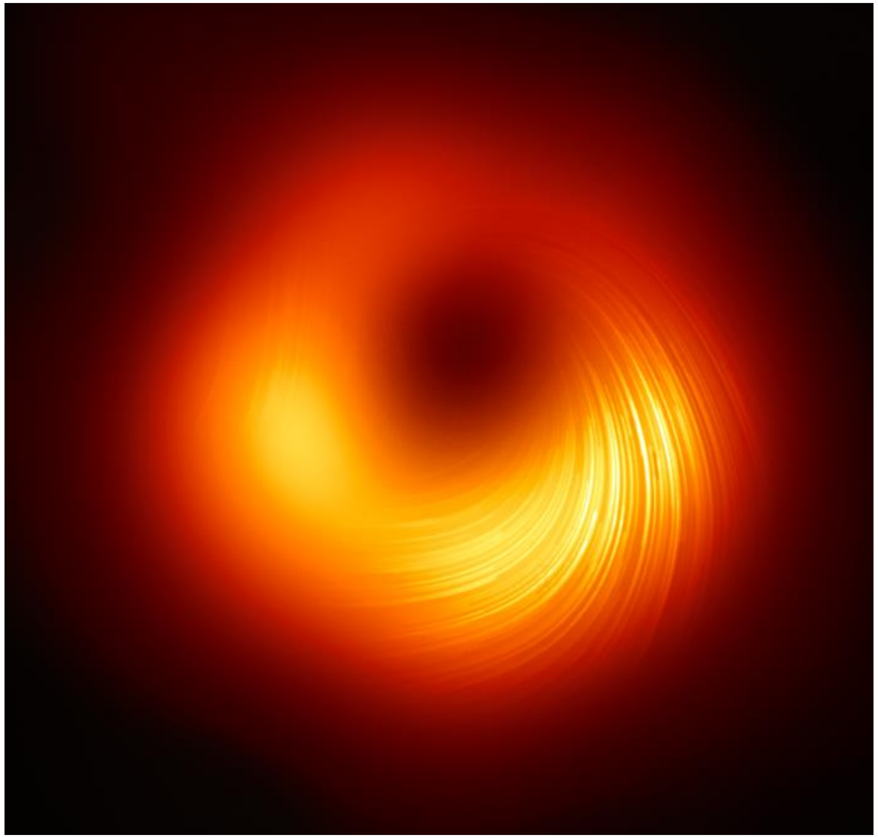

[1]


Dutch for *dolphin* = *dolfijn*, which also means *very nice*.

Let's dive into it!

[1] https://www.thoughtco.com/learning-about-dolphins-1834133
https://eventhorizontelescope.org/blog/astronomers-image-magnetic-fields-edge-m87s-black-hole

NOTE (2024-04-28):

Some parts of this document are no longer conform my very latest insight.

All of:

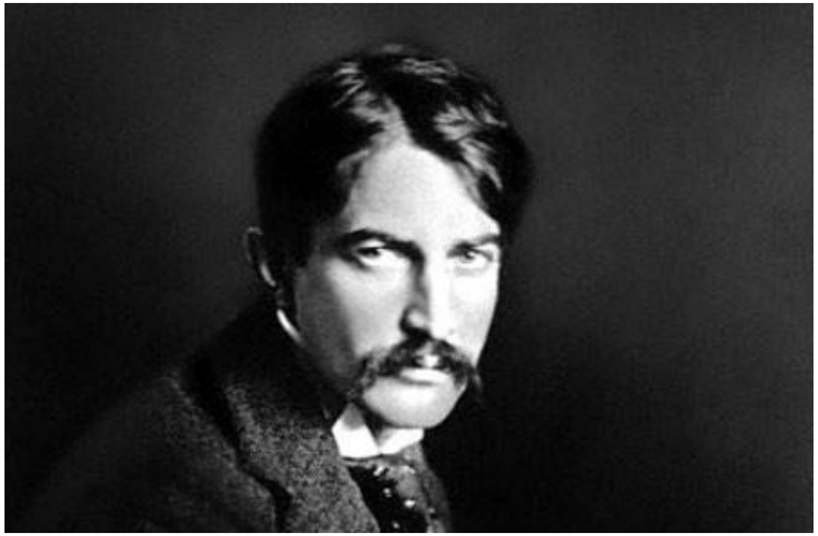
1. http://henk-reints.nl/astro/HR-flawed-black-hole-equation.pdf
2. http://henk-reints.nl/astro/HR-Deflection-of-light-passing-a-mass.pdf
3. http://henk-reints.nl/astro/HR-Deflected-light-stuff.pdf
4. http://henk-reints.nl/astro/HR-truly-black-Black-Hole.pdf
5. http://henk-reints.nl/astro/HR-BH-internals.pdf
6. http://henk-reints.nl/astro/HR-BH-temperature.pdf

(please read them in this order)

have precedence!

A man said to the universe:
"Sir, I exist!"
"However," replied the universe,
"The fact has not created in me
A sense of obligation."

The universe
is under
no obligation
to make sense
to you.



Stephen Crane (1871-1900)

Neil deGrasse Tyson (1958-)

Do you realize that if you fall into a black hole, you will see the entire future of the universe unfold in front of you in a matter of moments and you will emerge into another space-time created by the singularity of the black hole you just fell into?

Neil deGrasse Tyson.

From which ascertained truths
did he deduce this gobbledygook?

Do you realise that if you fall into a black hole,
you will instantly be dead if you were not already?

Henk Reints.

Propositiones ex veris non deducitur in scientia locum non habent!

Statements not deduced from truths ***have <u>no</u> place in science!***

Main goals of this presentation:

- ☞ clear understanding of event horizon without concoctions about its inside;
- ☞ get rid of the silly idea of a singularity; it cannot ever be something physical.

Scenario:

A distant observer watches a victim that is radially falling towards a *Schwarzschild black hole*.

Bull's eye trajectory.

Observation by distant observer:

Gravitational time dilation prevents distant observer to ever see victim get within *Schwarzschild radius*.

Distant observer sees victim asymptotically approach event horizon.

To distant observer, it is totally unclear what takes place beyond it, so he'll contrive some concoctions...

Observation by victim:

He simply falls straight into black hole in finite *time* and then... uh, yeah, what?

In fact, he can only stay put at the origin of his own local frame.

He sees black hole come towards him at ever increasing *velocity* and after finite *time Schwarzschild sphere* engulfs him.

Observation by victim (2):

At that very moment,
the black hole's
velocity of approach
has precisely reached
the very *speed of light*.

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Ever heard of
Lorentz contraction?

Observation by victim (3):

Unless **YOU**  **PROVE** the contrary,

Lorentz contraction applies to the *Schwarzschild radius* just like to ANY longitudinal *distance*.

$$\sqrt{1-\left(\frac{v=c}{c}\right)^2} =$$ Sweet Fanny Adams

3. *Zur Elektrodynamik bewegter Körper;*
von A. Einstein.

(...)

§ 4. Physikalische Bedeutung der erhaltenen Gleichungen, bewegte starre Körper und bewegte Uhren betreffend.

(...)

wegung nicht modifiziert erscheinen, erscheint die X-Dimension im Verhältnis $1:\sqrt{1-(v/V)^2}$ verkürzt, also um so stärker, je größer v ist. Für $v = V$ schrumpfen alle bewegten Objekte — vom „ruhenden" System aus betrachtet — in flächenhafte Gebilde zusammen. Für Überlichtgeschwindigkeiten werden unsere Überlegungen sinnlos; wir werden übrigens in den

For $v = c$ all moving objects — viewed from the "stationary" system — shrivel up into plane figures.

Admittedly, he wrote this before he published GR.

Observation by victim (4):

At very moment *Schwarzschild radius* touches victim, it has for him been Lorentz contracted to nought point nought.

The victim receives a **direct hit** from the black hole's central *mass* at the very ***speed of light***.

BANG!

Observation by BH's central mass:

It sees victim approach at ever increasing *velocity* and after finite *time* victim passes *Schwarzschild radius* at very *speed of light*.

Of course it keeps accelerating, keepsn't it?
Then it's obvious that victim will become

superluminahahaHaHaHAHAHA...

Please tell me another one!

Observation by BH's central mass (2):

Around the
black hole's
central *mass*
exists a very strong
gravitational field.

Ever heard of
gravitational length contraction?

Observation by BH's central mass (3):

Unless **YOU**  **PROVE** the contrary,

gravitational length contraction applies to the *Schwarzschild radius* just like to ANY radial *distance*.

$$\sqrt{1-\frac{r_s}{r=r_s}} =$$

Diddly squat

Nada

Zilch

Observation by BH's central mass (4):

Schwarzschild radius has for
BH's central mass been gravitationally
contracted to nought point nought.

The black hole's central mass
receives a direct hit by the victim
at the very *speed of light*.

GOTCHA!

https://mirellietc.com/wp-content/uploads/2019/01/why-didnt-I-think-of-that.jpg

Lorentz contraction is symmetrical between both observers; **Eq.Pr. prescribes same for**

"*Schwarzschild contraction*":

as seen locally (i.e. at r), *each & every* radial length at a position anywhere in the entire range $[0, \infty]$ is contracted

("**local Schwarzschild contraction**")

& as observed from infinity, any dr at location r appears contracted

by $\sqrt{1-(v_{\mathrm{ff}}/c)^2} = \sqrt{1-r_{\mathrm{S}}/r}$.

Lorentz contraction: $\sqrt{1-\beta^2}$

applies to ***any*** length in direction of motion

& ***depends only on*** $\boldsymbol{\beta} =$ ***mutual velocity***,

not on location or whatever details of contracted entity.

Local Schwarzschild contraction: $\sqrt{1-r_{\mathrm{S}}/r}$

applies to ***any*** radial length

& ***depends only on*** $\boldsymbol{r} =$ ***local observer's location***

(as perceived from infinitely far away and in units of r_{S}),

not on location or whatever details of contracted entity.

Equivalence principle: both must yield same.

There exists not a single reason why the Schwarzschild radius should be excluded from any type of relativistic length contraction.

Equivalence Principle:

both Lorentz & gravitational
length contraction yield same.

Collision is
one and same single event
for both victim and central mass.

Colliding bodies ultimately perceive
no event horizon whatsoever,
but direct hit at the very *speed of light*.

They "collight".

BANG! GOTCHA!

A BH is not a hole at all!

Victim does *not* fall ***in**to* the mysterious unknown,
but straight ***on**to* a massive body
at the speed of light. ouch.

Lorentz contraction depends on *velocity;*

during free fall it increases over time;

to victim, event hor. vanishes **ad ultimo**;

central mass *suddenly* appears

& at that very same moment:

I'll be ba... **BANG!** *Hasta la vista, baby...*

Gravitational contraction is timeless,

so central mass never observes

any "gotcha horizon".

The event horizon merely
is a geometrical illusion
to the distant observer only;
it is an inflated spatial nought.

It has NO geometrical inside.

"*Inside or beyond the event horizon*"
is a meaningless concept.

ERGO:

ALL theories based on the illusive event horizon are to be rejected!

Ex falso sequitur quod libet.

The **Penrose theorem**[2] is about trapped regions,
i.e. *inside the event horizon*.
Hasn't the latter just been falsified?
Roger, your invention is unrealistic. Sorry.

Hawking radiation is about the *event horizon*.
Hasn't the latter just been falsified?
Stephen, your invention is unrealistic. Sorry.

Ex falso sequitur quod libet.

---

[2] 2020 Nobel Prize in Physics.

Inversion of standard interpretation:

Not: gravitational contraction:

$$r' = r\sqrt{(1 - r_S/r)} = \sqrt{r(r - r_S)}$$

but: "ungravitational" extension of distance to M:

$$r = \frac{1}{2}\left(r_S + \sqrt{r_S^2 + 4(r')^2}\right) \qquad r' \geq 0 \;\; \rightarrow \;\; r \geq r_S$$

Taylor series at $r' = 0$: $\quad r = r_S + \frac{(r')^2}{r_S} - \frac{(r')^4}{r_S^3} + \mathcal{O}((r')^5)$

Laurent series at $r' = \infty$: $\quad r = r' + \frac{1}{2} r_S + \frac{r_S^2}{8r'} - \frac{r_S^4}{128(r')^3} + \mathcal{O}\left(\frac{1}{(r')^4}\right)$

Distance from gravitated body to central mass:

r is what's perceived from infinity, r' is measured on the spot.

As seen from ∞, things appear blown up
by at least half the Schwarzschild radius.

Measured on the spot = only true value;
measured from a distance = illusory.

Point masses blown up to r_S as seen from infinity;
on the spot: size is nought, including event horizon!

$$r' \geq 0 \quad \rightarrow \quad r \geq r_S$$

Concept of "inside event horizon" is malarkey.

Singularity ≡ point mass itself. NO inside.

Albert Einstein, Zur Elektrodynamik bewegter Körper.

On the electrodynamics of moving bodies.

Annalen der Physik 17 (1905) pp.891-921; @p.903:

Für Überlichtgeschwindigkeiten werden unsere Überlegungen sinnlos; wir werden übrigens in den folgenden Betrachtungen finden, daß die Lichtgeschwindigkeit in unserer Theorie physikalisch die Rolle der unendlich großen Geschwindigkeiten spielt.

For superluminal velocities our deliberations become senseless; moreover, in the following considerations we will find that in our theory the speed of light plays the role of the infinitely large velocities.

Relativistic trinity:

Finite speed of light plays role of *infinite* velocities,

as if infinity has been contracted to finitude.

Distant observer's *infinite* time until collision
appears *finite* to colliding bodies,

as if infinity has been contracted to finitude.

Ultimate *infinite* proximity (reciprocal distance) of colliding bodies
appears *finite Schwarzschild proximity* to distant observer,

as if infinity has been contracted to finitude.

By the way...

I think *proximity* is more fundamental than *distance*,

but distance is easier to measure

(e.g. by counting steps or paving stones).

"*Gravitational Influence*":

$$\tilde{g} \coloneqq \frac{m}{r} = mass \times proximity;$$

$$F_{\mathrm{g}} = G \cdot \frac{m_1}{r} \cdot \frac{m_2}{r} = G{\cdot}\tilde{g}_1{\cdot}\tilde{g}_2$$

gravity equals product of influences

(*G is necs. because we use rather silly units...*)

Black hole equation:

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

uses spherical coordinates w.r.t.
black hole's centre, but they are as
perceived by the distant observer;

the falling victim & the black hole's core
have another perception thereof.

*One should not try to describe what
is behind a mirror by looking into it.*

SCHWARZSCHILD: Über das Gravitationsfeld eines Massenpunktes 191

$$ds^2 = F dt^2 - G(dx^2 + dy^2 + dz^2) - H(x\,dx + y\,dy + z\,dz)^2$$

wobei F, G, H Funktionen von $r = \sqrt{x^2 + y^2 + z^2}$ sind.

Die Forderung (4) verlangt: Für $r = \infty$: $F = G = 1$, $H = 0$.

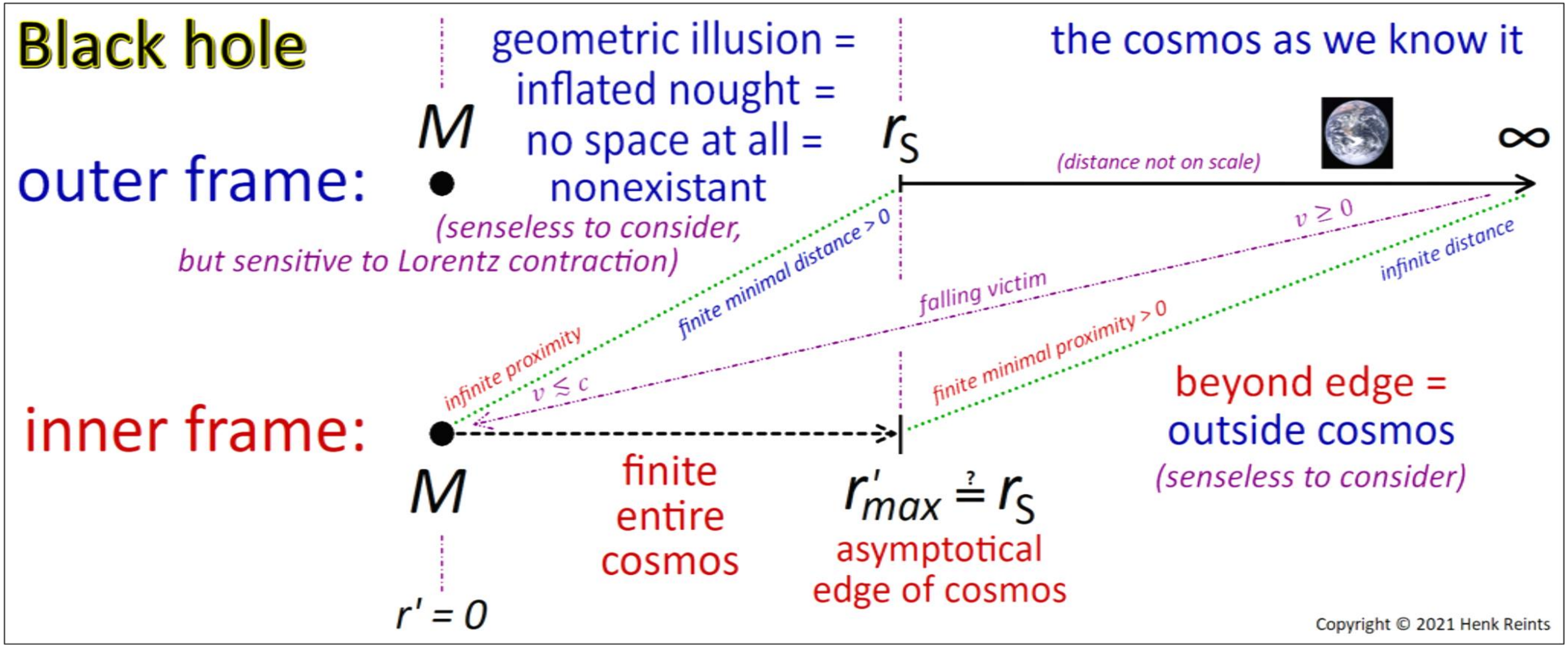
Schwarzschild soln. is attached to ∞ ("outer" frame).

__Desired__: "inner" frame attached to central point mass with apparent contraction of entire cosmos to a finite sphere (note: this is *not* the interior Schwarzschild solution):

$$r_S \to 0 \quad \& \quad \infty \to r'_{max}$$

where finite $r'_{max} (\stackrel{?}{=} r_S)$ plays the role of infinity.

Could a boundary condition at $r = r'_{max} = a \cdot r_S$ (i.e. with some scale factor a) instead of $r = \infty$ yield such?



(My apologies for swapping the inner/outer colours in the image...)

Geometric inflation of *zero space* around M to *illusionary* nonzero space would also apply to the body's surface, as perceived in the outer frame.

Lorentz contraction $=$ gradual transition from outer to inner frame, as perceived by falling victim while his velocity increases.

In outer frame: $\forall(r \geq r_S)$: $\rho := \frac{r}{r_S} \in [1, \infty]$

in inner frame: $\forall(r' \leq r'_{max})$: $\rho' := \frac{r'}{r'_{max}} \in [0, 1]$

Conversion might be like:

$$\boldsymbol{\rho'} = \sqrt{1 - \frac{1}{\boldsymbol{\rho}}} \quad \Leftrightarrow \quad \boldsymbol{\rho} = \frac{1}{1-(\boldsymbol{\rho'})^2}$$

☹ I did not explicitly verify this against the Einstein equation ☹

but it essentially is Schwarzschild's solution thereof

and it properly converts both end points:

nearest: $(r \searrow r_S) \Leftrightarrow (r' \searrow 0)$

farthest: $(r \nearrow \infty) \Leftrightarrow (r' \nearrow r'_{max})$

outer frame: distance ranges from: > 0 to ∞

inner frame: proximity ranges from: ∞ to > 0.

Please take good notice:

INner frame concerns ***OUTside*** of event horizon.

Inside event horizon is a **meaningless concept**;
geometrically, it contains ***nothing spatial***
and *not even that*.

The entire Schwarzschild sphere *IS* the origin of the frame!

BANG! GOTCHA!

https://en.wikipedia.org/wiki/Two-body_problem_in_general_relativity#Effective_radial_potential_energy:

Effective radial potential energy:

$$U(r) = -\frac{GMm}{r} + \frac{L^2}{2\mu r^2} - \frac{G(M+m)L^2}{c^2\mu r^3} = -\frac{G\mathcal{M}\mu}{r} + \frac{L^2}{2\mu r^2}\left(1 - \frac{2G\mathcal{M}}{rc^2}\right)$$

(where: $\mathcal{M} = M + m,\ \mu = Mm/\mathcal{M}$)

Specif. ang. mom.: $\mathcal{L} = L/\mu$

Einsteinian potential: $V_\mathrm{E}(r) = \frac{U(r)}{\mu} = -\frac{G\mathcal{M}}{r} + \frac{\mathcal{L}^2}{2r^2} \cdot \left(1 - \frac{2G\mathcal{M}}{rc^2}\right)$

Newtonian: $V_\mathrm{N}(r) = -\frac{G\mathcal{M}}{r} + \frac{\mathcal{L}^2}{2r^2}$

Note: $\mathcal{L}_\mathrm{E} = \mathcal{L}_\mathrm{N} \cdot \sqrt{1 - \frac{2G\mathcal{M}}{rc^2}}$ (due to grav. contr. of radius).

If $\boldsymbol{\mathcal{L} = 0}$: $\boldsymbol{V_\mathrm{E}(r) = V_\mathrm{N}(r)}$

For an exactly radial free fall, the *Einsteinian* effective gravitational potential equals the *Newtonian* potential.

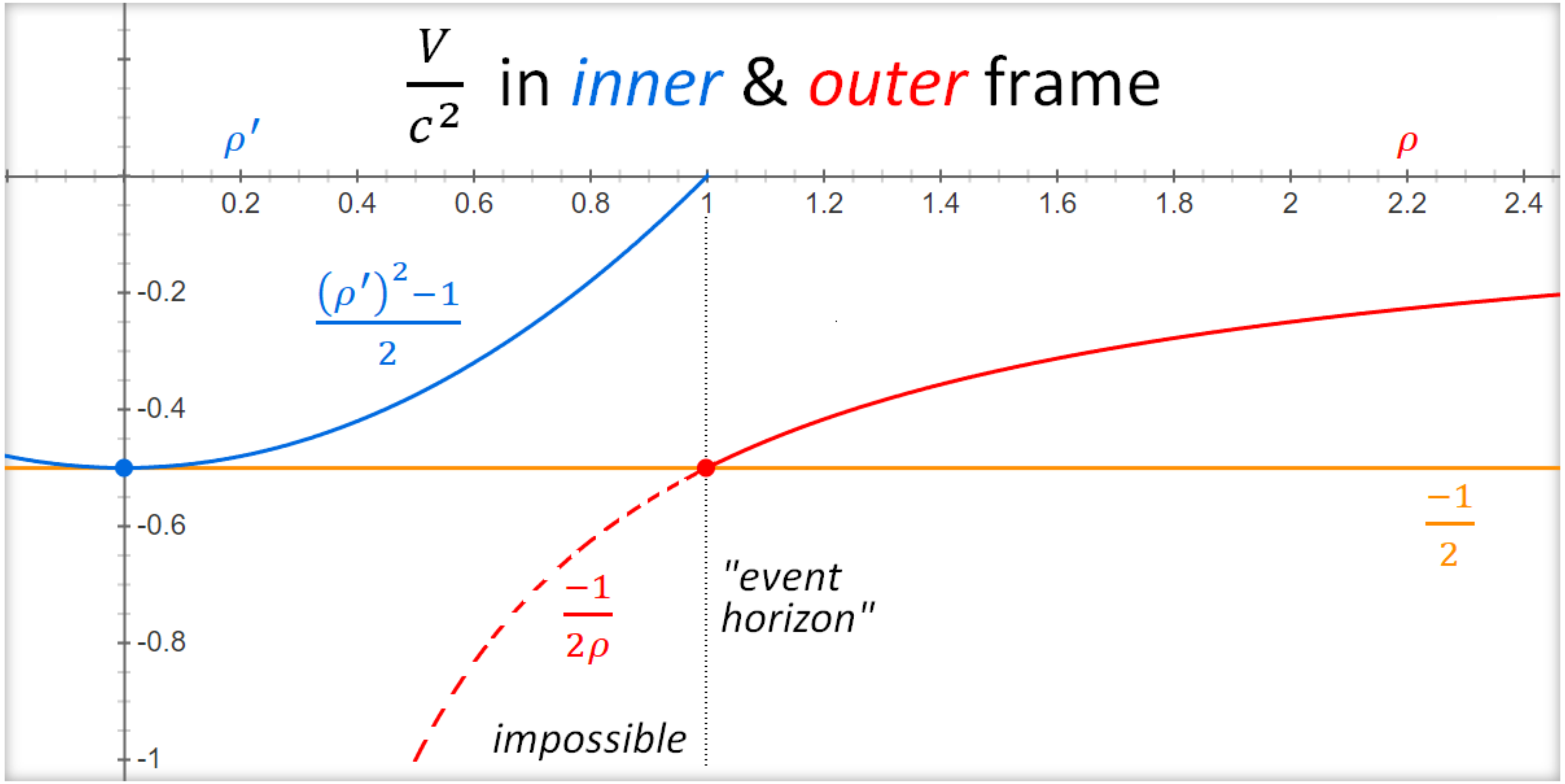
We have: $$\rho' = \sqrt{1 - \frac{1}{\rho}}$$

hence: $$\rho = \frac{1}{1-(\rho')^2}$$

Gravitational potential: $$\frac{V}{c^2} = \frac{-GM}{c^2 r} = \frac{-r_S}{2r} = \frac{-1}{2\rho}$$

in inner frame: $$\frac{V}{c^2} = \frac{(\rho')^2 - 1}{2}$$

Gravitational potential:



ρ' in the *inner frame* definitely does ***not*** describe inside of event horizon, which would have $\rho < 1$ in *outer frame*. Both frames span entire cosmos.

Inner frame **has quadratic potential well, cf. harmonic oscillator.**

As perceived by freely falling victim:

dimensionless distance yet to go until collision:

$$\varrho = \rho \cdot \sqrt{1 - \frac{1}{\rho}} = \sqrt{\rho^2 - \rho}$$

ρ = rho, ϱ has a curly tail & I pronounce it "crho".

We have: $\varrho = \sqrt{\rho^2 - \rho}$

hence: $\rho^2 - \rho - \varrho^2 = 0 \;\therefore\; \rho = \frac{1 \pm \sqrt{1+4\varrho^2}}{2}$

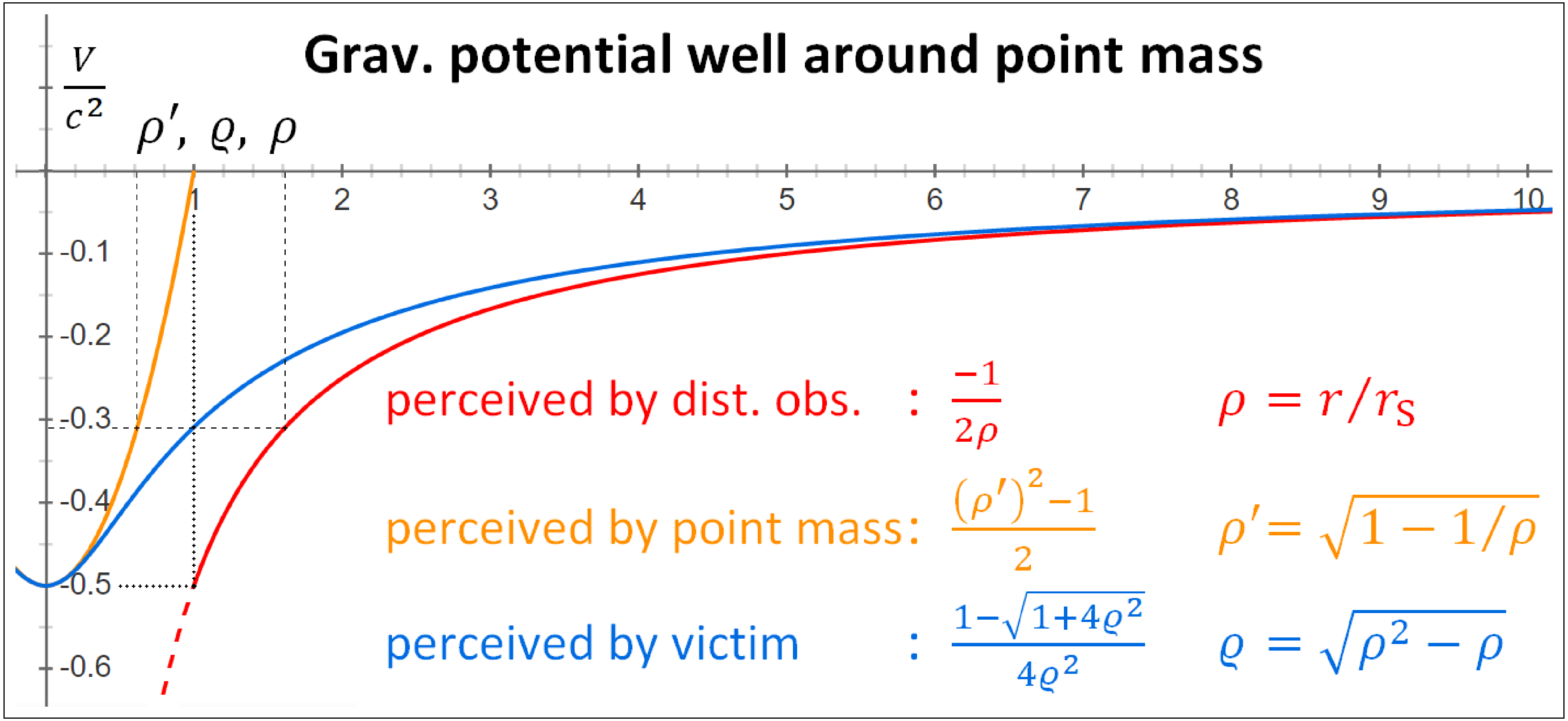
$\rho \geq 1 \;\therefore \qquad \boldsymbol{\rho = \frac{1+\sqrt{1+4\varrho^2}}{2}}$

Gravitational potential: $\frac{V}{c^2} = \frac{-GM}{c^2 r} = \frac{-r_S}{2r} = \frac{-1}{2\rho}$

$$= \frac{-1}{1+\sqrt{1+4\varrho^2}} \cdot \frac{1-\sqrt{1+4\varrho^2}}{1-\sqrt{1+4\varrho^2}}$$

$$\boldsymbol{\frac{V}{c^2} = \frac{1-\sqrt{1+4\varrho^2}}{4\varrho^2}}$$

as perceived by victim, i.e. on the spot.



$0 \leftarrow \varrho \lesssim \frac{1}{3}$: $\frac{1-\sqrt{1+4\varrho^2}}{4\varrho^2} = \frac{\varrho^2-1}{2} + \mathcal{O}(\varrho^4) \rightarrow$ *inner frame* (now orange)

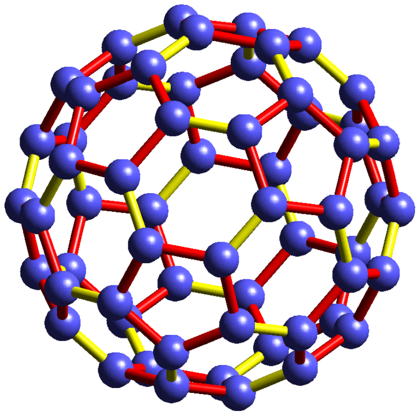
$\varrho \rightarrow \infty$: $\frac{1-\sqrt{1+4\varrho^2}}{4\varrho^2} = \frac{-1}{2\varrho} + \mathcal{O}\left(\frac{1}{\varrho^2}\right) \rightarrow$ *outer frame*

Gold: $\frac{V(\boldsymbol{\rho}=\mathbf{1})}{V(\boldsymbol{\varrho}=\mathbf{1})} = \boldsymbol{\varphi}$ $\quad V\left(\rho' = \frac{\mathbf{1}}{\boldsymbol{\varphi}}\right) \equiv V(\varrho = \mathbf{1}) \equiv V(\rho = \boldsymbol{\varphi}) \equiv \frac{-c^2}{2} \cdot \frac{\mathbf{1}}{\boldsymbol{\varphi}}$

Golden Ratio is nothing my{st|th}ical;

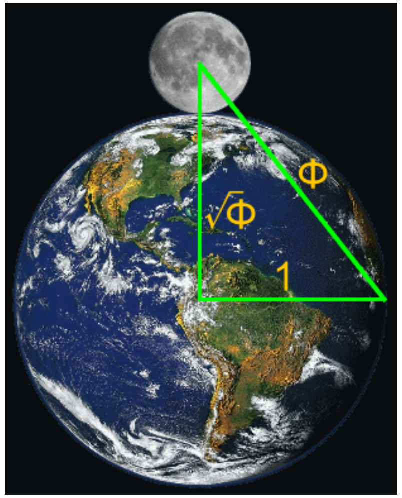
it is nowhere necessary as an input premise

(unless you want to give a lecture about it), but:



When I am working on a problem, I never think about beauty, but when I have finished, if the solution is not beautiful, I know it is wrong.

Richard Buckminster Fuller



$$\left(\frac{R_{\oplus}+R_{\leftmoon}}{R_{\oplus}}\right)^2 = \left(\frac{6371.0+1737.4}{6371.0}\right)^2 = (1.27270)^2 \approx 1.00107\varphi$$

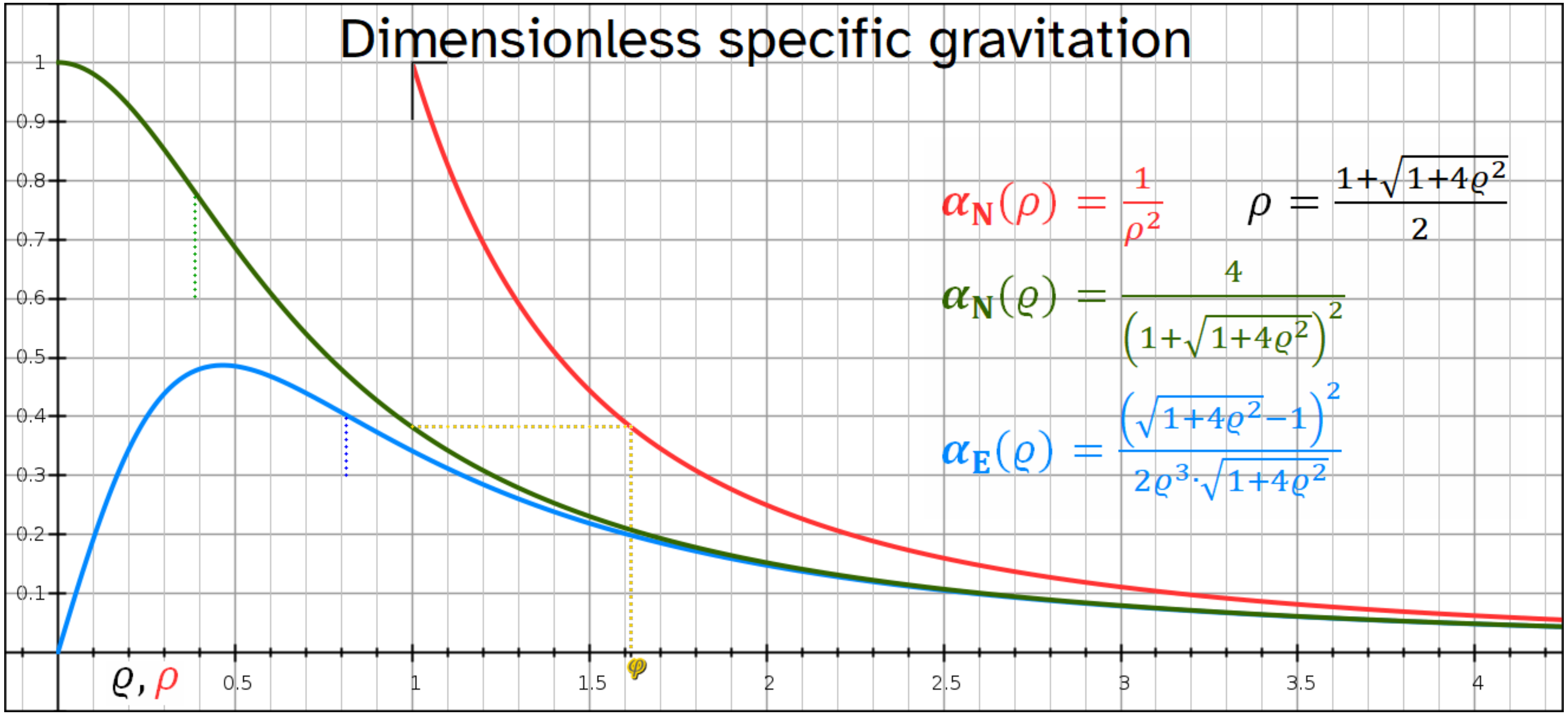
Earth & moon nearly form a Kepler triangle!

Dimensionless potential: (upsilon): $\Upsilon := \frac{V}{\frac{1}{2}c^2} = \frac{1-\sqrt{1+4\varrho^2}}{2\varrho^2}$

Specific gravitation (i.e. $\frac{F}{m} = a = g$): $\alpha_E = \frac{d\Upsilon}{d\varrho} = \frac{\left(\sqrt{1+4\varrho^2}-1\right)^2}{2\varrho^3\cdot\sqrt{1+4\varrho^2}}$

Newtonian: $\alpha_N = \frac{1}{\rho^2}$

$$g_E = \frac{GM\left(\sqrt{(GM)^2+r^2c^4}-GM\right)^2}{r^3c^2\sqrt{(GM)^2+r^2c^4}}$$



max. @~0.465 ≈ 0.487, flex. @~0.818 ≈ 0.401; flex. @ $\left[\left(\sqrt{6\sqrt{21}-6}\right)/12 \approx 0.386\right] = 6\left(17-3\sqrt{21}\right)/25 \approx 0.781$

For $\varrho \lesssim \frac{1}{3}$:

☞ specific gravitation (= victim's acceleration) approaches zero;

☞ consistent with aforementioned impact at *speed of light*.

Innermost **S**table **C**ircular **O**rbit:

perceived by:

distant observer:	ρ	$= 3$	$= 3$
victim:	$\varrho = \sqrt{\rho^2 - \rho}$	$= \sqrt{2 \cdot 3}$	≈ 2.4495
BH's centre:	$\rho' = \sqrt{1 - 1/\rho}$	$= \sqrt{2/3}$	≈ 0.8165

Marginally **B**ound **O**rbit (unstable):

distant observer:	ρ	$= 2$	$= 2$
victim:	ϱ	$= \sqrt{2}$	≈ 1.4142
BH's centre:	ρ'	$= \frac{1}{2}\sqrt{2}$	≈ 0.7071

Photon **S**phere:

distant observer:	ρ	$= \frac{1}{2} \cdot 3$	$= 1.5$
victim:	ϱ	$= \frac{1}{2}\sqrt{3}$	≈ 0.8660
BH's centre:	ρ'	$= \frac{1}{3}\sqrt{3}$	≈ 0.5774

Inner frame has *finite edge of universe*,
but only as observed from $\boldsymbol{\rho}' \equiv$ **exactly zero**.

For victim, infinity will not be contracted
to finitude before $\varrho \equiv 0$ is a reality;

unachievable if BH's core has any size > 0,
which thus avoids discontinuity (singularity).

Consistent with Heisenberg's uncertainty principle,
which essentially also says zero is unattainable.

Newtonian gravitational potential at r_S:

$$V = \frac{-GM}{r_S} = \frac{-\,\cancel{GM}\,c^2}{2\,\cancel{GM}},$$

i.e. independent of the central mass,

hence each and every mass (say a non-decaying neutron) freely falling from $r = \infty$ & $v_\infty = 0$ would impinge with:

$E_k = \frac{1}{2} m_n c^2$, which would become: $\frac{3}{2} k_B T$ (or $\frac{5}{2} k_B T$ if enthalpy);

⇒ **black hole core temperature** would be:

$$T_{bhc} = \frac{2\left(\frac{1}{2} m_n c^2\right)}{3 k_B} \approx 3.63 \times 10^{12}\ \mathrm{K} \quad \text{(or 2.2 TK)},$$

which is half the T where $E_{therm} = E_{rest}$ (cf. Hagedorn temperature).

This T_{bhc} would be an upper limit: impact yields way less until M has become a BH, but it might be approached in SMBHs.

It would imply: $\lim_{M\to\infty} M_{obs} = \frac{3}{2} M_{cold}$.

Newtonian: impact on event horizon would be at speed of light with kinetic energy: $E_{\mathrm{k,N}} = \frac{1}{2}mc^2$.

Relativistic kinetic energy: $E_{\mathrm{k,r}} = (\gamma - 1)mc^2$

should be same: $\therefore \boldsymbol{\gamma = \frac{3}{2} \therefore \beta_{\mathrm{imp}} = \frac{1}{3}\sqrt{5} \approx 0.745}$,

which would be the **maximum impact velocity**

(relative to both BH and stationary observer at infinity:

$$\boldsymbol{\beta_{\mathrm{vict,BH}}} = \frac{\beta_{\mathrm{vict,dist}} - (\beta_{\mathrm{dist,BH}} = 0)}{1 - \beta_{\mathrm{vict,dist}}\beta_{\mathrm{dist,BH}}} = \boldsymbol{\beta_{\mathrm{vict,dist}}}).$$

More energy is not available.

$$\boldsymbol{\rho = 1 \rightarrow \varrho = 0 = \text{impact } @\gamma^{-1} = \frac{2}{3}}$$

is it at all possible that a body is smaller than $\frac{2}{3}r_{\mathrm{S}}$?

Who told you the event horizon is passed at the very speed of light?

Isn't that uncome-at-able?

In a finite-depth potential well, there is not enough energy.

Albert Einstein: Zur Elektrodynamik bewegter Körper.

On the electrodynamics of moving bodies. Annalen der Physik, 17 (1905), 891–921; @p.920:

$$W = \int \varepsilon X \, dx = \int_0^v \beta^3 v \, dv = \mu V^2 \left\{ \frac{1}{\sqrt{1 - \left(\frac{v}{V}\right)^2}} - 1 \right\}.$$

W wird also für $v = V$ unendlich groß. Überlichtgeschwindigkeiten haben — wie bei unseren früheren Resultaten — keine Existenzmöglichkeit.

Auch dieser Ausdruck für die kinetische Energie muß dem oben angeführten Argument zufolge ebenso für ponderable Massen gelten.

$$E_\mathrm{k} = mc^2 \left\{ \frac{1}{\sqrt{1 - (v/c)^2}} - 1 \right\} = \gamma mc^2 - mc^2$$

becomes infinite if $v = c$, hence superluminality cannot exist.

∴ infinite energy required to acquire *speed of light*.

But see also: http://henk-reints.nl/astro/HR-grav-contr-eq-Newsteinian-Lorentz.pdf

Newtonian escape velocity:

$$E_{\mathrm{k}} + E_{\mathrm{p}} = 0 \therefore \frac{1}{2} m v^2 + m V = 0 \therefore \frac{1}{2} m v_{\mathrm{esc}}^2 = m \frac{GM}{r} \therefore \boldsymbol{v}_{\mathbf{esc}} = \sqrt{\frac{\mathbf{2}\boldsymbol{GM}}{\boldsymbol{r}}}$$

independent of the *direction* of the velocity

(unless you shoot your own foot… ☺).

Newtonian: free fall velocity ≡ escape velocity,

but how can $v_{\mathrm{ff}} = v_{\mathrm{esc}}$ when $v_{\mathrm{esc}} = c$?

$\boldsymbol{v}_{\mathbf{ff}} = \boldsymbol{v}_{\mathbf{esc}} = \boldsymbol{c}$ **at** $\boldsymbol{r} = \boldsymbol{r}_{\mathbf{S}}$

is Newtonian, haphazardly put

on top of Schwarzschild solution;

it cannot have been *derived* from it.

Correct free fall velocity:

gravitational potential (New/Ein): $\frac{E_{\text{pot}}}{m} = \frac{-c^2}{2\rho}$

specific kinetic energy (Ein): $\frac{E_{\text{kin}}}{m} = (\gamma - 1)c^2$

conservation of energy (≡ Eq.Pr.!): $E_{\text{kin}} + E_{\text{pot}} = 0$

therefore: $(\gamma - 1)c^2 - \frac{c^2}{2\rho} = 0 \therefore \gamma = 1 + \frac{1}{2\rho}$

rendering: $\gamma = \frac{2\rho+1}{2\rho} \therefore \gamma^2 = \frac{4\rho^2+4\rho+1}{4\rho^2} \therefore \gamma^2 - 1 = \frac{4\rho+1}{4\rho^2}$

We also have: $\frac{1}{\gamma} = \sqrt{1-\beta^2} \therefore \beta = \sqrt{1 - \frac{1}{\gamma^2}} = \sqrt{\frac{\gamma^2-1}{\gamma^2}}$

⇒ **free fall velocity:** $\boldsymbol{\beta_{\text{ff}}} = \sqrt{\frac{4\rho+1}{4\rho^2+4\rho+1}} = \sqrt{\frac{4\rho+1}{(2\rho+1)^2}} = \boldsymbol{\frac{\sqrt{4\rho+1}}{2\rho+1}}$

as well as: $\boldsymbol{\gamma_{\text{ff}} = \frac{2\rho+1}{2\rho} = 1 + \frac{1}{2\rho}}$ $\rho = 1 \rightarrow \gamma = \frac{3}{2}$

We also find: $\lim_{\rho\to\infty}(\beta_{\text{ff}}) = \frac{1}{\sqrt{\rho}}$ = Newtonian

Equivalence principle implies **grav. time stretching & length contraction**

should be by $\boldsymbol{\gamma_{\text{ff}} = (1 + 2\rho)/2\rho}$ and not by $1/\sqrt{1 - 1/\rho}$.

It must be that the true radius of a BH,
as measured on the spot, equals $\frac{2}{3}r_S$.

It cannot be smaller, since, as shown/derived in
http://henk-reints.nl/astro/HR-Schwarzschild-interior.pdf,
it has an internal expansive pressure that exceeds the compressive external pressure, so it is internally blown up.

This implies:

- a true point mass cannot ever exist;
  it merely is a (very useful) mathematical concept;
- the stuff derived further above is not correct;
  I should have used the just derived γ_{ff} , but as for now,
  I'll leave it as is, i.e. valid for the just denied point mass.

The photon sphere is locally contracted to $\frac{2\cdot(3/2)}{1+2\cdot(3/2)}\cdot\frac{3}{2}=\frac{9}{8}$.

Dimensionless: $\sigma \coloneqq \frac{s}{r_S}, \quad \rho \coloneqq \frac{r}{r_S}, \quad \tau \coloneqq \frac{ct}{r_S}$

Schwarzschild factor squared: $\xi^2 \coloneqq \frac{1}{1-\frac{1}{\rho}} = \frac{\rho}{\rho-1} \qquad = 1 + \frac{1}{\rho} + \frac{1}{\rho^2} + \mathcal{O}\left(\frac{1}{\rho^3}\right)$

Free fall Lorentz factor sq'd: $\gamma_{\text{ff}}^2 = \left(\frac{2\rho+1}{2\rho}\right)^2 = \left(1 + \frac{1}{2\rho}\right)^2 \quad = 1 + \frac{1}{\rho} + \frac{1}{\mathbf{4}\rho^2}$

Schwarzschild reciprocal: $\frac{1}{\xi^2} = \frac{\rho-1}{\rho} \qquad = 1 - \frac{1}{\rho}$

Lorentz reciprocal: $\frac{1}{\gamma_{\text{ff}}^2} = \left(\frac{2\rho}{2\rho+1}\right)^2 \qquad = 1 - \frac{1}{\rho} + \frac{3}{4\rho^2} + \mathcal{O}\left(\frac{1}{\rho^3}\right)$

?? should we replace ξ^2 with γ_{ff}^2 in the Schwarzschild equation**???**

?? i.e. instead of: $d\sigma^2 = \frac{\rho-1}{\rho}\, d\tau^2 - \frac{\rho}{\rho-1}\, d\rho^2 + \cdots$

?? it would be: $d\sigma^2 = \left(\frac{2\rho}{2\rho+1}\right)^2 d\tau^2 - \left(\frac{2\rho+1}{2\rho}\right)^2 d\rho^2 + \cdots$

Über das Gravitationsfeld eines Massenpunktes nach der EINSTEINschen Theorie.

Von K. SCHWARZSCHILD.

(...)

Das läßt sich unmittelbar integrieren und gibt

$$c'')\quad \frac{1}{f_4}\frac{\partial f_4}{\partial x_1} = \alpha f_1\,, \qquad (\alpha \text{ Integrationskonstante})$$

(...) so ergibt sich das Linienelement, welches die strenge Lösung des EINSTEINschen Problems bildet:

$$ds^2 = (1-\alpha/R)dt^2 - \frac{dR^2}{1-\alpha/R} - R^2(d\vartheta^2 + \sin^2\vartheta\, d\phi^2),\; R = (r^3+\alpha^3)^{1/3}. \quad (14)$$

Dasselbe enthält die eine Konstante α, welche von der Größe der im Nullpunkt befindlichen Masse abhängt.

Schwarzschild published:

$$ds^2 = (1 - \alpha/R)dt^2 - \frac{dR^2}{1-\alpha/R} - R^2(d\vartheta^2 + \sin^2\vartheta\, d\phi^2), \quad R = (r^3 + \alpha^3)^{1/3}$$

("t" should be read: "ct")

In the std. BH eqn., one equates $\alpha = r_S$ and $R = r$.

The latter seems however completely wrong if $r \to \alpha$.

We have: $dR = \frac{1}{3}(r^3 + \alpha^3)^{-2/3} \cdot 3r^2 dr = \frac{r^2 dr}{(r^3+\alpha^3)^{2/3}} \therefore dR^2 = \frac{r^4 dr^2}{(r^3+\alpha^3)^{4/3}}$

and: $1 - \frac{\alpha}{R} = 1 - \frac{\alpha}{(r^3+\alpha^3)^{1/3}} = \frac{(r^3+\alpha^3)^{1/3} - \alpha}{(r^3+\alpha^3)^{1/3}}$

hence: $ds^2 = \frac{(r^3+\alpha^3)^{1/3} - \alpha}{(r^3+\alpha^3)^{1/3}} dt^2 - \frac{(r^3+\alpha^3)^{1/3}}{(r^3+\alpha^3)^{1/3} - \alpha} \cdot \frac{r^4 dr^2}{(r^3+\alpha^3)^{4/3}} - (r^3 + \alpha^3)^{2/3} d\$^2$

or: $ds^2 = \frac{(r^3+\alpha^3)^{1/3} - \alpha}{(r^3+\alpha^3)^{1/3}} dt^2 - \frac{r^4}{(r^3+\alpha^3)\left[(r^3+\alpha^3)^{1/3} - \alpha\right]} dr^2 - (r^3 + \alpha^3)^{2/3} d\$^2$

***THIS* would be the true Schwarzschild solution.**

wobei die Hilfsgröße

$$R = (3x_1 + \rho)^{1/3} = (r^3 + \alpha^3)^{1/3}$$

eingeführt ist.

"where the ***auxiliary*** quantity $\boldsymbol{R = \sqrt[3]{r^3 + \alpha^3}}$ has been introduced".

$$(r = \alpha = r_S) \rightarrow R = r_S\sqrt[3]{2} \approx 1.26 r_S$$

MIGHT this be a minimal distance instead of the ISCO?

In the standard BH equation, this R is interpreted as the distance to M as measured by a distant observer.

However, the std. BH eqn. does *not match observations*.

Via grav. waves, we *DO* observe impacts in a finite time!

Fieri debet ne argumentum inductionis tollatur per hypothefes.

One should not gainsay observed phenomena with a flawed equation.

Should use $\boldsymbol{r}$ instead of $\boldsymbol{R}$ as the perceived distance to $\boldsymbol{M}$.

We found: $ds^2 = \frac{(r^3+\alpha^3)^{1/3}-\alpha}{(r^3+\alpha^3)^{1/3}} dt^2 - \frac{r^4 dr^2}{(r^3+\alpha^3)[(r^3+\alpha^3)^{1/3}-\alpha]} - (r^3+\alpha^3)^{2/3} d\$^2$

With: $\sigma := s/\alpha\ ,\ \tau := t/\alpha\ ,\ \rho := r/\alpha\ ,$ as well as: $\alpha = 2GM/c^2$

we obtain: $\boldsymbol{d\sigma^2 = A d\tau^2 - \frac{d\rho^2}{B} - C d\$^2}$

where: A: $\frac{(\rho^3+1)^{1/3}-1}{(\rho^3+1)^{1/3}} = \mathbf{1 - \frac{1}{\rho}} + \frac{1}{3\rho^4} - \frac{2}{9\rho^7} + \mathcal{O}\left(\frac{1}{\rho^8}\right)$

and: B: $\frac{(\rho^3+1)\left[(\rho^3+1)^{1/3}-1\right]}{\rho^4} = \mathbf{1 - \frac{1}{\rho}} + \frac{4}{3\rho^3} - \frac{1}{\rho^4} + \mathcal{O}\left(\frac{1}{\rho^5}\right)$

as well as: C: $(\rho^3+1)^{2/3} = \boldsymbol{\rho^2} + \frac{2}{3\rho} - \frac{1}{9\rho^4} + \mathcal{O}\left(\frac{1}{\rho^5}\right)$

The factors in the standard black hole equation are not exact!

$\rho = 1 \quad \Rightarrow \quad$ Schw.: $\{A: (\sqrt[3]{2}-1)/\sqrt[3]{2},\ B: 2(\sqrt[3]{2}-1),\ C: \sqrt[3]{4}\}$ vs. std.: $\{A: 0,\ B: 0,\ C: 1\}$

Hasn't that so called singularity been derived from this flawed equation?

Ex falso sequitur quod libet.

NOTE: my own version also has a different series expansion ☹,
but I deduced it from what I consider ascertained truths (pg. 37).
☹ Could either the Schw. soln. or even the Einstein eqn. be flawed? ☹

My version *DOES* agree with observations (see further below).

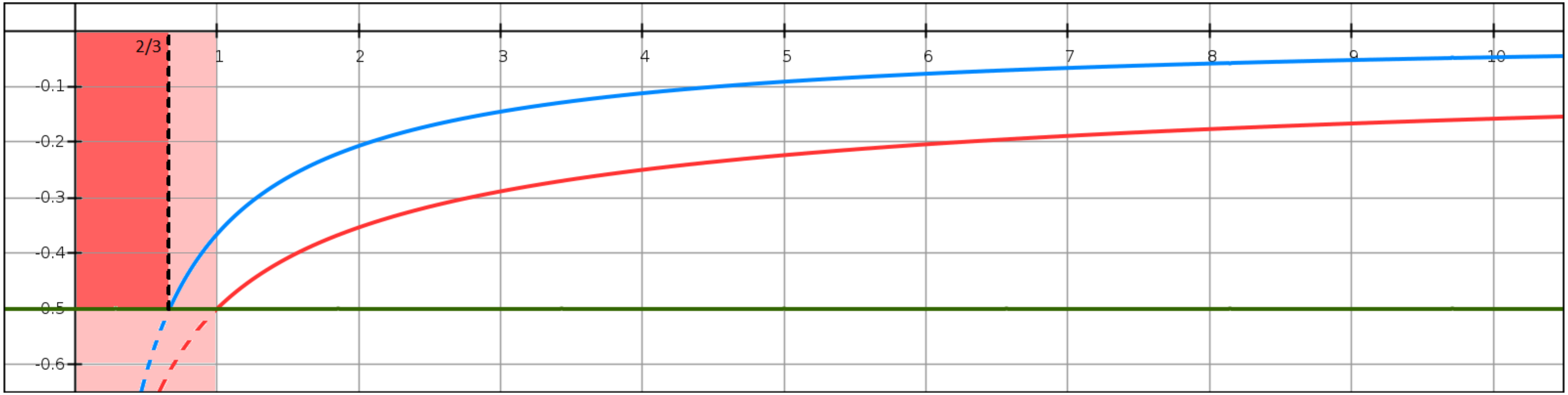
Distance perceived by victim: $\varrho = \rho \cdot \sqrt{1 - \frac{1}{\rho}}$

should have been: $\varrho = \rho \cdot \frac{2\rho}{1+2\rho}$

yielding: $2\rho^2 - 2\varrho\rho - \varrho = 0$

hence: $\rho = \frac{2\varrho \pm \sqrt{4\varrho^2+8\varrho}}{4} = \frac{\varrho + \sqrt{\varrho^2+2\varrho}}{2}$

therefore: $\frac{V}{c^2} = \frac{-1}{2\rho} = \frac{-1}{\varrho+\sqrt{\varrho^2+2\varrho}}$



Various free fall velocities to point mass:

Victim:

$$E_\mathrm{k} = (\gamma - 1)mc^2 = -mV(\varrho) = mc^2 \cdot \frac{\sqrt{1+4\varrho^2}-1}{4\varrho^2} \therefore \gamma(\varrho) = \frac{4\varrho^2+\sqrt{1+4\varrho^2}-1}{4\varrho^2}$$

sees BH approach at: $$\boldsymbol{\beta(\varrho)} = \sqrt{1-\frac{1}{\gamma^2}} = \sqrt{\frac{(8\varrho^2-2)\sqrt{1+4\varrho^2}-20\varrho^2+7}{(4\varrho^2-3)^2}}$$

gets hit by M at: $$\beta(\varrho = 0) = \sqrt{5}/3 \approx 0.7454$$

Newton:

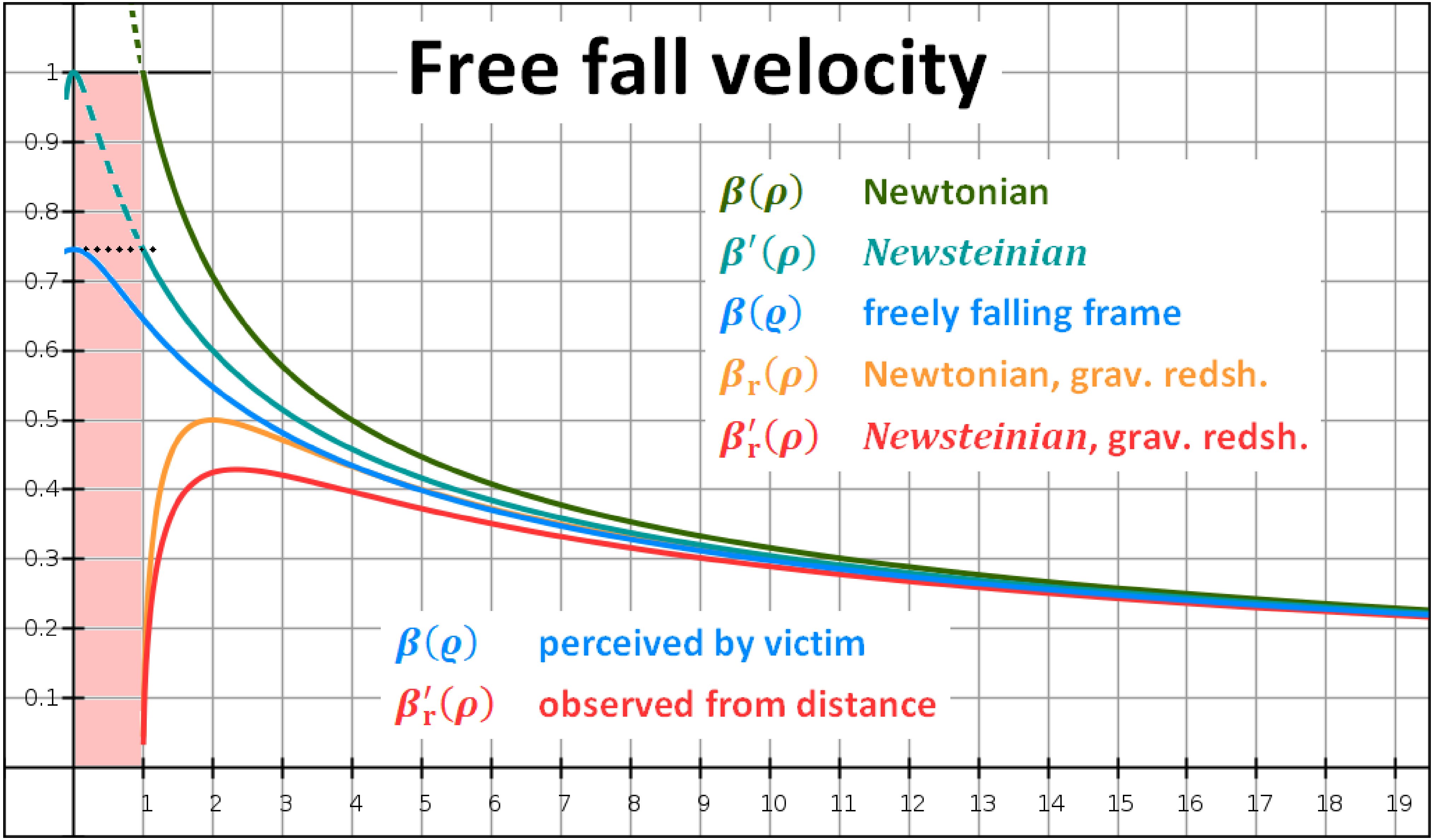
$$E_\mathrm{k} = \frac{mv^2}{2} = -mV(\rho) = \frac{mc^2}{2\rho} \quad \therefore \boldsymbol{\beta(\rho)} = \frac{1}{\sqrt{\rho}}$$

grav. redshifted: $$\beta_\mathrm{r}(\rho) = \beta(\rho) \cdot \sqrt{1-\frac{1}{\rho}} \quad \therefore \boldsymbol{\beta_\mathrm{r}(\rho)} = \sqrt{\frac{\rho-1}{\rho^2}}$$

Newstein:

$$(\gamma - 1)mc^2 = -mV(\rho) = \frac{mc^2}{2\rho} \quad \therefore \boldsymbol{\beta'(\rho)} = \sqrt{\frac{4\rho+1}{(2\rho+1)^2}}$$

grav. redshifted: $$\beta'_\mathrm{r}(\rho) = \beta'(\rho) \cdot \sqrt{1-\frac{1}{\rho}} \quad \therefore \boldsymbol{\beta'_\mathrm{r}(\rho)} = \sqrt{\frac{4\rho^2-3\rho-1}{\rho(2\rho+1)^2}}$$


Free fall velocity
$\beta(\rho)$ Newtonian
$\beta'(\rho)$ *Newsteinian*
$\beta(\varrho)$ freely falling frame
$\beta_r(\rho)$ Newtonian, grav. redsh.
$\beta'_r(\rho)$ *Newsteinian*, grav. redsh.
$\beta(\varrho)$ perceived by victim
$\beta'_r(\rho)$ observed from distance
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19

Gravitational redshift:

https://en.wikipedia.org/wiki/Gravitational_redshift:

$$1 + z = \frac{\lambda_\infty}{\lambda_e} = \left(1 - \frac{r_S}{R_e}\right)^{-\frac{1}{2}}$$

$$1 + z = \gamma_e = \frac{1}{\sqrt{1 - \left(\frac{v_e}{c}\right)^2}}$$

https://astronomy.swin.edu.au/cosmos/g/Gravitational+Redshift:

$$1 + z = \frac{1}{\sqrt{1 - \frac{2GM}{rc^2}}}$$

So:

$$\frac{\nu_{obs}}{\nu_{em}} = \sqrt{1 - \frac{1}{\rho}} = \sqrt{1 - \beta_e^2}$$

"Schwarzschild factor":

$$\frac{1}{\sqrt{1-\frac{1}{\rho}}} = \sqrt{\frac{\rho}{\rho-1}}$$

is equivalent to Lorentz factor:

$$\gamma = \frac{1}{\sqrt{1-\beta^2}}$$

Redshift is however
by the *Doppler factor*:

$$\zeta = \sqrt{\frac{1+\beta}{1-\beta}},$$

not by the Lorentz factor!

See also:

http://henk-reints.nl/astro/HR-Redshift-and-equivalence-principle.pdf

If **Doppler redshift** and **gravitational redshift** would not yield the same, then ***acceleration*** and ***gravitation*** would be **distinguishable**, thus **undermining** the **equivalence principle**, one of the major foundations of GR!

http://henk-reints.nl/astro/HR-Equivalence-principle.pdf ⇒ Eq.Pr. = cons. of energy!

EITHER: $\frac{1}{\rho} \triangleq \beta^2 \therefore \beta \triangleq 1/\sqrt{\rho} \Rightarrow \frac{\nu_{\mathrm{obs}}}{\nu_{\mathrm{em}}} = \frac{E_{\mathrm{obs}}}{E_{\mathrm{em}}} = \sqrt{\frac{\rho-\sqrt{\rho}}{\rho+\sqrt{\rho}}}$

OR: $\frac{\nu_{\mathrm{obs}}}{\nu_{\mathrm{em}}} = \frac{E_{\mathrm{obs}}}{E_{\mathrm{em}}} = \sqrt{\frac{1-\beta_{Newstein}}{1+\beta_{Newstein}}} = \sqrt{\frac{2\rho+1-\sqrt{4\rho+1}}{2\rho+1+\sqrt{4\rho+1}}}$

yielding: $\beta_{\mathrm{obs}} = \sqrt{\frac{4\rho+1}{(2\rho+1)^2}} \cdot \sqrt{\frac{2\rho+1-\sqrt{4\rho+1}}{2\rho+1+\sqrt{4\rho+1}}}$

hence: $(\rho = 1) \Rightarrow \beta_{\mathrm{imp,obs}} = \frac{3\sqrt{5}-5}{6} \approx 0.2847$

2024-04-12: **I realised I made a severe mistake.**

Gravitational redshift does not need to equal
Doppler redshift corresponding to *free fall velocity*.

The latter arises because mutual distance, hence signal travel time, truly changes between successive events (i.e. emission of wave's next period occurs at another distance).

However , gravitational redshift applies when *stationary* in a gravitational field, i.e. the distance does *not* change.

Apples ≠ oranges, appels ≠ peren!

The ***properly working*** Global Positioning System has been corrected by the Schwarzschild root & not by some free fall Doppler factor.

Even I should not contradict facts of experience...

Fieri debet ne argumentum inductionis tollatur per hypothefes.

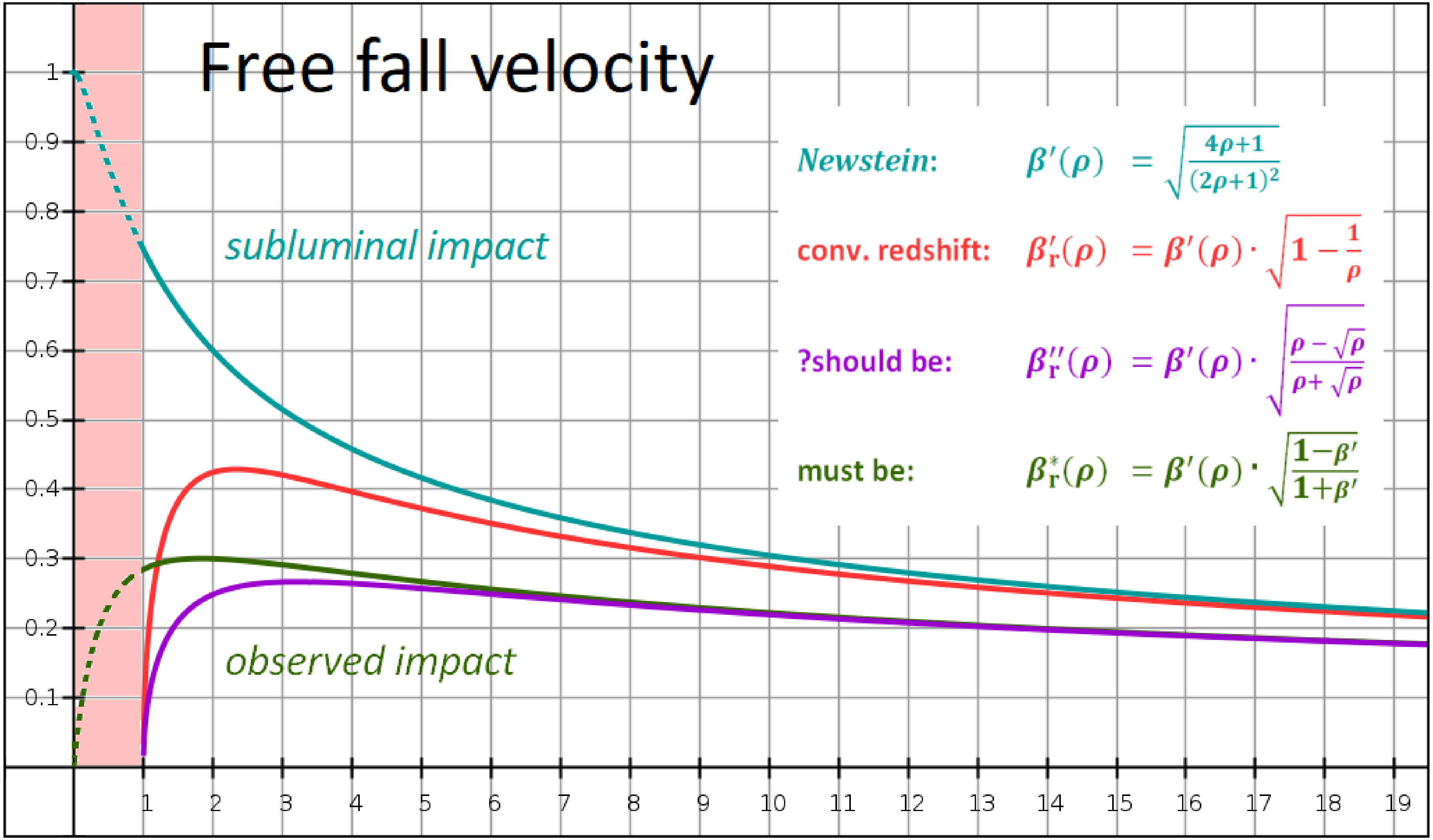
Please read *free fall* redshift instead of *gravitational* redshift everywhere below.

Newstein: $\beta'(\rho) = \sqrt{\dfrac{4\rho+1}{(2\rho+1)^2}}$

conv. redshift: $\beta'_{\mathrm{r}}(\rho) = \beta'(\rho)\cdot\sqrt{1-\dfrac{1}{\rho}} = \sqrt{\dfrac{4\rho+1}{(2\rho+1)^2}}\cdot\sqrt{\dfrac{\rho-1}{\rho}}$

?should be: $\beta''_{\mathrm{r}}(\rho) = \beta'(\rho)\cdot\sqrt{\dfrac{\rho-\sqrt{\rho}}{\rho+\sqrt{\rho}}} = \sqrt{\dfrac{4\rho+1}{(2\rho+1)^2}}\cdot\sqrt{\dfrac{\rho-\sqrt{\rho}}{\rho+\sqrt{\rho}}}$

must be: $\beta^{*}_{\mathrm{r}}(\rho) = \beta'(\rho)\cdot\sqrt{\dfrac{1-\beta'}{1+\beta'}} = \sqrt{\dfrac{4\rho+1}{(2\rho+1)^2}}\cdot\sqrt{\dfrac{2\rho+1-\sqrt{4\rho+1}}{2\rho+1+\sqrt{4\rho+1}}}$



Grav. waves ⇒ we *DO* observe impacts in finite time.

Sir Isaac Newton:

Fieri debet ne argumentum inductionis tollatur per hypotheſes.

Don't gainsay observed phenomena, no matter how clever you are!

Relativistic gravitational effects:

NOT: $1/\sqrt{1-2GM/rc^2} = 1/\sqrt{1-1/\rho} = 1 + 1/2\rho + \mathcal{O}(1/\rho^2)$

BUT: $\gamma_{\mathrm{ff}} = (2\rho+1)/2\rho = 1 + 1/2\rho$ **+ NOUGHT**

AND: $\beta_{\mathrm{ff}} = \frac{\sqrt{4\rho+1}}{2\rho+1}$ & $\frac{\nu_{\mathrm{obs}}}{\nu_{\mathrm{em}}} = \sqrt{\frac{1-\beta_{\mathrm{ff}}}{1+\beta_{\mathrm{ff}}}} = \sqrt{\frac{2\rho+1-\sqrt{4\rho+1}}{2\rho+1+\sqrt{4\rho+1}}}$

Substantiation:

☞ **conservation of energy,**

which is the very same as the

☞ **equivalence principle;**

☞ **we DO observe impacts!**

BUT... should we apply redshift to free fall velocity at all?

Isn't it a precondition of relativity that both observers continually agree on their mutual velocity?

If we apply free fall redshift to the free fall velocity, shouldn't we then be consistent and always apply it to any constant velocity as well?

Wouldn't that imply I will see you slow down with increasing velocity above some threshold?

Approaching Sweet Fanny Adams when speed of flight → speed of light?

Ex contradictione quodlibet!

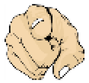
I see you hit the damn thing at (subluminal) Newsteinian velocity!

- I'm far away, radially stationary w.r.t. central mass M;
- M's velocity in my frame $= 0$;
- M's velocity in your frame $=$ your velocity in M's frame;
- your velocity in my frame $=$ your velocity in M's frame;
- your free fall velocity in M's frame $= (v > 0) \to c$.

A. Your velocity in my frame $\to 0$?
B. Your velocity in my frame $= v$?

Ex contradictione quodlibet!

I see you hit the damn thing at (subluminal) Newsteinian velocity!

YOU  fall into BH, towards event horizon:

($\beta_{X,Y} =$ speed of X w.r.t. Y, $\beta_{X,Y} < 0$ when approaching)

$$\beta_{BH,me} = \frac{\beta_{BH,you} + \beta_{you,me}}{1 + \beta_{BH,you}\beta_{you,me}}$$

$$\beta_{BH,me} + \beta_{BH,me}\beta_{BH,you}\beta_{you,me} = \beta_{BH,you} + \beta_{you,me}$$

$$\beta_{BH,me} - \beta_{BH,you} = \beta_{you,me} - \beta_{BH,me}\beta_{BH,you}\beta_{you,me}$$

$$\beta_{BH,me} - \beta_{BH,you} = \beta_{you,me}\left(1 - \beta_{BH,me}\beta_{BH,you}\right)$$

$$\beta_{you,me} = \frac{\beta_{BH,me} - \beta_{BH,you}}{1 - \beta_{BH,me}\beta_{BH,you}}$$

I am stationary w.r.t. the BH: $\beta_{BH,me} = 0$

so: $\beta_{you,me} = \frac{0 - \beta_{BH,you}}{1 - 0 \cdot (\beta_{BH,you} < \infty)} = -\beta_{BH,you} \neq 0$

$$\beta_{BH,you} \to -1 \therefore \beta_{you,me} \to 1 \neq 0$$

I CANNOT SEE YOU SLOW DOWN!

Free fall redshift: $\frac{\nu_{\text{obs}}}{\nu_{\text{em}}} = \sqrt{\frac{2\rho+1+\sqrt{4\rho+1}}{2\rho+1-\sqrt{4\rho+1}}}$

maximum: $(\rho = 1) \rightarrow \frac{\nu_{\text{obs}}}{\nu_{\text{em}}} = \sqrt{\frac{3+\sqrt{5}}{3-\sqrt{5}}} = 1 + \boldsymbol{\varphi} = \boldsymbol{\varphi}^2 \approx \mathbf{2.618}$

Max. impact velocity: $\boldsymbol{\beta}_{\mathbf{imp}} = \frac{\sqrt{5}}{3} \approx \frac{\mathbf{3}}{\mathbf{4}}$ = clearly subluminal escape velocity.

PRESUMED temperature: $T = T_{\text{Hag}} \approx$ 1.22 terakelvin

should radiate: $j^* = \sigma_{\text{SB}} T^4 > 1.266 \times 10^{41}$ W/m²

Sgr A*: $L = 4\pi r_S^2 j^* \approx 2.4 \times 10^{62}$ W

$\boldsymbol{\mathcal{M}}_{\mathbf{bol}} = -2.5 \log_{10} \frac{2.4\times10^{62}}{3.0128\times10^{28}} \approx \mathbf{-85}$

How come the thing appears black?

See: http://henk-reints.nl/astro/HR-truly-black-Black-Hole.pdf

Do you realize that if you fall towards what we erroneously call a black *hole*, the last part of your journey will take two thirds of the time as observed from a great distance and then you will hit the damn thing at three quarters of the *speed of light* and then you will go to smithereens and then your remains will be boiled at over one terakelvin and then people at a safe distance will start smiling?

Prof. Wotsy Snayme, R.I.P.[3]

[3] **R**ealistic **I**nvestigator of **P**ure science.

Do *space* and *time* swap inside a black hole?

"Inside a black hole"
is a meaningless concept,
so draw your own conclusion.

Ex falso sequitur quod libet.

Incompressibility of black hole's core.

Many of the following pages contain early conclusions made before I included the pages just presented (which take precedence in case of ambiguity).

From the Schwarzschild interior solution[4] follows a BH's internal pressure is homegeneous and expansive.

However, the reasoning below uses Newtonian grav. pressure inside a homogeneous sphere.

Target = substantiate incompressibility & get rid of that *silly fiction* of a SINGULARITY.

4 http://henk-reints.nl/astro/HR-Schwarzschild-interior.pdf

NOTE: (2023-10-05)

In the remainder of this document, I used:

$$P_D = \frac{3GM^2}{8\pi R^6}(R^2 - D^2) = \frac{3G\cdot 16\pi^2\rho^2}{8\pi\cdot 9}(R^2 - D^2) = \frac{2\pi G\rho^2}{3}(R^2 - D^2)$$

where: $R =$ radius of sphere, $\rho =$ hom. density, $D =$ distance to centre,

$$\rho = \frac{3M}{4\pi R^3} \therefore \frac{M}{R^3} = \frac{4\pi\rho}{3} \therefore \frac{M^2}{R^6} = \frac{16\pi^2\rho^2}{9}$$

for the **Newtonian gravitational pressure** inside an incompressible sphere.

In http://henk-reints.nl/HR-Gravitational-pressure-surface-tension.pdf

& http://henk-reints.nl/astro/HR-white-dwarf.pdf I explain this is **WRONG**.

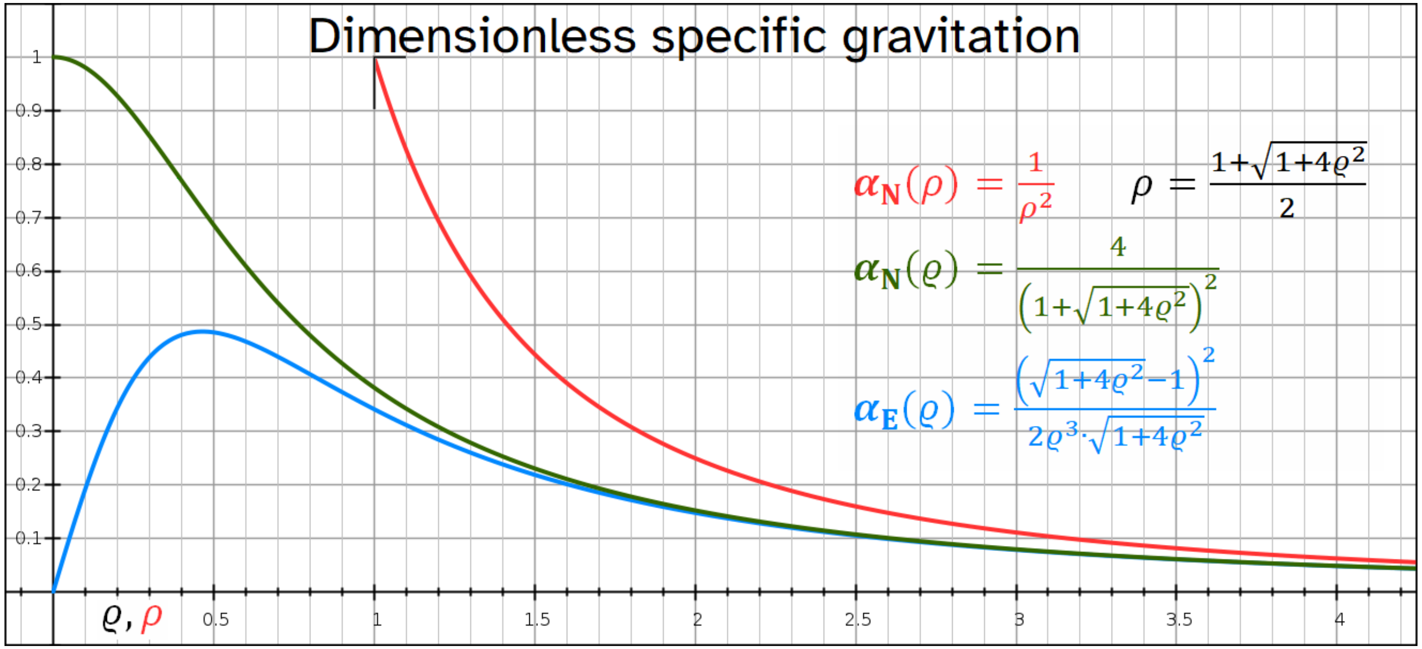
It should be:

$$P_D = \frac{2\pi G\rho^2}{3}(RD - D^2) = \frac{2\pi G\rho^2}{3}D(R - D)$$

yielding **ZERO** pressure at the very centre and a maximum (at $D = R/2$) of merely $1/4$ of what's shown below, allowing $2M$ for same $P_{\max}$.

Below, I have not yet made significant corrections.

Around a *point mass*, Einsteinian gravitation would become way less than Newtonian, which suggests Newtonian can be used as an upper limit in calculations/estimations.



Graph applies to gravity around a ***point mass***.

If *mass* were homogeneous within Schwarzschild sphere:

Schwarzschild density: $$\rho_S = \frac{M}{\frac{4\pi}{3} r_S^3} = \frac{3M}{4\pi\left(\frac{2GM}{c^2}\right)^3} = \frac{3c^6}{32\pi G^3} \cdot \frac{1}{\boldsymbol{M^2}}$$

Newtonian *gravitational pressure* at centre of homogeneous sphere: $$p_\heartsuit = \frac{2\pi G}{3}\rho^2 r^2 = \frac{3GM^2}{8\pi r^4}$$

At centre of BH: $$p_{S\heartsuit} = \frac{3GM^2}{8\pi r_S^4} = \frac{3GM^2}{8\pi\left(\frac{2GM}{c^2}\right)^4} = \frac{3c^8}{128\pi G^3 M^2} = \frac{c^2}{4}\rho_S$$

The smaller a BH's *mass*, the smaller of course its *gravitation*, but ***density*** (& gravitational *pressure*) would grow quadratically.

But by what could it be compressed?

⇒ There must exist some maximum density.

Mini & micro black holes are a fiction.

George Berkeley (1685-1753):

Esse est percipi.

To be is to be perceived.

HR: observation of an event :=
interaction that occurs
if and only if the event takes place.

exist := being observable, able to interact;

fact := a verifiabl{y|e} observed phenomenon;

reality := *all* that exists; the entirety of *all* facts
(i.e. observable & observed reality).

There exists no observational evidence of anything unobservable.

Physics is about reality & not about brainchildren.

"Existance postulate":

An entity cannot exist unless it is able to fully manifest all of its properties.

Based on common sense, essentially refines definition of exist.

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An entity having *mass* has at least two spatial properties: its *Schwarzschild radius* and its *Compton wavelength*.

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Based on common sense, essentially refines definition of exist.

∴ An entity having any spatial property requires a minimal amount of space in order to exist.

An entity having *mass* has at least two spatial properties: its *Schwarzschild radius* and its *Compton wavelength*.

∴ **A *mass* requires more than zero space in order to exist.**
We could (re)define ***size*** as this minimally required space.

Density = *mass* ÷ *volume;*

division by zero is impossible;

infinity is unattainable.

Physical limitlessness is not realistic;

it has never been observed.

<u>Conclusion:</u>

A *mass* must have a non-zero *size*.

Singularity: **mathematical qualification of a point where something is impossible.**

Impossible things cannot exist.

If even (abstract) mathematics does not yield a solution, then how can one presume it is something physical?

Physical singularities are a meaningless concept.

Something that "is" requires space;

⇒ matter cannot be compressible to zero *volume*;

⇒ there must exist some finite upper limit to *density*.

Newtonian *gravitational pressure*

at centre of homogeneous sphere: $p_{\heartsuit} = \frac{2\pi G}{3}\rho^2 r^2$

density of single neutron: $\rho_n = \frac{m_n}{\frac{4\pi}{3} r_n^3} \approx 7.8 \times 10^{17}$ kg/m^3

close-packed neutronium: $\rho_{n,cp} = \frac{\pi}{3\sqrt{2}}\rho_n \approx 5.8 \times 10^{17}$ kg/m^3

at this *density*: $\boldsymbol{r_{bh}} = \sqrt{3c^2/8\pi G\rho} = \mathbf{16.65\ km}$

neutron star: $p_{\heartsuit} = \frac{2\pi G}{3}(5.8 \times 10^{17}\ \mathrm{kg/m^3})^2(\mathbf{10\ km})^2 = 4.7 \times 10^{33}$ Pa

observed[5]: *pressure* inside proton $\approx 10^{35}$ Pa

never observed: any persistent *density* > single neutron

No observation to my knowledge suggests neutrons would be compressible to zero volume.

[5] Burkert, V.D., Elouadrhiri, L. & Girod, F.X. The pressure distribution inside the proton. *Nature* **557,** 396-399 (2018).

Suppose a sphere with *diameter* = *Compton wavelength*:

"*Compton volume*": $V_{\mathrm{C}} = \frac{4\pi}{3}\left(\frac{\lambda_{\mathrm{C}}}{2}\right)^3 = \frac{\pi}{6}\left(\frac{h}{mc}\right)^3$

"***Compton density***": $\boldsymbol{\rho_{\mathrm{C}} = \frac{m}{V_{\mathrm{C}}} = \frac{6c^3m^4}{\pi h^3}}$

Neutron: $2r_n \approx 1.6\ \mathrm{fm} = \varnothing_{\boldsymbol{n}} > \boldsymbol{\lambda_{\mathrm{C},n}} \approx 1.3196\ \mathrm{fm}$

in agreement with the "existance postulate";

no greater *density* than that of a neutron ever observed;

∴ arbitrary **POSSIBLE** value for upper density limit:

$$\boldsymbol{\rho_{\mathrm{C},n}} = \frac{6c^3m_n^4}{\pi h^3} \approx \mathbf{1.392 \times 10^{18}\ kg/m^3}$$

I do not claim this would be *the* fundamental upper density limit, it merely is a usable practical limit, but it *is* a constant of nature.

FEBRUARY 15, 1939 PHYSICAL REVIEW VOLUME 55

On Massive Neutron Cores

J. R. OPPENHEIMER AND G. M. VOLKOFF
Department of Physics, University of California, Berkeley, California

(Received January 3, 1939)

It has been suggested that, when the pressure within stellar matter becomes high enough, a new phase consisting of neutrons will be formed. In this paper we study the gravitational equilibrium of masses of neutrons, using the equation of state for a cold Fermi gas, and general relativity. For masses under $\frac{1}{3}\odot$ only one equilibrium solution exists, which is approximately described by the nonrelativistic Fermi equation of state and Newtonian gravitational theory. For masses $\frac{1}{3}\odot < m < \frac{3}{4}\odot$ two solutions exist, one stable and quasi-Newtonian, one more condensed, and unstable. For masses greater than $\frac{3}{4}\odot$ there are no static equilibrium solutions. These results are qualitatively confirmed by comparison with suitably chosen special cases of the analytic solutions recently discovered by Tolman. A discussion of the probable effect of deviations from the Fermi equation of state suggests that actual stellar matter after the exhaustion of thermonuclear sources of energy will, if massive enough, contract indefinitely, although more and more slowly, never reaching true equilibrium.

HR: black hole's core temperature may be over a terakelvin.

Ex falso sequitur quod libet.

(⋯)

If the matter supports no transverse stresses and has no mass motion, then its energy momentum tensor is given by[6]

$$T_1{}^1 = T_2{}^2 = T_3{}^3 = -p, \quad T_4{}^4 = \rho \tag{2}$$

where p and ρ are respectively the pressure and the macroscopic energy density measured in proper coordinates.

(⋯)

If the matter is taken to consist of particles of rest mass μ_0 obeying Fermi statistics, and their thermal energy[12] and all forces between them are neglected, then it may be shown that a parametric form for the equation of state is:[13]

$$\rho = K(\sinh t - t), \tag{11}$$

$$p = \tfrac{1}{3}K(\sinh t - 8 \sinh \tfrac{1}{2}t + 3t), \tag{12}$$

where $K = \pi \mu_0{}^4 c^5 / 4h^3$ (13)

and $$t = 4 \log \left(\frac{\hat{p}}{\mu_0 c} + \left[1 + \left(\frac{\hat{p}}{\mu_0 c} \right)^2 \right]^{\frac{1}{2}} \right), \tag{14}$$

where $\hat{p}$ is the maximum momentum in the Fermi distribution and is related to the proper particle density N/V by

$$\frac{N}{V} = \frac{8\pi}{3h^3} \hat{p}^3. \tag{15}$$

$$\Rightarrow t = 4 \operatorname{arsinh} \left(\frac{h}{\mu_0 c} \cdot \sqrt[3]{\frac{3}{8\pi} \cdot \frac{N}{V}} \right) =$$ measure of *particle density*.

$t = t_0$ at $r = 0.$

TABLE I. *Mass, radius and neutron density for various values of t_0.*

t_0	Mass: In units of Eqs. (18), (19)	Mass: In units of ⊙ for neutrons	Radius: In units of Eqs. (18), (19)	Radius: In kilometers, for neutrons	$\left(\frac{\hat{p}}{\mu_0 c}\right)_{r=0}$	$\left(\frac{N}{V}\right)_{r=0}$ Neutrons cm³
1	0.033	0.30	1.55	21.1	0.25	0.062×10^{39}
2	0.066	0.60	0.98	13.3	0.52	0.56×10^{39}
3	0.078	0.71	0.70	9.5	0.82	2.2×10^{39}
4	0.070	0.64	0.50	6.8	1.17	6.4×10^{39}
∞	0.037	0.34	0.23	3.1	∞	∞

6.4×10^{39} n/cm³ $\approx 1.1\times10^{19}$ kg/m³

$0.34\odot \approx 6.76\times10^{29}$ kg $\approx 4\times10^{56}$ n $(r_S \approx 1.0$ km$)$

$\Big/ \frac{4\pi}{3}(3.1\ \text{km})^3 \approx 9.6\times10^{40}$ n/cm³ $\approx 1.6\times10^{20}$ kg/m³

HR: PRESUMED maximum density: $\boldsymbol{\rho}_{\mathbf{C},\boldsymbol{n}} \approx 8.3\times10^{38}$ n/cm³ $\approx 1.4\times10^{18}$ kg/m³

O&V derived densities of $\sim\mathbf{8}\rho_{C,n}$ & $\sim\mathbf{115}\rho_{C,n}$

$\left(\frac{N}{V}\right)_{r=0} = \infty$ means they presumed proper neutron volume $= 0.$

Collapse of neutronium above TOV limit?

Collapse? O+V: (...) contract indefinitely, although more and more slowly, never reaching true equilibrium.

Relativity is about empty space & not about "inside" of elementary matter/particles

(considering baryons elementary for this purpose).

If neutrons would be not compressible to nought then only the empty space between them (i.e. the tare volume) can/will (more and more slowly) contract.

With a core at *neutron Compton density* the smallest possible black hole would be:

$$\boldsymbol{m_{bh,\rho_{C,n}}} = \sqrt{\frac{3c^6}{32\pi G^3 \rho_{C,n}}} \approx \mathbf{3.64 M_\odot} \qquad (\sim 5.65 M_\odot @ \rho_{n,cp})$$

$$\boldsymbol{\varnothing_{bh,\rho_{C,n}}} = 2 \cdot \sqrt{\frac{3c^2}{8\pi G \rho_{C,n}}} \approx \mathbf{21.5\ km} \qquad (\approx \frac{1594}{375}\pi\ \text{mi}).$$

No mini black holes, let alone micro.

Oppenheimer & Volkov: $t_0 \geq 3 \rightarrow r < 10.75$ km.

Hawking radiation:

$$L = \frac{\hbar c^6}{15360\pi G^2 M^2} = 6.8 \times 10^{-30}\ \text{W} \triangleq \mathbf{1\ amu/(696\ Ga \approx 51 t_H)}$$

Total evaporation: $t_{ev} = \frac{5120\pi G^2 M^3}{\hbar c^4} \approx \mathbf{7.35 \times 10^{58} t_H}$

Nope. It would not evaporate to below $m_{bh,\rho_{C,n}}$

Newtonian gravitational acceleration at r_S:

$$g = \frac{GM}{r_S^2} = \frac{GMc^4}{(2GM)^2} = \frac{c^4}{4GM}$$

Said BH: $g \approx 4.2 \times 10^{12}$ m/s^2.

London (UK) vs. smallest possible BH:

(9×10^6 inhabitants) / (2.8 per household) $\approx 3.2 \times 10^6$ residences;

estimating: ~ 130 tonne/residence, yielding: ~ 415 megatonne;

assuming: about same mass for other buildings (shops, offices, etc.);

rough guess: **total of all buildings in Greater London**: **830 megatonne**;

weight of a **single brick** at said **BH**: $\sim 8.4 \times 10^{12}$ N $\asymp$ **850 megatonne**.

(1 megatonne = 1 billion [NL: miljard] kg).

London area: 1572 km^2, BH's surface area: 1452 km^2.

Density comparison

"*Schwarzschild density*": $\rho_S = 3c^6/32\pi G^3 M^2$

object	mass/$M_\odot$	r_S	density [kg/m³]
BH @$\rho_{C,n}$	3.64	10.75 km	ρ_S: 1.392 $\times 10^{18}$
Sgr A*	4.154×10^6	12.27×10^6 km 31.92 lun 17.64 $R_\odot$ 0.082 au	ρ_S: 1.067 $\times 10^6$ $\sqrt[3]{1\ \text{amu}/\rho_S} \approx 0.22 r_B \approx 4.8\lambda_{C,e}$
solar core:			ρ:~150×10^3 $\sqrt[3]{1\ \text{amu}/\rho} \approx 0.42 r_B \approx 9.2\lambda_{C,e}$
close-packed H			ρ: 1996
sun (mean)	1	2953.25 m 4.24×10^{-6} $R_\odot$	ρ: 1410 $\sqrt[3]{1\ \text{amu}/\rho} \approx 2 r_B \approx 44\lambda_{C,e}$
water			ρ: 1000
metallic hydrogen			ρ: 600
solid H_2			ρ: 86
liquid H_2			ρ: 71
TON 618	66×10^9	280×10^3 $R_\odot$ 1303 au	ρ_S: 4.23 $\times 10^{-3}$

Newtonian grav. *pressure* at centre of homogeneous sphere:

$$p_\heartsuit = \frac{2\pi G}{3}\rho^2 r^2,\ r^3 = \frac{3M}{4\pi\rho} \ \therefore\ p_\heartsuit = G\cdot\sqrt[3]{\frac{\pi\rho^4 M^2}{6}} \quad \text{or:}\ \ p_\heartsuit = \frac{3GM^2}{8\pi r^4}$$

Pressure if mass would have *neutron Compton density*:			
black hole's *mass*	*Schwarzschild radius*	central *pressure*	description
$3.64M_\odot$	10.75 km	3.1×10^{34} Pa	critical $\boldsymbol{\rho_{C,n}}$ black hole
$20.8M_\odot$	61.43 km	10^{35} Pa	observed internal proton pressure
$4.3\times10^6 M_\odot$	33 lun[6]	$\mathbf{3.5\times10^{38}}$ **Pa**	Sagittarius A* at centre of Milky Way
$66\times10^9 M_\odot$	1300 au	$\mathbf{2.2\times10^{41}}$ **Pa**	Tonantzintla 618, most massive BH known

white dwarf's *mass*	material *radius*	central *pressure*	description
$1.018M_\odot$	5850 km	$\mathbf{2.8\times10^{22}}$ **Pa**	Sirius B
$\rho\approx 2.4\times10^9\ \text{kg/m}^3$		$p_\heartsuit = p_{degen.,e}\rightarrow\rho_e = \left(\frac{5m_e p_\heartsuit}{(3\pi^2)^{2/3}\hbar^2}\right)^{3/5}\approx \mathbf{8.3}/V_{C,e}$ $\rho_e = 1/V_{C,e}\rightarrow p_{degen.,e}\approx 8.17\times10^{20}\ \text{Pa}\approx p_\heartsuit/\mathbf{34}$ $\rho_e = 1/V_{C,e}\wedge \#e\times V_{C,e}\le V_{tot}\rightarrow \#n/\#p\approx\mathbf{10}$	

[6] lun = earth-moon distance (which rounds to 384400.195711180206 km 😛)

Thermodynamics: $p = \frac{2}{3} \cdot \frac{E}{V} = \frac{2}{3} \rho_E$

Schwarzschild volume: $V_S = \frac{4\pi}{3} r_S^3 = \frac{32\pi G^3 M^3}{3c^6}$

mean *energy density* of BH: $\rho_{E,bh} = \frac{\boldsymbol{Mc^2}}{V_S} = \frac{3c^8}{32\pi G^3 M^2}$

corresp. internal *pressure*: $p_{0,bh} = \frac{2}{3} \rho_{E,bh} = \frac{c^8}{16\pi G^3} \cdot \frac{1}{M^2}$

central gravitational *pressure*: $p_{S\heartsuit} = \frac{3c^8}{128\pi G^3} \cdot \frac{1}{M^2} = \boldsymbol{\frac{3}{8} p_{0,bh}}$

Doesn't $p_{S\heartsuit} = \frac{3}{8} p_{0,bh}$ mean that (Newtonian) gravitation cannot ever compress the thing to nought?

(2023-04-19) According to the Schwarzschild interior solution[7], it has a homogeneous *expansive* internal pressure of $\rho_{E,bh} = \boldsymbol{\frac{3}{2}} p_{0,bh}$, i.e. ***repulsive gravitation*****!** *There is nothing to be withstood.*

[7] http://henk-reints.nl/astro/HR-Schwarzschild-interior.pdf ($\rho_{E,bh}$ is there called Ωc^2)

Homogeneous black hole: $M^2 = \frac{3c^6}{32\pi G^3 \rho}$

hence: $\boldsymbol{p_{0,bh} = \frac{c^8}{16\pi G^3} \cdot \frac{32\pi G^3 \rho}{3c^6} = \frac{2}{3}\rho c^2}$

minimal BH[8]: $p_{0,bh_{min}} = \frac{2}{3}\rho_{C,n} c^2 = \frac{4c^5 m_n^4}{\pi h^3}$

which would be the internal pressure of a **single neutron**.

Its value is:

[8] Please don't read that the Dutch way... ☺

Homogeneous black hole: $M^2 = \dfrac{3c^6}{32\pi G^3 \rho}$

hence: $\boldsymbol{p_{0,bh} = \dfrac{c^8}{16\pi G^3} \cdot \dfrac{32\pi G^3 \rho}{3c^6} = \dfrac{2}{3}\rho c^2}$

minimal BH: $p_{0,bh_{min}} = \dfrac{2}{3}\rho_{\mathrm{C},n} c^2 = \dfrac{4c^5 m_n^4}{\pi h^3}$

which would be the internal pressure of a **single neutron**.

Its value is: $\boldsymbol{\sim 8.34 \times 10^{34}}$ **Pa**

Observed proton *pressure*[9]: $\boldsymbol{\sim 10^{35}}$ **Pa**

Not mentioned in paper: $\dfrac{2}{3} \cdot m_p c^2 / \dfrac{4\pi}{3}\left(\dfrac{\lambda_{\mathrm{C},p}}{2}\right)^3$ $\approx 8.30 \times 10^{34}$ Pa

nor (with proton charge radius): $\dfrac{2}{3} \cdot \; m_p c^2 / \dfrac{4\pi}{3} r_p^3$ $\approx 4.02 \times 10^{34}$ Pa

Electron: $(m_e, \lambda_{\mathrm{C},e})$ $\approx 7.30 \times 10^{21}$ Pa

See also: http://henk-reints.nl/astro/HR-electron-extreme-conditions.pdf

[9] Burkert, V.D., Elouadrhiri, L. & Girod, F.X. The pressure distribution inside the proton. *Nature* **557,** 396-399 (2018).

Compton pressure: $p_{\mathrm{C}} \coloneqq \frac{2}{3}\rho_{\mathrm{C}} c^2 = \frac{4c^5 m^4}{\pi h^3}$

$F_{\mathrm{C}} \coloneqq$ force on spherical area of Compton volume:

neutron: $p_{\mathrm{C},n} \approx 8.34 \times 10^{34}$ Pa, $F_{\mathrm{C},n} \approx 456 \times 10^3$ N

electron: $p_{\mathrm{C},e} \approx 7.30 \times 10^{21}$ Pa, $F_{\mathrm{C},e} \approx 0.135$ N

In: "Proton internal pressure distribution suggests a simple proton structure" (2019)

https://www.degruyter.com/document/doi/10.1515/jmbm-2019-0001/html

C.G. Vayenas, D. Grigoriou & E. Martino derive nearly the same from a so-called "rotating lepton model" (≠ ascertained truth!):

$$p_p = \frac{4}{\pi} \cdot \frac{(m_p c^2/3)^4}{(\hbar c)^3} \approx 2.36 \times 10^{35} \text{ Pa} \quad (17)$$

$$= \frac{4}{\pi} \cdot \frac{2^3\pi^3}{h^3 c^3} \cdot \frac{m_p^4 c^8}{3^4} = \frac{32\pi^2}{81} \cdot \frac{m_p^4 c^5}{h^3} = \frac{8\pi^3}{81} p_{\mathrm{C}} \approx 3.06 \cdot p_{\mathrm{C}}$$

2023-09-01:

I realised that the factor of $\frac{2}{3}$ is arguable.

I am willing to agree that it applies only to thermodynamic pressure caused by particle collisions and that in other cases the full energy density should be used.

However, I will tentatively leave this document as is, since it has little effect on insight and comprehensibility.

It affects only a not too large amount of equations and numerical values which can easily be re-evaluated on the fly.

Plausible:

electrons cannot exist if $\boldsymbol{p > p_{\mathrm{C},e}} \approx 7.30 \times 10^{21}$ Pa;

(or maybe: $p_{\mathrm{C},pe} = \frac{2(m_p+m_e)c^2}{3(V_{\mathrm{C},p}+V_{\mathrm{C},e})} \approx 1.34 \times 10^{25}$ Pa)

∴ neutrons cannot decay if $p > p_{\mathrm{C},e}$;

∴ inside neutron star:

no: $n \to p + e + \bar{\nu}_e + E$;

⇒ nor: $p + e + E \to n + \nu_e$ (endothermic);

∴ no quick decline of neutron star's core temperature, but surface (and plasma atmosphere) could cool quickly (cf. Kelvin cooling period).

Neutrino flux originating from neutron star observed?
Amounts of $\bar{\nu}_e$ & ν_e in equilibrium? What fraction might annihilate?

$$T_{\mathrm{C}} = \frac{p_{\mathrm{C}} V_{\mathrm{C}}}{N k_{\mathrm{B}}} = \frac{\frac{2}{3}\rho_{\mathrm{C}} c^2 \cdot V_{\mathrm{C}}}{N k_{\mathrm{B}}} = \frac{2mc^2}{3Nk_{\mathrm{B}}}$$ (m, N = all mass & #particles within V_{C})

electron:			fully ionised hydrogen plasma:		
m_e	$\approx 9.11 \times 10^{-31}$	kg	m_{pe}	$\approx 1.67 \times 10^{-27}$	kg
$V_{\mathrm{C},e}$	$\approx 7.48 \times 10^{-36}$	m³	$V_{\mathrm{C},e}$	$\approx 7.48 \times 10^{-36}$	m³
$\rho_{\mathrm{C},e}$	$\approx 1.22 \times 10^{5}$	kg/m³	$\rho_{\mathrm{C}_e,pe}$	$\approx 2.24 \times 10^{8}$	kg/m³
$p_{\mathrm{C},e}$	$\approx 7.30 \times 10^{21}$	Pa	$p_{\mathrm{C}_e,pe}$	$\approx 1.34 \times 10^{25}$	Pa
$T_{\mathrm{C},e}$	$\approx 3.95 \times 10^{9}$	K $(N = 1)$	$T_{\mathrm{C}_e,pe}$	$\approx 3.63 \times 10^{12}$	K $(N = 2)$
lacks resistance if $V < V_{\mathrm{C},e}$?			inevitable collapse if $V < V_{\mathrm{C},e}$?		

I *THINK* (but cannot prove) a plasma cannot (persistently) withstand $T > T_{\mathrm{C},e} \approx 3.95 \times 10^9$ K and/or $p > p_{\mathrm{C},e} \approx 7.30 \times 10^{21}$ Pa.

Phase transition?

Please note: $T_{\mathrm{C}_e,pe} \approx 3.63 \times 10^{12}$ K $= T_{\mathrm{bhc}}$ (see p.48) $\approx 3\, T_{\mathrm{Hag}}$.

Presumption:

If $p > p_{\mathrm{C},e}$, electrons will "marry" protons

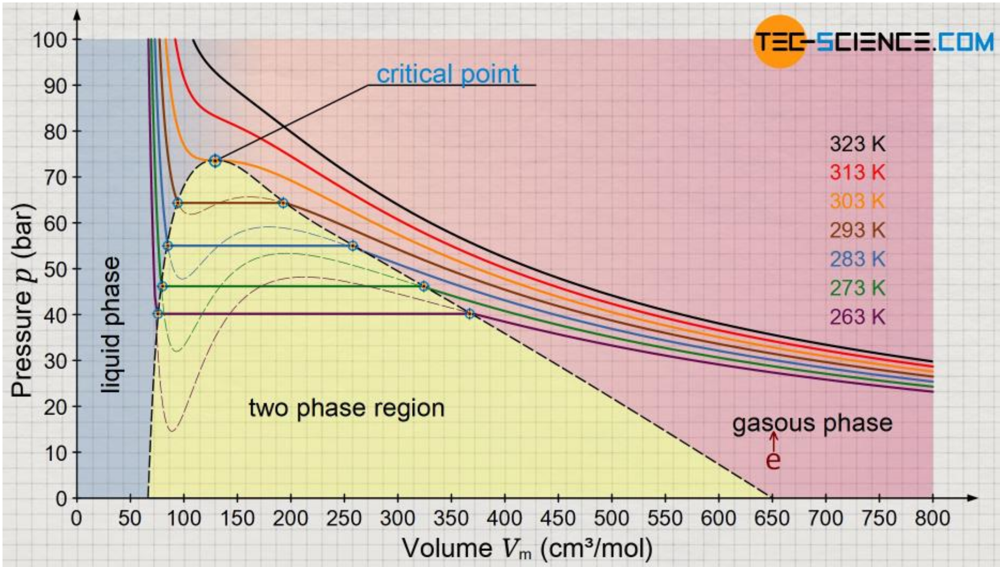
(i.e. part of the plasma collapses to neutronium)

until pressure drops below $p_{\mathrm{C},e}$.

IFF no plasma left, p can rise above $p_{\mathrm{C},e}$,

but $p_{\mathrm{C},n}$ would be a fundamental upper limit.

Phase transition à la Van der Waals?

?  ?

Consider a spherical mass M, partly consisting of neutronium at $\rho_{\mathrm{C},n}$ and partly of a fully ionised $p+e$ plasma with only $V_{\mathrm{C},e}$ per pair (which we presume to be cubical and $V_{\mathrm{C},p}$ can be neglected).

We have: $M = M_n + M_{pe} = M_n + \#e \cdot m_{p+e} \approx M_n + \#e \cdot m_n$

its volume is: $V = \frac{M_n}{\rho_{\mathrm{C},n}} + \frac{M_{pe}}{\rho_{\mathrm{C},e}} = \frac{M_n}{\rho_{\mathrm{C},n}} + \#e \cdot V_{\mathrm{C},e}$

which would equal: $V = \frac{4\pi}{3} r^3$

where: $r = \rho_m r_S = \rho_m \frac{2GM}{c^2}$

but this is gravitationally contracted by: $\frac{1}{\gamma_{\mathrm{ff}}} = \frac{2\rho_m}{1+2\rho_m}$

yielding: $r' = \frac{4\rho_m^2 GM}{(1+2\rho_m)c^2}$

so: $V = \frac{4\pi}{3}(r')^3 = \frac{256\pi\rho_m^6 G^3 M^3}{3(1+2\rho_m)^3 c^6}$ (available volume)

hence: $\#e \cdot V_{\mathrm{C},e} = \frac{256\pi\rho_m^6 G^3 M^3}{3(1+2\rho_m)^3 c^6} - \frac{M_n}{\rho_{\mathrm{C},n}}$

therefore: $$\#e=\frac{256\pi\rho_m^6G^3M^3}{3(1+2\rho_m)^3c^6V_{C,e}}-\frac{M_n}{\rho_{C,n}V_{C,e}}$$

We have: $$\rho_{C,n}=\frac{6c^3m_n^4}{\pi h^3}$$

and: $$V_{C,e}=\frac{\pi h^3}{6m_e^3c^3}$$

yielding: $$\#e=\frac{256\pi\rho_m^6G^3M^3}{3(1+2\rho_m)^3c^6\frac{\pi h^3}{6m_e^3c^3}}-\frac{M_n}{\frac{6c^3m_n^4}{\pi h^3}\cdot\frac{\pi h^3}{6m_e^3c^3}}$$

which is: $$\#e=\frac{256\pi\rho_m^6G^3M^3}{(1+2\rho_m)^3\cdot\frac{\pi h^3c^3}{2m_e^3}}-\frac{M_n}{m_n^4/m_e^3}$$

hence: $$\#e=\frac{512m_e^3\rho_m^6G^3M^3}{h^3c^3(1+2\rho_m)^3}-\frac{M_nm_e^3}{m_n^4}$$

We had: $$M_n=M-\#e\cdot m_n$$

therefore: $$M_n=M-\frac{512m_e^3m_n\rho_m^6G^3M^3}{h^3c^3(1+2\rho_m)^3}+\frac{M_nm_e^3}{m_n^3}$$

or: $$M_n-\frac{M_nm_e^3}{m_n^3}=M-\frac{512m_e^3m_n\rho_m^6G^3M^3}{h^3c^3(1+2\rho_m)^3}$$

so: $$M_n\left(1-\frac{m_e^3}{m_n^3}\right)=M\left(1-\frac{512m_e^3m_n\rho_m^6G^3M^2}{h^3c^3(1+2\rho_m)^3}\right)$$

i.e.: $$M_n\frac{m_n^3-m_e^3}{m_n^3}=M\frac{h^3c^3(1+2\rho_m)^3-512m_e^3m_n\rho_m^6G^3M^2}{h^3c^3(1+2\rho_m)^3}$$

hence: $$\frac{M_n}{M}=\frac{h^3c^3(1+2\rho_m)^3-512m_e^3m_n\rho_m^6G^3M^2}{h^3c^3(1+2\rho_m)^3}\cdot\frac{m_n^3}{m_n^3-m_e^3}$$

or: $$\frac{M_n}{M}=\left(1-\frac{512m_e^3m_nG^3\rho_m^6M^2}{h^3c^3(1+2\rho_m)^3}\right)\frac{m_n^3}{m_n^3-m_e^3}$$

which would be the neutronium fraction as a function of M & ρ_m .

Since: $$\frac{m_n^3}{m_n^3-m_e^3}\approx 1.000\,000\,000\,16$$

we can ignore it: $$\frac{M_n}{M}=1-\frac{512m_e^3m_nG^3}{h^3c^3}\cdot\frac{\rho_m^6M^2}{(1+2\rho_m)^3}$$

and then: $$\frac{M_{pe}}{M}=\frac{512m_e^3m_nG^3}{h^3c^3}\cdot\frac{\rho_m^6M^2}{(1+2\rho_m)^3}$$

would be the plasma fraction.

We find: $$\frac{512m_e^3m_nG^3}{h^3c^3}\approx 2.45878\times 10^{-71}\ /\text{kg}^2$$

If we express M in solar masses ($M_{\odot} \approx 1.98847 \times 10^{30}$ kg),

we obtain: $$\frac{M_{pe}}{M} = \frac{512 m_e^3 m_n G^3 M_{\odot}^2}{h^3 c^3} M_{/\odot}^2 \frac{\rho_m^6}{(1+2\rho_m)^3}$$

and of course: $$\frac{M_n}{M} = 1 - \frac{M_{pe}}{M}$$

where: $$\frac{512 m_e^3 m_n G^3 M_{\odot}^2}{h^3 c^3} \approx 9.722 \times 10^{-11} \approx 10^{-10}$$

Also: $$r = \rho_m \frac{2GM}{c^2} = \frac{2GM_{\odot}}{c^2} \rho_m M_{/\odot} \approx \rho_m M_{/\odot} \cdot 2953 \text{ m}$$

and: $$r' = \frac{2\rho_m \cdot r}{(1+2\rho_m)}$$

but I'm convinced length contraction applies to empty space only.

r is as measured from great distance, r' is measured on the spot.

Densest possible objects: neutr. $@\rho_{C,n}$ and/or plasma $@(1p+1e)/V_{C,e}$:

Estimated neutronium percentage in massive spheres; mass unit: solar mass; length units: K = km, E = earthRadius, M = earth-moon, A = au

\## : 100%, $$: 100% but size < 2rS/3, // : neutron density < close-packed, $: contains plasma but size < 2rS/3, -- : diluted plasma

\rhoM	1.0	1.6	2.5	4.0	6.3	1.0e1	1.6e1	2.5e1	4.0e1	6.3e1	1.0e2	1.6e2	2.5e2	4.0e2	6.3e2	1.0e3	1.6e3	2.5e3	4.0e3	6.3e3
M \r	3K	4.7K	7.4K	12K	19K	30K	47K	74K	120K	190K	300K	470K	740K	1200K	1900K	3000K	4700K	1.2E	1.8E	2.9E
1	++	++	##	//	//	//	//	//	//	//	//	//	//	//	//	99	95	81	23	--
1.6	++	++	##	//	//	//	//	//	//	//	//	//	//	//	99	97	88	52	--	--
2.5	++	##	//	//	//	//	//	//	//	//	//	//	//	//	98	92	70	--	--	--
4	##	##	//	//	//	//	//	//	//	//	//	//	//	99	95	81	23	--	--	--
6.3	##	//	//	//	//	//	//	//	//	//	//	//	99	97	88	52	--	--	--	--
M \r	30K	47K	74K	120K	190K	300K	470K	740K	1200K	1900K	3000K	4700K	1.2E	1.8E	2.9E	4.6E	7.3E	12E	18E	29E
10	$$	//	//	//	//	//	//	//	//	//	//	//	98	92	70	--	--	--	--	--
16	//	//	//	//	//	//	//	//	//	//	//	99	95	81	24	--	--	--	--	--
25	//	//	//	//	//	//	//	//	//	//	99	97	88	52	--	--	--	--	--	--
40	//	//	//	//	//	//	//	//	//	//	98	92	70	--	--	--	--	--	--	--
63	//	//	//	//	//	//	//	//	//	99	95	81	24	--	--	--	--	--	--	--
M \r	300K	470K	740K	1200K	1900K	3000K	4700K	1.2E	1.8E	2.9E	4.6E	7.3E	12E	18E	29E	46E	1.2M	1.9M	3.1M	4.8M
100	//	//	//	//	//	//	//	//	99	97	88	52	--	--	--	--	--	--	--	--
160	//	//	//	//	//	//	//	//	98	93	70	--	--	--	--	--	--	--	--	--
250	//	//	//	//	//	//	//	99	95	81	24	--	--	--	--	--	--	--	--	--
400	//	//	//	//	//	//	99	97	88	53	--	--	--	--	--	--	--	--	--	--
630	//	//	//	//	//	//	98	93	71	--	--	--	--	--	--	--	--	--	--	--
M \r	3000K	4700K	1.2E	1.8E	2.9E	4.6E	7.3E	12E	18E	29E	46E	1.2M	1.9M	3.1M	4.8M	7.7M	12M	19M	31M	48M
1000	//	//	//	//	//	99	96	82	26	--	--	--	--	--	--	--	--	--	--	--
1600	//	//	//	//	99	97	89	54	--	--	--	--	--	--	--	--	--	--	--	--
2500	//	//	//	//	98	93	72	--	--	--	--	--	--	--	--	--	--	--	--	--
4000	//	//	//	99	96	83	30	--	--	--	--	--	--	--	--	--	--	--	--	--
6300	//	//	//	98	90	58	--	--	--	--	--	--	--	--	--	--	--	--	--	--
M \r	4.6E	7.3E	12E	18E	29E	46E	1.2M	1.9M	3.1M	4.8M	7.7M	12M	19M	31M	48M	77M	120M	190M	310M	1.2A
10000	//	//	99	95	76	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
16000	//	99	97	86	39	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
25000	//	99	93	66	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
40000	99	97	82	15	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
63000	99	92	56	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
M \r	46E	1.2M	1.9M	3.1M	4.8M	7.7M	12M	19M	31M	48M	77M	120M	190M	310M	1.2A	2A	3.1A	5A	7.9A	12A
1.0e5	96	79	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1.6e5	91	47	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
2.5e5	77	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
4.0e5	43	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
6.3e5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

"//" : $\geq$ 99.5% neutr. of $\rho_n < \rho_{cp,n}$, BUT: $T_{M_J>M} \in \{(\rho_m = 630)$: 2.5 GK $\Leftrightarrow$ $(\rho_m = 1)$: 2.5 TK$\}$

BHs for which I found a mass (2023-04-23), ordered by descending mass (unit = $M_\odot$):

Ton 618	:	66	e9			
S5 0014+81	:	40	e9			
APM 08279+5255	:	23	e9			
NGC 4889	:	21.5	e9	+/-	15.5	e9
NGC 1277	:	17	e9			
4C +37.11 a	:	10	e9			
Messier 87	:	6.5	e9	+/-	900	e6
NGC 4564	:	5.6	e9	+/-	800	e6
4C +37.11 b	:	5	e9			
Messier 60	:	4.5	e9	+/-	1	e9
NGC 1271	:	3	e9	+/-	1.1	e9
IC 1459	:	2.6	e9	+/-	1	e9
Q0906+6930	:	2	e9			
Messier 84	:	1.5	e9			
Messier 104	:	1	e9			
NGC 3115	:	1	e9			
Mrk 501	:	900	e6	+/-	3.4	e9
NGC 3998	:	810	e6	+/-	200	e6
NGC 1332	:	660	e6	+/-	66	e6
NGC 6251	:	590	e6	+/-	200	e6
NGC 1399	:	510	e6			
NGC 4261	:	490	e6	+/-	100	e6
NGC 7052	:	425	e6	+/-	205	e6
Messier 105	:	170	e6	+/-	30	e6
Messier 31 (Andromeda)	:	170	e6	+/-	60	e6
Fornax A	:	140	e6	+/-	10	e6
NGC 1097	:	140	e6			
NGC 4697	:	130	e6	+/-	18	e6
NGC 4473	:	100	e6			
NGC 3377	:	80	e6	+/-	6	e6
NGC 4596	:	78	e6			
Messier 81	:	70	e6			
NGC 4459	:	70	e6			

NGC 4579	:	70	e6			
Centaurus A	:	55	e6			
NGC 1023	:	44	e6	+/-	5	e6
NGC 2787	:	41	e6	+/-	5	e6
NGC 4151 a	:	40	e6			
Messier 106	:	39	e6	+/-	1	e6
Messier 82 a	:	30	e6			
NGC 3384	:	16	e6	+/-	2	e6
NGC 1566	:	13	e6	+/-	6	e6
NGC 4151 b	:	10	e6			
NGC 253	:	5	e6			
Sagittarius A* (Milky Way)	:	4.154	e6			
Messier 32	:	3.25	e6	+/-	1.75	e6
NGC 3079	:	3	e6	+/-	1.8	e6
NGC 7314	:	8.70	e5	+/-	4.50	e5
Messier 82 b	:	2600		+/-	2400	?
M82 X-1	:	550		+/-	450	?
Cygnus X-1	:	21.2		+/-	2.2	
M33 X-7	:	15.65				
GRS 1915+105/V1487 Aql	:	14		+/-	4	
XTE J1550-564/V381 Nor	:	10				
V404 Cyg	:	9				
XTE J1650-500	:	7.5		+/-	2.5	
MOA-2011-BLG-191/OGLE-2011-BLG-0462	:	7.1				
A0620-00/V616 Mon	:	6.6				
IGR J17091-3624	:	6.5		+/-	3.5	
GX 339-4/V821 Ara	:	5.8				
GS 2000+25/QZ Vul	:	5				
GRO J0422+32	:	4.315		+/-	0.655	
Cygnus X-3	:	3.5		+/-	1.5	
SN 1997D	:	3				

Most massive stars known: $60 \le M_{/\odot} \le 125$: $\# = \mathbf{183}$; $125 < M_{/\odot} \le 250$: $\# = \mathbf{24}$.

When rounding to
order of magnitude,
we are left with a **gap**

from: $\sim 1 \times 10^2$
to: $\sim 1 \times 10^6$
with merely two objects
around $\sim 1 \times 10^3 \pm 1 \times 10^3$.

This more or less
matches the mass range
of globular clusters.

https://en.wikipedia.org/wiki/Globular_cluster

Globular cluster

Messier 2

Characteristics	
Type	Star cluster
Mass range	1K $M_\odot$ - >1M $M_\odot$[1]
Size range	10-300 ly across[1]
Density	~2 stars/cubic ly [1]
Average luminosity	~25 000 $L_\odot$[1]

In: http://henk-reints.nl/astro/HR-Geometry-of-universe-slideshow.pdf
(in & beyond the "Gravitational collapse" chapter)

I *derive* that *all* SMBHs must have formed
well within ½ million years since the BB.

A protostar lasts roughly 10 mln. years, so those gas clouds plausibly collapsed into SMBHs way before sufficient heating by nuclear energy could prevent a further collapse.

A smaller cloud, taking $> \sim 10$ mln. years, may very well get fragmented during the collapse, resulting in a globular star cluster with stars that *did* get hot enough to prevent a further collapse. This *could* explain why no BHs below say 1 mln. $M_\odot$ have reliably and convincingly been observed.

Plausibly, the smaller BHs ($< \sim 100 M_\odot$) are stellar remnants.

I *think* no other BH types exist than SMBH and stellar.

Sun:

Core density: $\rho_\odot \approx 1.54 \times 10^5$ kg/m³

Core pressure: $p_\odot \approx 2.35 \times 10^{16}$ Pa

Sgr A*:

Schw. density: $\rho_S \approx 1.07 \times 10^6$ kg/m³

internal pressure[10]: $p \approx 9.59 \times 10^{22}$ Pa $> p_{C,e}$

exceeds electron Compton pressure

⇒ plausibly contains neutronium which lowers amount of plasma such that $p < p_{C,e}$

TON 618:

Schw. density: $\rho_S \approx 4.23 \times 10^{-3}$ kg/m³

internal pressure[10]: $p \approx 3.80 \times 10^{14}$ Pa $< p_{C,e}$

$\approx$ 3.8 gigabar.

[10] see http://henk-reints.nl/astro/HR-Schwarzschild-interior.pdf

Based on maximum black hole impact *velocity* of $\beta = \sqrt{5}/3$,

(if $r_\mathrm{c} = \frac{2}{3} r_\mathrm{S}$ then $\rho_\mathrm{c} = \frac{81c^6}{256\pi G^3 M^2}$ i.e. $M = \sqrt{\frac{81c^6}{256\pi G^3 \rho_\mathrm{c}}}$)

maximum *mass* of neutronium core **would** be:

$\rho_\mathrm{c} = \rho_{\mathrm{C},n} \rightarrow M = 6.68 \cdot M_\odot \rightarrow p_\heartsuit \approx 4.7 \times 10^{34}$ Pa

$\rho_\mathrm{c} = \rho_{n,cp} \rightarrow M = 10.4 \cdot M_\odot \rightarrow p_\heartsuit \approx 2.0 \times 10^{34}$ Pa

Above this, it would be smaller than $\frac{2}{3} r_\mathrm{S}$, which seems impossible, based on impact velocity $\beta_\mathrm{imp} = \sqrt{5}/3$.

Note: the above greatly exceeds the TOV limit.

Conjecture:

TOV ~~collapse~~ contraction: **only tare volume**; body would approach neutron Compton density when $M \gtrsim M_{\mathrm{TOV}}$, but **NO COLLAPSE TO NOUGHT!**

As listed in http://henk-reints.nl/astro/massBH.html:

$M > 3.64 M_\odot \rightarrow r_\mathrm{S} > r_{\mathrm{mat}@\rho_{\mathrm{C},n}} \rightarrow$ BH

$M > 5.65 M_\odot \rightarrow r_\mathrm{S} > r_{\mathrm{mat}@\rho_{\mathrm{cp},n}} \dashrightarrow$ BH

$M > 6.68 M_\odot \rightarrow r_{\mathrm{mat}@\rho_{\mathrm{C},n}} < \frac{2}{3} r_\mathrm{S}$ $\rho_{\mathrm{C},n}$ unattainable?

$M > 10.37 M_\odot \rightarrow r_{\mathrm{mat}@\rho_{\mathrm{cp},n}} < \frac{2}{3} r_\mathrm{S}$ $\rho_{\mathrm{cp},n}$ unattainable?

$M < 15.84 M_\odot \rightarrow$ central Newtonian *gravitational pressure* at *neutron Compton density* always less than *neutron Compton pressure*, so it cannot crush them into collapse.

NOTE (2023-10-05, see p.77): the latter would be 2 times larger, i.e $32 M_\odot$, nicely near the 36 in http://henk-reints.nl/astro/HR-Schwarzschild-interior.pdf .

*We calculated with Newtonian gravitational pressure at very centre & **neutron Compton density** seems truly unattainable, hence it **might** indeed be a fundamental upper density limit.*

For a spherically symmetrical body we can apply Newton's shell theorem[11] and *calculate* as if it were concentrated in a single mathematical point, but

a physical point mass seems fundamentally impossible

(*which was my very first thought when I - as a teenager - first learned about point masses*).

Moreover (see http://henk-reints.nl/astro/HR-Schwarzschild-interior.pdf), from Schwarzschild's interior solution follows that **BH's interior** has an **expansive** (homogeneous) **pressure**,

so there is no compressive pressure to resist at all; hence the thing will not collapse; no singularity!

[11] **IFF** Newtonian gravitation & ***NOT*** to nearly flat disks like spiral galaxies, see http://henk-reints.nl/astro/HR-Dark-matter-slideshow.pdf

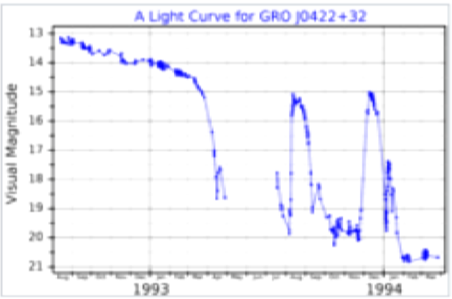
Smallest black holes we know are consistent with $M \geq 3.64 M_{\odot}$:

GRO J0422+32 - Wikipedia

en.wikipedia.org/wiki/GRO_J0422%2B32

GRO J0422+32

From Wikipedia, the free encyclopedia



A visual band light curve for GRO J0422+32, adapted from Chevalier and Ilovaiski (1995)[3]

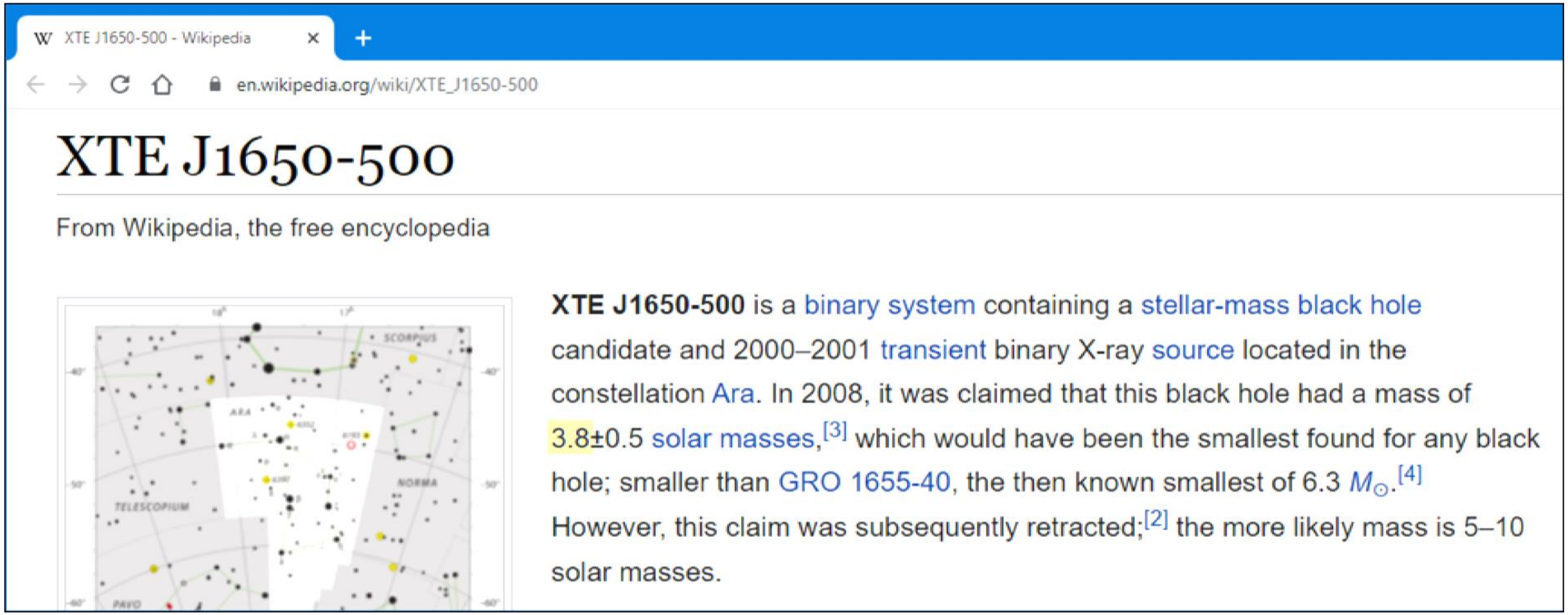
GRO J0422+32[1] is an X-ray nova and black hole candidate that was discovered by the BATSE instrument on the Compton Gamma Ray Observatory satellite on 5 August 1992.[4][5] During outburst, it was observed to be stronger than the Crab Nebula gamma-ray source out to photon energies of about 500 keV.[2]

The mass of the black hole in GRO J0422+32 falls in the range 3.66 to 4.97 solar masses.[6] This is the smallest yet found for any stellar black hole, and near the theoretical upper mass limit (~2.7 $M_{\odot}$) for a neutron star. Further analysis in 2012 calculated a mass of 2.1 $M_{\odot}$, which raises questions as to what the object actually is.[7]

It is also known to have a companion M-type main-sequence star, **V518 Per**,[8] in the constellation Perseus. It has a magnitude of 13.5 in the B spectral band, and 13.2 in the visible band.

https://en.wikipedia.org/wiki/GRO_J0422%2B32

3.66 to 4.97 solar masses.



XTE J1650-500 - Wikipedia

en.wikipedia.org/wiki/XTE_J1650-500

XTE J1650-500

From Wikipedia, the free encyclopedia

XTE J1650-500 is a binary system containing a stellar-mass black hole candidate and 2000–2001 transient binary X-ray source located in the constellation Ara. In 2008, it was claimed that this black hole had a mass of 3.8±0.5 solar masses,[3] which would have been the smallest found for any black hole; smaller than GRO 1655-40, the then known smallest of 6.3 $M_\odot$.[4] However, this claim was subsequently retracted;[2] the more likely mass is 5–10 solar masses.

https://en.wikipedia.org/wiki/XTE_J1650-500

Original claim: 3.8 solar masses; more likely: 5 – 10.

Both XTE J1650-500 & GRO J0422+32 have a *Schwarzschild density* for which: $\rho_{C,n} \lesssim \rho_S \lesssim \rho_{n,cp}$ ∴ they very plausibly consist of neutronium with $M > M_{\mathrm{TOV}}$.

I claim: a blob of neutronium can be way more massive than the TOV limit.

And possibly (see page 48): $M_{\mathrm{obs}} = 3M_{\mathrm{cold}}/2$.

QUOTE:

(...) will, if massive enough, contract indefinitely, although more and more slowly, never reaching true equilibrium.

UNQUOTE.

That's no collapse & it doesn't say it's a maximum mass!

I claim: only its tare volume will contract;

neutrons are not crushed; it remains a blob of neutronium.

I presume: if *material radius* $< 2r_S/3$ it gets diluted,

i.e. can no longer consist of compact neutronium,

which I can substantiate only by the depth of the potential well,

yielding a maximum free fall impact at $\gamma = 3/2$.

As said, impact occurs at $\gamma = \frac{3}{2}$ (more energy not available).

⇒ core *radius*:

$$\beta = \frac{\sqrt{5}}{3} \therefore \gamma = \frac{3}{2} \therefore r_{\mathrm{c}} = \frac{2}{3} r_{\mathrm{S}} = \frac{\mathbf{4GM}}{\mathbf{3c^2}}$$

Sgr A*: $\sim 8.2 \times 10^6$ km

⇒ core *volume*:

$$V_{\mathrm{c}} = \frac{4\pi}{3} r_{\mathrm{c}}^3 = \frac{256\pi G^3 M^3}{81 c^6}$$

⇒ core *density*:

$$\rho_{\mathrm{c}} = \frac{M}{V_{\mathrm{c}}} = \frac{81 c^6}{256\pi G^3 M^2}$$

Sgr A*: $\sim 3.6 \times 10^6$ kg/m^3

if homogeneous neutron gas: $\sim 3.6 \times 10^9$ mol/m^3

interneutron *distance*: $\sim r_{\mathrm{B}}/10 \approx 2.2 \cdot \lambda_{\mathrm{C},e}$

solar core: $\left(\pi/3\sqrt{2}\right)^{1/3} \times 9.2 = 8.3 \cdot \lambda_{\mathrm{C},e}$

Newtonian grav. central *pressure* if $r_\mathrm{c} = \frac{2}{3} r_\mathrm{S}$:

$$\boldsymbol{p}_\heartsuit = \sqrt[3]{\frac{\pi\rho^4 G^3 M^2}{6}} = \sqrt[3]{\frac{\pi \cdot \frac{81^4 c^{24}}{256^4 \pi^4 G^{12} M^8} \cdot G^3 M^2}{6}} = \sqrt[3]{\frac{81^4 c^{24}}{6 \cdot 256^4 \pi^3 G^9 M^6}} = \sqrt[3]{\frac{3^{16} c^{24}}{3 \cdot 2 \cdot 2^{32} \pi^3 G^9 M^6}} = \sqrt[3]{\frac{3^{15} c^{24}}{2^{33} \pi^3 G^9 M^6}}$$

$$= \frac{\boldsymbol{3^5 c^8}}{\boldsymbol{2^{11} \pi G^3 M^2}}$$

Sgr A*: $\sim 1.2 \times 10^{23}$ Pa $\approx \frac{p_\mathrm{proton}}{\mathbf{10^{12}}}$

Thermal *pressure*:

$$p = \frac{N}{V} k_\mathrm{B} T = \frac{M}{V_\mathrm{c} m_\mathrm{n}} k_\mathrm{B} T = \frac{8}{9} p_\heartsuit$$ with T as shown before.

Sgr A*: $\sim 1.1 \times 10^{23}$ Pa

Note: $p_\heartsuit$ applies to core's centre only, where it is highest.

It would have: $\rho_\mathrm{e} \approx 0.016 / V_\mathrm{C,e}$ or $\sim 62\, V_\mathrm{C,e}/\mathrm{e}$.

But $p \approx 16 \times$ higher than electron's "*Compton pressure*";

$\Rightarrow$ presumably still a neutronium core?

Existance Postulate ⇒

body **requires** ≥ *Schwarzschild volume* in order to exist;

⇒ it might seemingly fill entire Schwarzschild sphere

(consistent with aforementioned inflated nought).

Would *Schwarzschild density* be homogeneous:

$$\rho_\mathrm{S} = \frac{3c^6}{32\pi G^3 M^2} \quad \& \quad \text{Newtonian: } p = \frac{2\pi G \rho_\mathrm{S}^2}{3}(r_\mathrm{S}^2 - r^2)$$

$$p_{r=0} = \frac{2\pi G}{3}\rho_\mathrm{S}^2 r_\mathrm{S}^2 = \frac{2\pi G}{3}\frac{9c^{12}}{1024\pi^2 G^6 M^4}\left(\frac{2GM}{c^2}\right)^2 = \frac{3c^8}{128\pi G^3 M^2}$$

Sgr A* ($M \approx 4.154 \times 10^6 M_\odot \approx 8.26 \times 10^{36}$ kg):

$p_\heartsuit \approx 2.4 \times 10^{22}$ Pa $\ll p_\mathrm{proton}$ ∴ no collapse to zero *volume*;

but $\approx 3.3 \cdot (p_\mathrm{electron} = 7.30 \times 10^{21}$ Pa) ∴ neutronium core?

Temperature required to compensate gravitational pressure

presuming core fully ionised: $p + e \Rightarrow N \approx \frac{2M}{m_n} \therefore \frac{N}{V} \approx \frac{2\rho_S}{m_n}$

$$T = \frac{pV}{Nk_B} = \frac{m_n p}{2\rho_S k_B} = \frac{\pi G m_n \rho_S}{3k_B}\left(r_S^2 - r^2\right) = \frac{m_n c^2 \cdot c^4}{32k_B (GM)^2}\left(r_S^2 - r^2\right)$$

$T_{r=r_S} = 0$ K, zero gravitational pressure requires zero thermal pressure;

$$\boldsymbol{T_{r=0}} = \frac{m_n c^2 \cdot c^4}{32k_B (GM)^2} r_S^2 = \frac{m_n c^2 \cdot c^4}{32k_B (GM)^2}\left(\frac{2GM}{c^2}\right)^2 = \frac{m_n c^2}{8k_B} \approx \mathbf{1.36 \times 10^{12}}\ \text{K}$$

(cf. Hagedorn temperature!)

Independent of M.

Newtonian *gravitation*

is a *force* at a *distance* ⇒ pierces **empty space**.

Einstein's General Relativity

distorts **empty space**-time around a body.

Apparently, *gravitation* is about **empty space**,

but at *neutron Compton density*

all empty space has been "squeezed out".

Does *gravitation* then still apply?

Extrapolatio ad absurdum...

CONJECTURE:

gravitation operates only in empty space and is negligible inside compact matter like neutronium.

But inner mass still distorts spacetime outside body.

¿ Schwarzschild volume $\stackrel{?}{=}$ squeezed-out empty space ?

¿ Grav. force to be multiplied by: $\text{emptyness} := \dfrac{\text{tare volume}}{\text{gross volume}}$?

$\text{Net volume} =$ total Compton volume?

¿ Or: a penetration depth, similar to mean free path ?

Louis de Broglie about Albert Einstein:

He told me that all physical theories,
their mathematical expression apart, ought
to lend themselves to so simple a description
"that even a child could understand them".

http://books.google.com/books?id=xY45AAAAMAAJ&q=%22mathematical+expression+apart%22#search_anchor

My dear children:

gravitational "rays" can go only in straight lines
through empty space *between* particles
& *terminate* when they hit one.

Gravitons (if existing) *are terminated by a true hit.*
They'll not be back. Hasta la vista, baby...

Strong interaction ($\sim 10^{38} \times$ *grav.*)

would easily keep thing together;

but works only at a short *distance*

$$\Rightarrow\ p_{\heartsuit} < p_{\mathrm{proton}}$$

(cf. aforementioned $p_{\heartsuit}$ of Sgr A* & TON 618);

$\Rightarrow$ black hole's core does not collapse to zero;

gravitational spacetime curvature outside it causes return of nearly everything that would escape from core.

Altogether:

Black hole's core
must be greater than zero,
i.e. at least net *volume* of
particles themselves.

NO SINGULARITY!

Gravitational contraction of *Schwarzschild radius*

as seen by black hole's core:

were it a point *mass*: $r'_{\mathrm{S}} \to 0$

greater than zero: $r_{\mathrm{c}} > 0 \;\Rightarrow\; r'_{\mathrm{S}} < r_{\mathrm{c}}$

⇒ contraction definitely to within core's material *radius*.

Gravitational contraction of *Schwarzschild radius*

as seen by black hole's core:

were it a point *mass*: $r_S' \to 0$

greater than zero: $r_c > 0 \;\Rightarrow\; r_S' < r_c$

⇒ contraction definitely to within core's material *radius*.

Core's surface fully exposed

in the nude.

Hence: ~~Hawking radiation~~ (sorry, Stephen),

but $v_{esc} < c$, so core *can* lose *mass*.

Lorentz contraction of *Schwarzschild radius*

as seen by the falling victim:

before it is contracted to nought,

i.e. when still: $v < c \;\; \Rightarrow \;\; 0 < r'_{\mathrm{S}} < r_{\mathrm{c}}$

⇒ contraction definitely to within core's material *radius*.

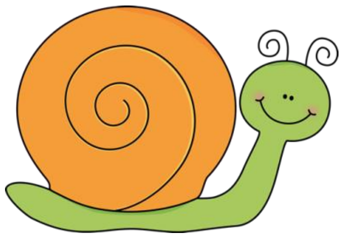
Lorentz contraction of *Schwarzschild radius* as seen by the falling victim:

before it is contracted to nought,

i.e. when still: $v < c \;\; \Rightarrow \;\; 0 < r'_{\mathrm{S}} < r_{\mathrm{c}}$

⇒ contraction definitely to within core's material *radius*.

Actual impact always at **subluminal** *velocity*.



http://clipart-library.com/new_gallery/snail-clipart-2.png

As already shown on page 6:

Observation by the distant observer:

Gravitational time dilation
prevents the distant observer to ever see
the victim get within the *Schwarzschild radius*.

He sees him asymptotically approach
this apparent event horizon.

Doesn't this imply that the actual impact in a black hole cannot ever be observed?

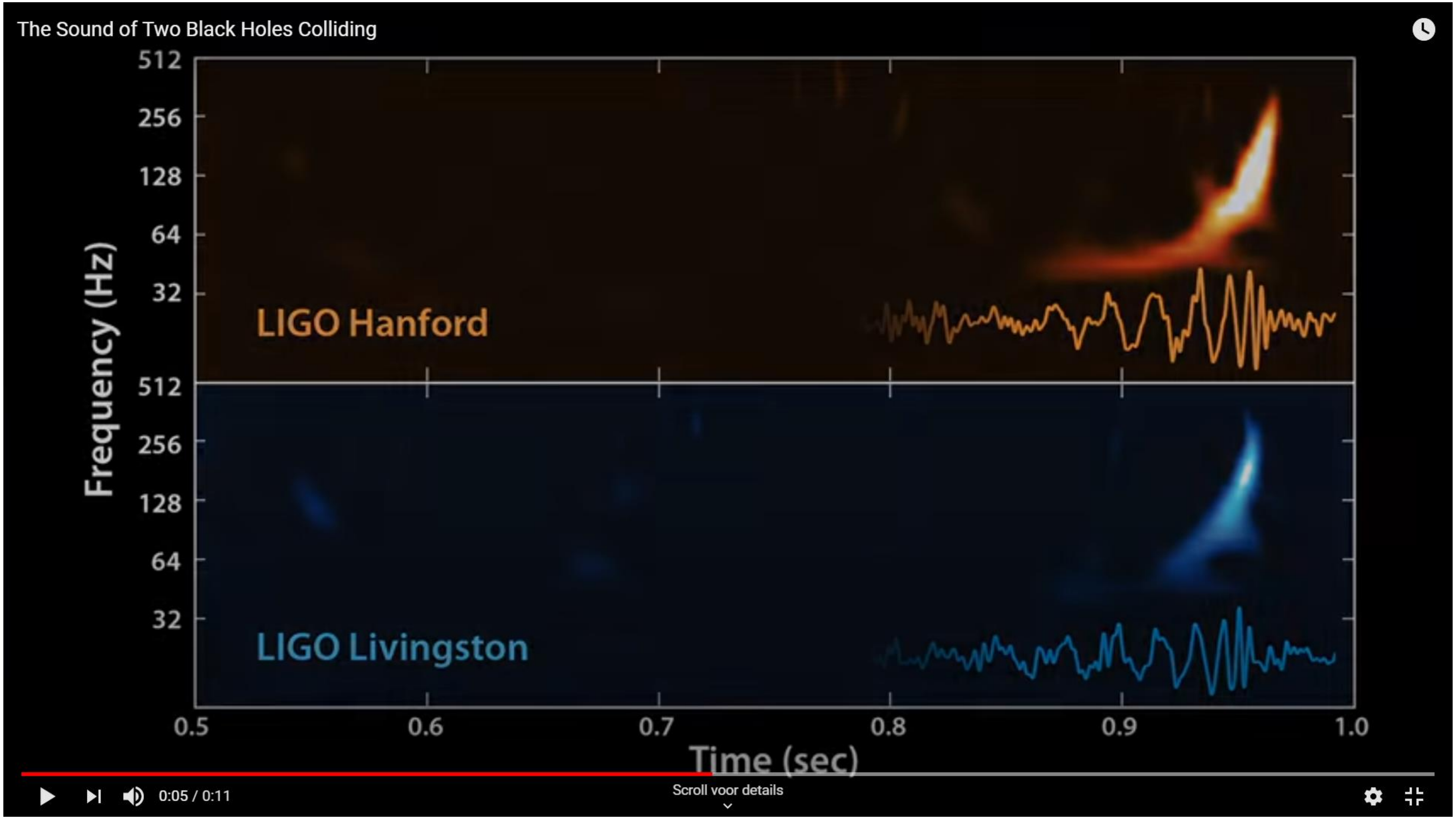
Subluminal impact occurs however

outside contracted *Schwarzschild radius,*

yielding a subluminal *escape velocity*

and finite *gravitational time dilation,*

thus enabling distant observation:



The Sound of Two Black Holes Colliding

https://www.youtube.com/watch?v=QyDcTbR-kEA

Clearly terminates after finite time.

Elimination of black hole mystery:

1. Application of *relativistic (Lorentz & Schwarzschild) length contraction* to *Schwarzschild radius* eliminates event horizon for colliding bodies.

2. Rejection of (the rather absurd idea of) infinite *density* or physical singularities exposes core's surface outside contracted r_S yielding subluminal $=$ observable impact.

ALL theories

using the event horizon

(or its inside) as a premise

(e.g. Penrose theorem & Hawking radiation)

are to be rejected.

CONSISTENT;

NO CONCOCTIONS;

NOTHING MYSTERIOUS;

AGREES WITH OBSERVATIONS;

IT ALL FALLS INTO PLACE.

We must trust to nothing but facts. These are presented to us by nature, and cannot deceive. We ought, in every instance, to submit our reasoning to the test of experiment, and never to search for truth but by the natural road of experiment and observation.

Antoine-Laurent de Lavoisier (1743-1794).

Black hole singularity? Swapping of space & time?

Wormholes? Dark energy? Cosmological constant?

93 billion light years? Cosmological redshift?

Inflationary universe? Phlogiston? FLAPDOODLE!

Black hole:

a HOLE?

Densest & least penetrable

body of all, hit at ¾ speed of light!