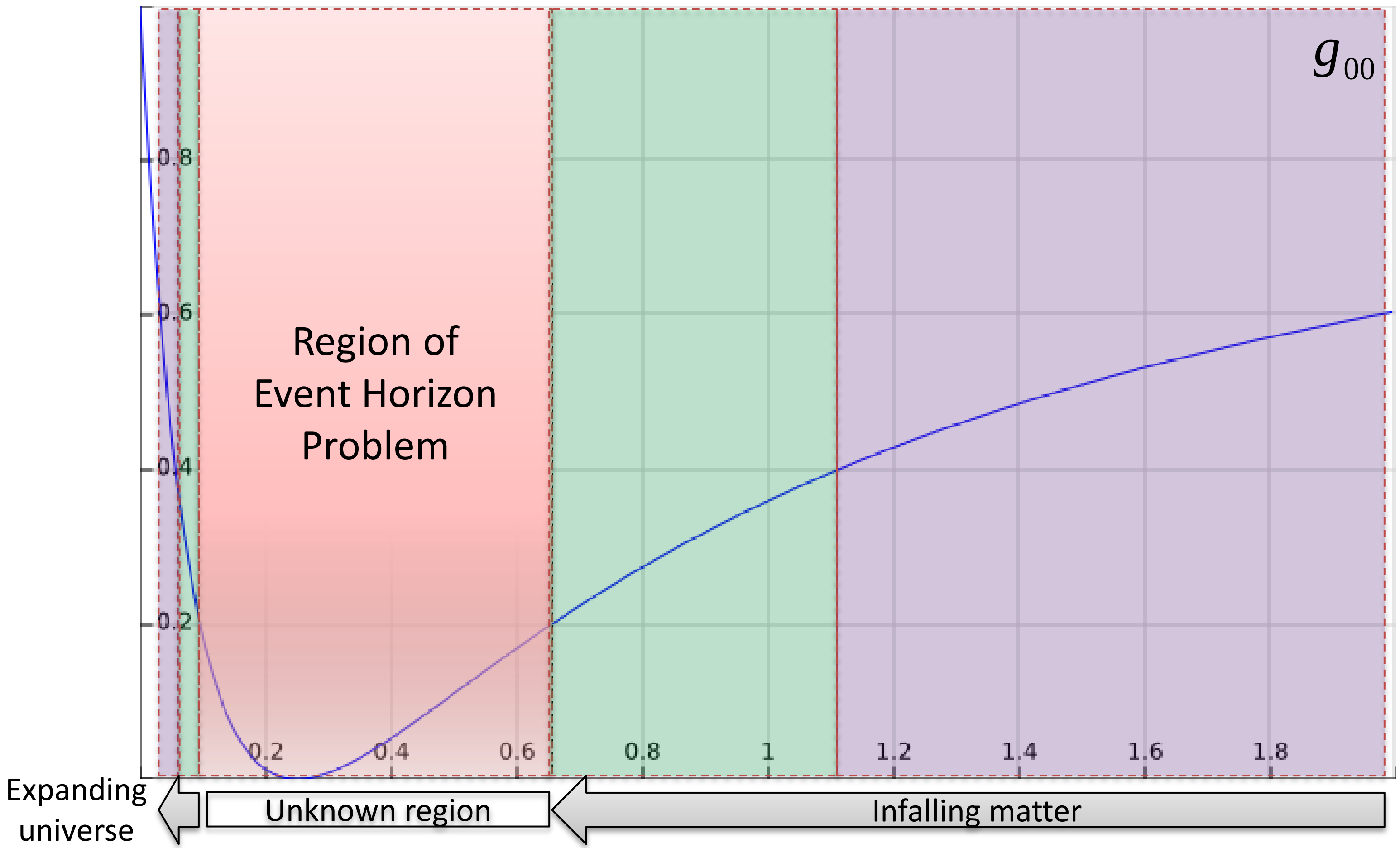
The event horizon problem



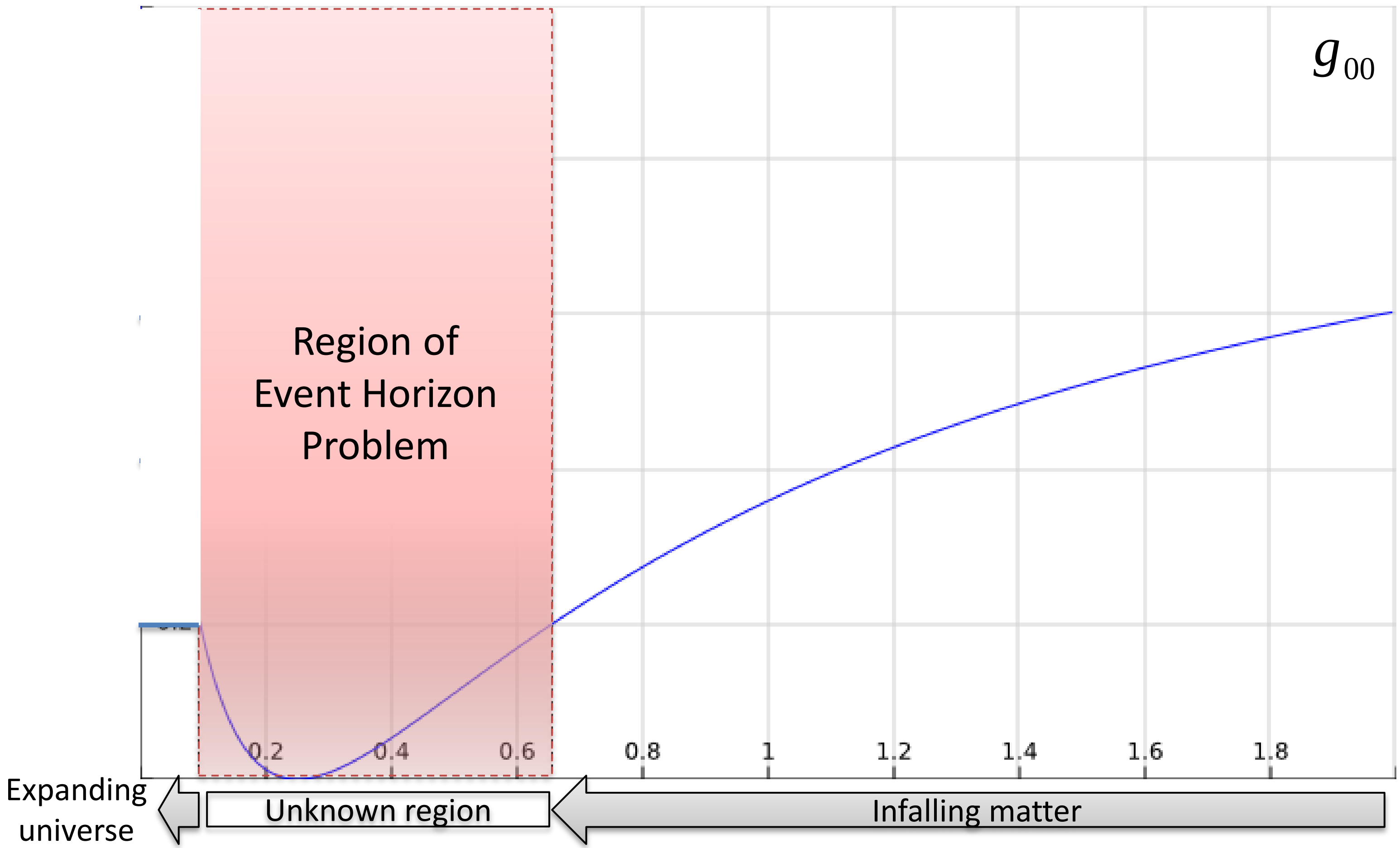
The event horizon problem

How to overcome Event-Horizon problem?

Evolution of Black-Hole & Inner Universe



Collapsing sphere



Conclusions

- There is nothing inside a black-hole ($r<r_s$) – except an inner universe
- GR can not be used near the event-horizon
- Modelling of evolution of universe with well-founded parameters at t_0 is possible
- (Conform-euclidean → coordinates superposition & possible analytic solution of 2-bodies problem)

Conclusions II. (phylosophy)

- There are lot of forgotten, important knowledge about GR
- We should understand the physical meaning of GR

- Might have been a better choice to explain the physical meaning of GR …
- Perhaps next time?