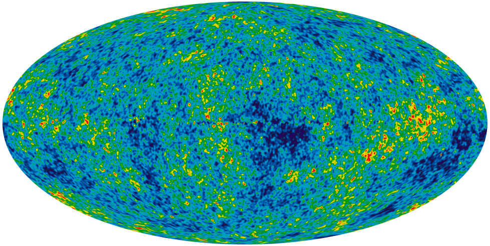


What is the the speed of gravity and WHY?

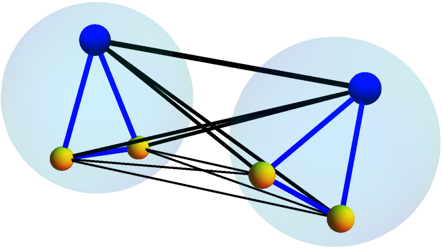
speed of light / ???

Is gravitational constant G important for planetary trajectories?

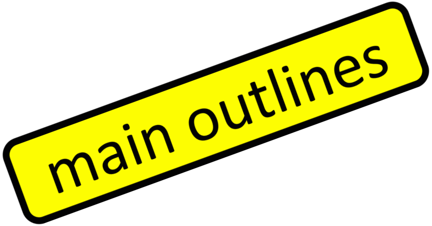
Yes / No

On the origins of **GRAVITY** and **INERTIA**

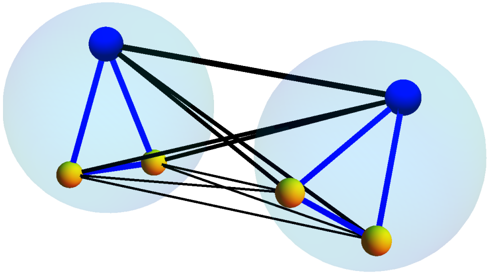
Jeroen van Engelshoven

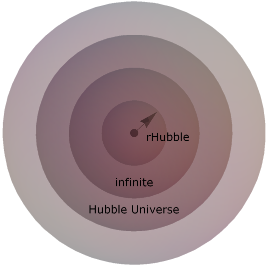


April 20, 2026



1. Foundations
2. Root cause for gravity
   - Optical properties of gravity
3. Root cause for inertia
   - Static universe
   - Expanding universe
   - Applications
4. Conclusions



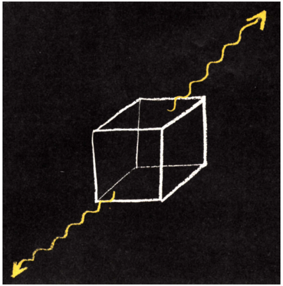


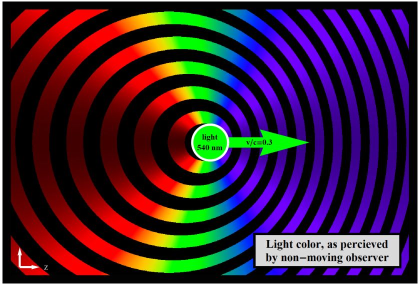
Special Relativty (1905)

- constant speed of light $\Longrightarrow$ Maxwell equations ($\vec{E}$ & $\vec{B}$)
  $\Longrightarrow$ Liénard-Wiechert fields ($\vec{E}$)

- Relativistic Doppler effect : $\nu_{obs} = \nu_{original} \frac{\sqrt{1-(v_z/c)^2}}{1+(v_z/c)\, Cos[\theta]}$

- $E = m\,c^2$





Field theory: retarded, dynamic Liénard-Wiechert (1898)

Force between 2 moving charged particles:

$$\vec{F} = q_{obs} \, (\vec{E} + \vec{v} * \vec{B})$$

$$\vec{E} = q_{part} / (4\pi\epsilon_0 \, s^3) \, (\, (1 - (v/c)^2) \, (\vec{r} - r\vec{v}/c) \; + \vec{r} * ((\vec{r} - r\vec{v}/c) * \vec{a}) \, / c^2 \,)$$

$$\vec{B} = \vec{r} * \vec{E} / (r \, c)$$

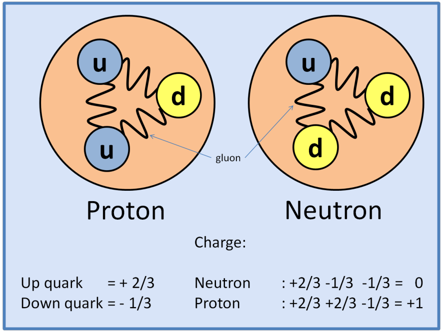
$\vec{F}$	Electro-dynamical interaction force between particle and observer (= 3D vector)
$\vec{E}$ $\vec{B}$	field vectors to arrive at the interaction force vector
$\vec{r}$	position of field generating particle $\overrightarrow{r_{part}}$ compared to observer $\overrightarrow{r_{obs}}$, in direction particle to observer: $\vec{r} = \overrightarrow{r_{obs}} - \overrightarrow{r_{part}}$. We use $\overrightarrow{r_{obs}} = \vec{0}$: observer in center.
$\vec{v}$ $\vec{a}$	velocity $\vec{v} = d\overrightarrow{r_{part}}/dt$ and acceleration $\vec{a} = d\vec{v}/dt$ vectors of particle relative to the observer
r v	vector norm of $\vec{r}$ and $\vec{v}$
c	velocity of electro-magnetic fields in vacuum = speed of light (≈ 299 792 km/s)
s	r - ($\vec{r} \bullet \vec{v}$) / c
ϵ_0	vacuum permittivity $\approx 8.854 \times 10^{-12} \, F / m$
q_{obs}	charge of the observer, located at the origin $(x, y, z) = (0, 0, 0)$
q_{part}	charge of the field generating particle
$\bullet$ $*$	represent the vector dot product and vector cross product

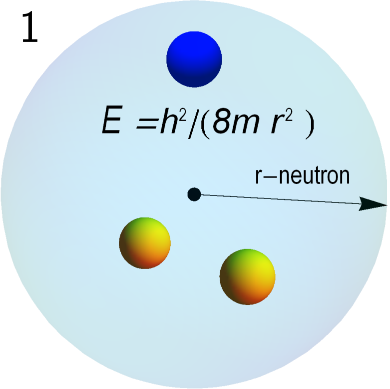
Quantum physics ($\pm$ 1930) - Standard model ($\pm$ 1970)

Particle in limited space $\Longrightarrow$ movement in ground state

$\downarrow$

Standard model $\Longrightarrow$ quarks with $v/c \rightarrow 1$





Fundamental forces in nature

force	**range**	**macroscopic static force [r]**	**velocity**
strong nuclear	nuclear	/	??
weak nuclear	nuclear	/	??
electro-dynamic	infinite	$1/r^2$	speed of light
gravity	infinite	$1/r^2$	speed of light
inertia	??	/	? ∞ ?

Fundamental forces in nature

force	range	macroscopic static force	velocity
strong nuclear	nuclear	/	??
weak nuclear	nuclear		
⤷ Electro-weak			
electro-dynamic	infinite	1/	f light
gravity	infinite	1/r	of light
inertia	??	/	? ∞ ?

Fundamental forces in nature

force	range	macroscopic static force [r]	velocity
strong nuclear	nuclear	/	??
weak nuclear	*nuclear*	*/*	*??*
electro-dynamic	infinite	$1/r^2$	speed of light
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Fundamental forces in nature

force	range	macroscopic static force [r]	velocity
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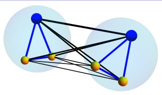
gravity	infinite	$1/r^2$	speed of light
inertia	??	/	? ∞ ?

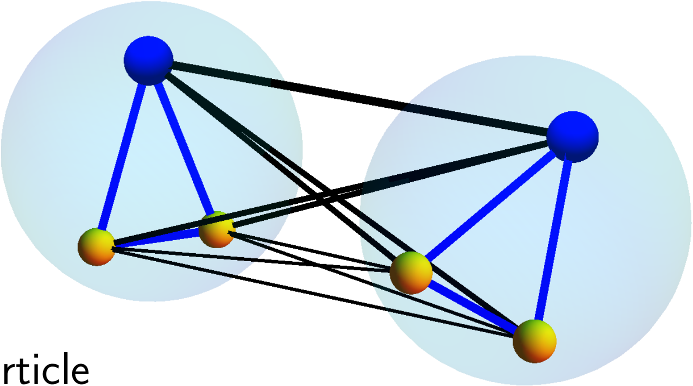
Can **gravity** be explained from the other forces?

Force between 2 neutrons - 1

What is $\overbrace{\text{the force}}^{electro-dynamical}$ between 2 neutrons?

that are macroscopically apart.





$$\underline{\text{neutron}}$$

$$\neq 1 \quad \text{static} \quad \text{neutral particle}$$

$$= 3 \; \boxed{\textbf{moving}} \; \text{charged quarks!}$$

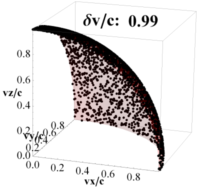
$$\overrightarrow{F_{n\leftrightarrow n}} = \sum_{i=1}^{3} \sum_{j=1}^{3} \overbrace{\overrightarrow{F_{q_i \leftrightarrow q_j}}}^{\text{Liénard-Wiechert}}$$

Force between 2 oscillatory moving charges

at origin and position $\vec{r} = (x, y, z), = (0, 0, r)$

and velocity: $\vec{v} = \delta v\,(Cos[\phi_v]\,Sin[\theta_v],\ Sin[\phi_v]\,Sin[\theta_v],\ Cos[\theta_v])$

total LW force: integrate over all velocities.

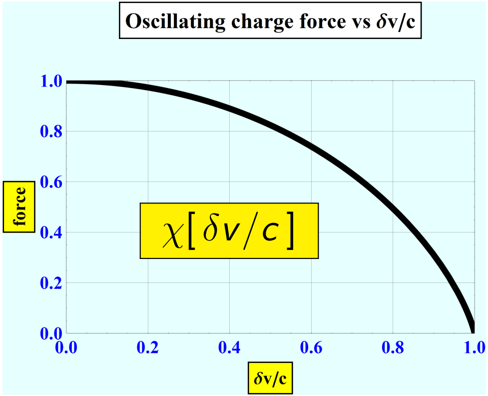


$$\overbrace{\overrightarrow{F_{q_i \leftrightarrow q_j}}}^{\text{Liénard-Wiechert}} = \frac{-q_i\,q_j}{4\,\pi\,\epsilon_0\,r^2} \cdots$$

$$\cdots \left(0,\ 0,\ \frac{1-(\delta v/c)^2}{\delta v/c}\,ArcTanh[\,\delta v/c\,]\right)$$

Note: $\delta v/c \rightarrow 1$

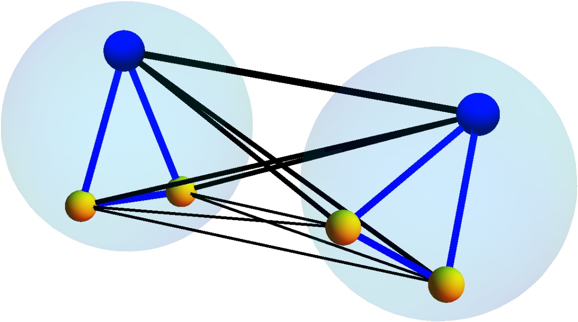
for quarks in proton/neutron

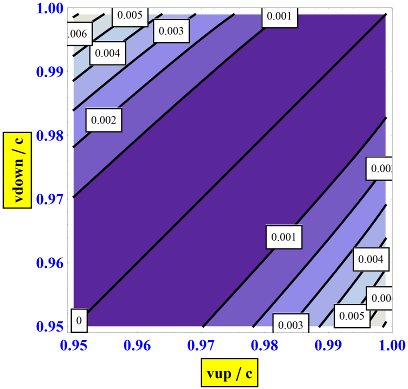


Force between 2 neutrons - 2

$$\overrightarrow{F_{n\leftrightarrow n}} = \left(\frac{-q_0^2}{4\,\pi\,\epsilon_0\,r^2}\right)\left(\frac{1}{9}\right)\left(0,\,0,\,4\chi[\delta v^{nn}_{uu}/c] - 8\chi[\delta v^{nn}_{ud}/c] + 4\chi[\delta v^{nn}_{dd}/c]\right)$$

with $\delta v^{nn}_{ud}/c$: velocity (delta) between up and down quarks of the 2 neutrons



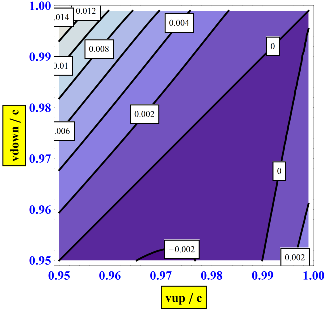


Forces proton-neutron & proton-proton

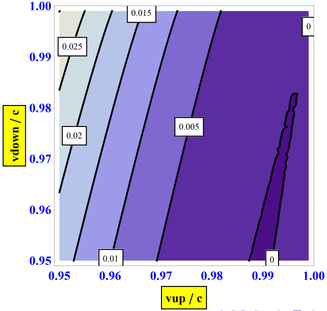
$$\overrightarrow{F_{p\leftrightarrow n}} = \left(\frac{-q_0^2}{4\,\pi\,\epsilon_0\,r^2}\right)\left(\frac{1}{9}\right)\left(0\,,\,0\,,\;8\chi[\delta v_{uu}^{pn}/c] - 10\chi[\delta v_{ud}^{pn}/c] + 2\chi[\delta v_{dd}^{pn}/c]\right)$$

$$\overrightarrow{F_{p\leftrightarrow p}} = \left(\frac{-q_0^2}{4\,\pi\,\epsilon_0\,r^2}\right)\left(\frac{1}{9}\right)\left(0\,,\,0\,,\;16\chi[\delta v_{uu}^{pp}/c] - 8\chi[\delta v_{ud}^{pp}/c] + \chi[\delta v_{dd}^{pp}/c]\right)$$

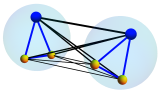
proton-neutron

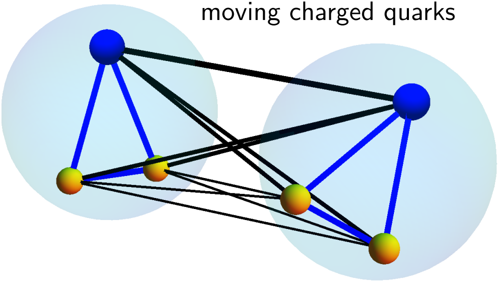


proton-proton



Conclusions: electro-dynamical forces between 2 static neutrons





Force properties:

STATIC

INFINITE

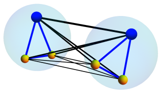
as function of distance: $1/r^2$

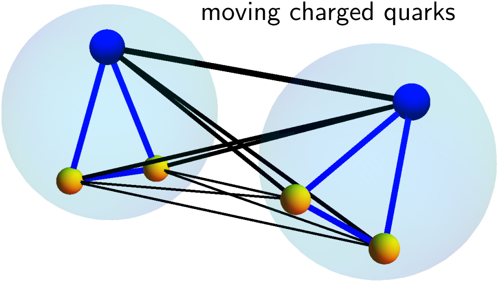
speed = speed of electro-dynamics = speed of light

$\Longrightarrow$

complies to Liénard-Wiechert equation

Conclusions: electro-dynamical forces between 2 static neutrons





Force properties: **quark-gravity**

STATIC

INFINITE

as function of distance: $1/r^2$

speed = speed of electro-dynamics = speed of light

$\Longrightarrow$

complies to Liénard-Wiechert equation

Fundamental forces in nature

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inertia	??	/	? ∞ ?

Can gravity be explained from the other forces?

Fundamental forces in nature

force	range	macroscopic static force [r]	velocity
strong nuclear	nuclear	/	??
weak nuclear	*nuclear*	/	*??*
electro-dynamic	infinite	$1/r^2$	speed of light
gravity	*infinite*	$1/r^2$	*speed of light*
inertia	?		?

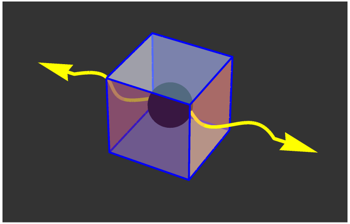
Can gravity be explained from the other forces?

yes: quark-gravity

gravitational mass in motion

Gravitation is due to oscillatory charges

$\Longrightarrow$ follows Doppler law !

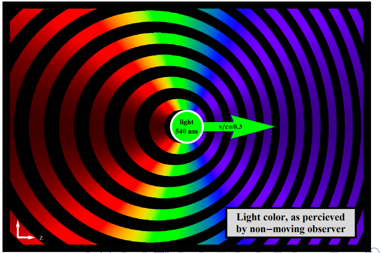


Alternatively :

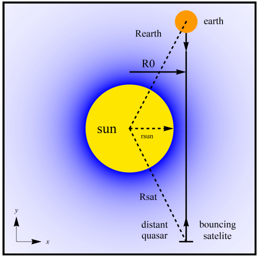
$$mass_{grav}\,[\,v_z\,,\theta\,] = E\,/c^2 = h\nu/c^2$$

$$= \frac{h\,\nu_0}{c^2}\;\frac{\sqrt{1-(v_z/c)^2}}{1+(v_z/c)\;Cos[\,\theta\,]}$$

$$= m_0\,\frac{\sqrt{1-(v_z/c)^2}}{1+(v_z/c)\;Cos[\,\theta\,]}$$



Optical properties of quark-gravity



moving quarks inside nucleus | moving electrons around nucleus

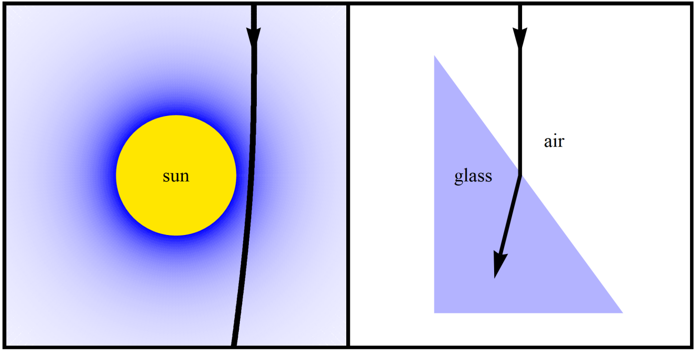
influence electric fields of passing light

leading to a
reduction of speed of light
$\Longrightarrow$ **refraction**

$$n = c/c_{grav} > 1$$

$$\Downarrow$$

Shapiro time delay !



Refraction in Full & Linearized General Relativity

In General Relativity (GR), the photon path is given by $d\,s^2 = 0$.
with metrics, around a central mass M :

Full General Releativity $\quad ds^2 = (1 - \frac{2\,G\,M_{sun}}{c^2\,r})\,c^2\,dt^2 - (1 - \frac{2\,G\,M_{sun}}{c^2\,r})^{-1}\,dr^2 - r^2\,(d\theta^2 + Sin^2[\theta]\,d\phi^2)$

Linearized General Releativity $\quad ds^2 = (1 - \frac{2GM_{sun}}{c^2 r})c^2 dt^2 - (1 + \frac{2GM_{sun}}{c^2 r})\,(dx^2 + dy^2 + dz^2)$

$$assuming\ \ 2\,G\,M_{sun}/(c^2\,r) \ll 1\ \ with\ \ r = \sqrt{x^2 + y^2 + z^2}\ \ we\ find :$$

$$c_{grav}^{lin\ GR} = \sqrt{\frac{dx^2+dy^2+dz^2}{dt^2}} = c\sqrt{\frac{1 - \frac{2\,G\,M_{sun}}{c^2\,r}}{1 + \frac{2\,G\,M_{sun}}{c^2\,r}}} \approx c\,\left(1 - \frac{2\,G\,M_{sun}}{c^2\,r}\right) = \sqrt{\frac{dr^2}{dt^2}} = c_{grav}^{full\ GR}$$

Both Full & Linearized General Relativity give as refractive index:

$$n = \frac{c}{c_{grav}^{lin}} = \frac{c}{c_{grav}^{full\ GR}} = \frac{1}{\left(1 - \frac{2\,G\,M_{sun}}{c^2\,r}\right)}$$

Refraction: relation General Relativity to quark-gravity

General Relativity

with $2\,G\,M_{sun}/(c^2\,r) \ll 1$

Linearized GR

$$n = \frac{1}{\left(1 - \frac{2\,G\,M_{sun}}{c^2\,r}\right)}$$

Gravitational Maxwell equations

Liénard-Wiechert force (quark-gravity)

From quark-gravity to refraction

General Relativity

with $2\,G\,M_{sun}/(c^2\,r) \ll 1$

Linearized GR

$$n = \frac{1}{\left(1 - \frac{2\,G\,M_{sun}}{c^2\,r}\right)} \approx 1 + \frac{2\,G\,M_{sun}}{c^2\,r}$$

Gravitational Maxwell equations

Liénard-Wiechert force (quark-gravity)

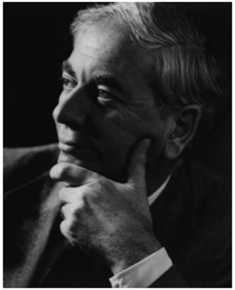
Fundamental forces in nature

force	**range**	**macroscopic static force [r]**	**velocity**
strong nuclear	nuclear	/	??
weak nuclear	*nuclear*	/	??
electro-dynamic	infinite	$1/r^2$	speed of light
gravity	*infinite*	$1/r^2$	*speed of light*
inertia	??	/	? ∞ ?

Can __inertia__ be explained from the other forces?

Approach

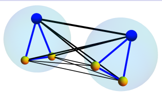
Suggestion by D.W. Sciama (1953) :

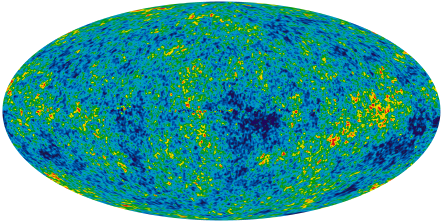


Can inertia be explained from gravity?

Compute force on an **accelerated** test mass,
as created by the gravitational Liénard-Wiechert force,
of **all masses** of the universse !

Where are all masses ? $\Longrightarrow$ model of universe

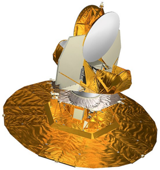




1900 : Universe is static and limited in size to Milky Way.

1930 : Universe is expanding, acc. Hubble law: $v = H\,r$
and much larger than distance to Andromeda.

2020 : Universe is expanding (accelerated)
and larger than $c/H = r_{Hubble}$.



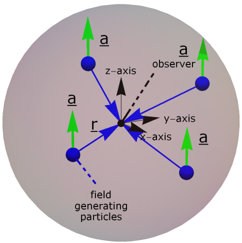
Inertia calculations for various models of universe

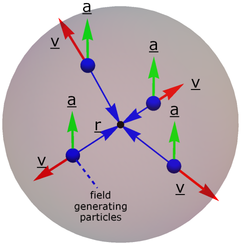
Determine impact of all gravitating masses on accelerated test mass

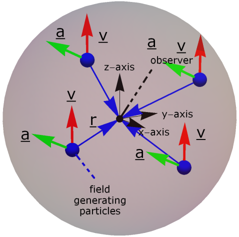
Accelerated test mass sees all masses of universe
instantaneously counter-accelerated

universe $\rightarrow$ $\downarrow$ observer $\vec{v}$	static	expanding
$v/c \rightarrow 0$	A	C
$0 \leq v/c < 1$	B	

Static universe for mathematical 'simplicity'







Gravitational Liénard-Wiechert force, between 2 moving masses

$$\vec{F_g} = -\, m_{obs} \, (\vec{E_g} + \vec{v} * \vec{B_g})$$

$$\vec{E_g} = (\, G \, m_{part} \, / s^3) (\, (1 - (v/c)^2) (\vec{r} - r\vec{v}/c) + \vec{r} * (\, (\vec{r} - r\vec{v}/c) * \vec{a}\,) / c^2 \,)$$

$$\vec{B_g} = \vec{r} * \vec{E_g} / (r\, c)$$

$\vec{F_g}$	Gravitational interaction force between particle and observer (= 3D vector)
$\vec{E_g}$ $\vec{B_g}$	field vectors to arrive at the interaction force vector
$\vec{r}$	position of gravity field generating particle $\overrightarrow{r_{part}}$ compared to observer $\overrightarrow{r_{obs}}$, in direction particle to observer: $\vec{r} = \overrightarrow{r_{obs}} - \overrightarrow{r_{part}}$. For $\overrightarrow{r_{obs}} = \vec{0}$: observer in center.
$\vec{v}$ $\vec{a}$	velocity $\vec{v} = d\overrightarrow{r_{part}}/dt$ and acceleration $\vec{a} = d\vec{v}/dt$ vectors of particle relative to the observer
r v	vector norm of $\vec{r}$ and $\vec{v}$
c	velocity of the expansion of gravity in vacuum
s	r - ($\vec{r}$ • $\vec{v}$) / c
G	Gravitational constant $\approx 6.67 \times 10^{-11} m^3\, kg^{-1}\, s^{-2}$
m_{obs}	gravitational mass of the static observer, located at the origin $(x, y, z) = (\,0\,,\,0\,,\,0\,)$
m_{part}	gravitational mass of the field generating, moving, particle
• $*$	represent the vector dot product and vector cross product

A: Static homogeneous Universe, accelerated: $\vec{v} = \vec{0}, \vec{a} \neq \vec{0}$

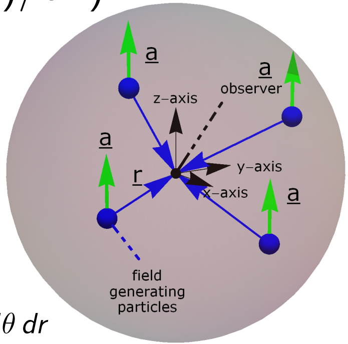
$$\vec{Fg} = -G\, m_{obs} \left(\vec{Eg} + \cancel{\vec{v} * \vec{Bg}} \right)$$

$$= -\frac{G\, m_{obs}\, mpart}{r^3} \left(\vec{r} + \left(\vec{r} * \left(\vec{r} * \vec{a} \right) \right) / c^2 \right)$$

$$= -\frac{G\, m_{obs}\, mpart}{r^3} \left(\vec{r} + \left(\left(\vec{r} \bullet \vec{a} \right) \vec{r} - r^2\, \vec{a} \right) / c^2 \right)$$

Integrate over all masses:

$$\overrightarrow{F_g^{tot}} = \int^{all\ \ mass} d\, \vec{Fg}$$



Model of static universe:
sphere with radius r_{max}
with constant mass density ρ.

$$m_{part} \rightarrow d\, m_{part} = \rho\, dx\, dy\, dz = \rho\, Sin[\theta]\, r^2\, d\phi\, d\theta\, dr$$

A: Impact of acceleration in static universe, $\vec{v} = \vec{0}, \vec{a} \neq \vec{0}$

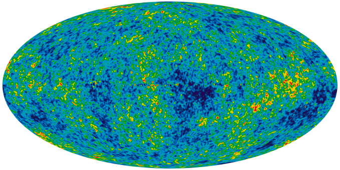
$$\overrightarrow{F_g^{tot}} = m_{obs}\, \vec{a}\, (\, 8\pi \rho\, G \,/\, 3\, c^2)\, \int_0^{r_{max}} r\, dr$$

$$find\ r_{max}\ via\ Hubble\ law :\ v = H\, r \rightarrow r_{max} = c / H$$

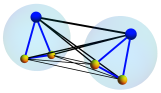
$$\overrightarrow{F_g^{tot}} = m_{obs}\, \vec{a}\, (\, 4\pi \rho\, G \,/\, 3\, H^2\,)$$

$$WMAP :\ flat\ space \rightarrow \Omega_{tot} = 8\pi \rho\, G / 3\, H^2 = 1.02 \pm 0.02$$

↪ Friedmann model in General Relativity (GR)



Newton's second law: $\vec{F} = m\, \vec{a}$!

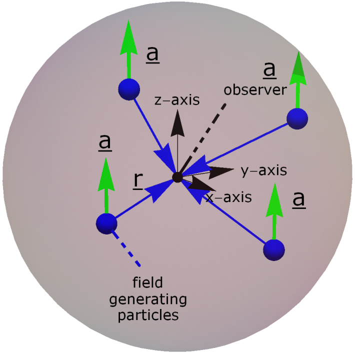


A: Acceleration in static universe: INERTIA

When all particles in static universe accelerate, the resulting **gravitational** force

is proportional to m_{obs} and $\vec{a}$

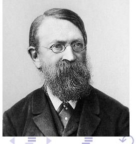
in the direction of acceleration.



The mass of the observer attempts to join the acceleration of all masses of the universe.

It resists the externally applied force: INERTIA.

Mach's principle

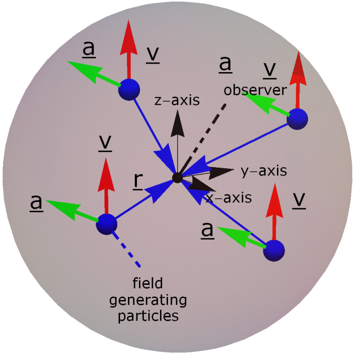


B: Impact of acceleration in static universe, $\vec{v} \neq \vec{0}, \vec{a} \neq \vec{0}$

When all particles of static universe move ($0 \leq v/c < 1$), it is the observer counter-moving.

Gravitational mass vs velocity follows Doppler law:

$$d\, m_{part} = \rho \frac{\sqrt{1-(v_z/c)^2}}{1+(v_z/c)\, Cos[\theta]} Sin[\theta]\, r^2\, d\phi\, d\theta\, dr$$



Again integrating over entire static universe, with $r_{max} = c/H$

B: Impact of acceleration in static universe, $\vec{v} \neq \vec{0}, \vec{a} \neq \vec{0}$

Total gravitational force on particle m_{obs} ,
which observes all masses of the static universe
to have velocity $\vec{v} = (0, 0, v_z)$
and acceleration $\vec{a} = (a_x, a_y, a_z)$

using: $\vec{E}^* = \vec{E}/m_{part}$ and $\vec{B}^* = \vec{B}/m_{part}$ and Mathematica SW.

$$\overrightarrow{F_g^{tot}} = -m_{obs} \int_0^{c/H} \int_0^{\pi} \int_0^{2\pi} (\vec{E}_g^* + \vec{v} * \vec{B}_g^*)\, \rho \, \frac{\sqrt{1-(v_z/c)^2}}{1+(v_z/c)\, Cos[\theta]} \, Sin[\theta]\, r^2 \, d\phi \, d\theta \, dr$$

$$= m_{obs} \, \frac{4\pi\rho\, G}{3\, H^2} \left(\frac{a_x}{\sqrt{1-(v_z/c)^2}} , \frac{a_y}{\sqrt{1-(v_z/c)^2}} , \frac{a_z - H\, v_z\, (1-(v_z/c)^2)}{\sqrt{1-(v_z/c)^2}^{\,3}} \right)$$

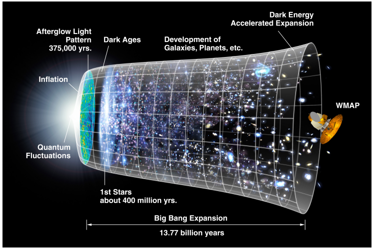
B: Impact of acceleration in static universe, $\vec{v} \neq \vec{0}, \vec{a} \neq \vec{0}$

This describes the relativistic momentum change,

When negletcting the new term, containing $H\, v_z$:

with: $\gamma[v_z/c] = 1/\sqrt{1-(v_z/c)^2}$

$$\overrightarrow{F_g^{tot}} = m_{obs} \frac{4\pi\rho\, G}{3\, H^2} d\left(\gamma[v_z/c]\, \vec{v}\right)/dt$$



The term containing $a_z - H\, v_z\, (1-(v_z/c)^2)$

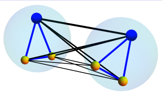
leads to an exponential increasing velocity v_z ,

which can happen quickly for large values of the Hubble contant H ,

as occured during the early phases of the universe.

accelerated universe?

Can this term be linked to 'inflation' of the early universe?



C: Hubble expansion of universe, $\vec{a} \neq \vec{0}$

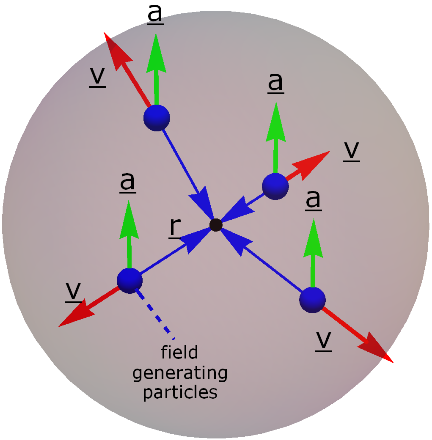
± 1930

Linear Hubble expansion law:

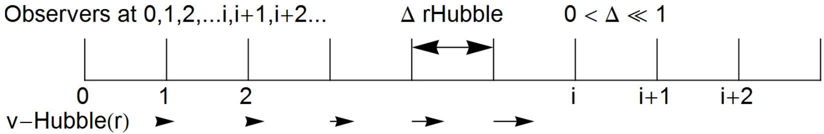
$$\vec{v} = H\,\vec{r} \rightarrow r_{Hubble} = c/H$$

Find relativistc form of Hubble law

No (initial) movement of observer, compared to average of 'nearby' masses ($< 0.01\, r_{Hubble}$).

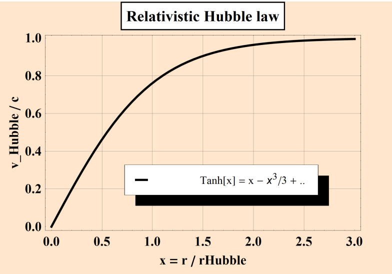


C: Hubble expansion - up to relativistic velocity



Equidistant lineup of observers, separated by distance $\Delta\, r_{Hubble}$,
Each observer i sees neighbor i+1 move with a velocity:
$v = H * \Delta\, r_{Hubble} = H * \Delta * c/H = \Delta\, c$
To calculate velocity of observer i+2 from observer i:
Apply recursive relativistic velocity addition, starting from:
$vnew(v1, v2) = (v1 + v2)/(1 + (v1 * v2)/c^2)$
For observer in origin this procedure can be used to obtain relativisctic velocity. Final (numerical) result:

$$v(r) = c\, Tanh\,[\, r/r_{Hubble}\,] \qquad \rightarrow\rightarrow\rightarrow\rightarrow$$



C: Inertia in Hubble expanding universe

All masses of universe are accelerated, and move radially away from observer. Doppler impact on gravitational mass:

$$d\,mass = \rho \frac{\sqrt{1-(v_{Hubble}/c)^2}}{1+(v_{Hubble}/c)}\, dx\, dy\, dz$$

$$= \rho\;\; e^{-r/r_{Hubble}}\; Sin[\theta]\, r^2\;\; d\phi\, d\theta\, dr$$

Compute total inertial force of **infinite** expaning universe, with acceleration $\vec{a} = (\,a_x\,,\,a_y\,,\,a_z\,)$,using integration variable $x = r/r_{Hubble}$:

$$\overrightarrow{F_g^{tot}} = -\,m_{obs} \int_0^\infty \int_0^\pi \int_0^{2\pi} (\,\vec{E}_g^* + \vec{v} * \vec{B}_g^*\,)\,\rho\;\; e^{-r/r_{Hubble}}\; Sin[\theta]\, r^2\;\; d\phi\, d\theta\, dr$$

$$= m_{obs} \frac{4\,\pi\,\rho\,G}{3\,H^2}\,(\,a_x\,,\,a_y\,,\,a_z\,) \int_0^\infty x\,e^{-x}\,(\,1 + e^{-2x}\,)\;dx$$

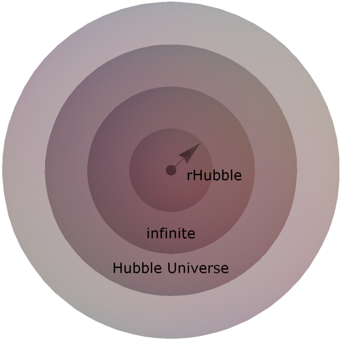
$$= m_{obs}\,\vec{a}\,\frac{40\,\pi\,\rho\,G}{27\,H^2} = m_{obs}\,\vec{a}$$

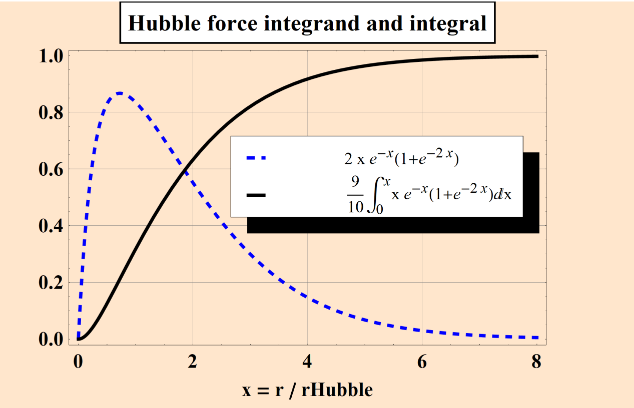
re-using WMAP (flat space) result: $8\pi\rho\,G/3\,H^2 = 1$ *in Friedmann model of GR.*

For convenience, we replace $^{40}/_{27}$ by $^{4}/_{3}$, without change of trends.

C: Inertia contribution by distant stars, in expanding universe

Inertia is mostly due to mass, at distances larger than r_{Hubble}





If universe is not infinite (implying earth is not in center), then asymmetrical mass distribution $\Longrightarrow$ asymmetrical inertial mass, but $\neq$ Eötvös experiments on equality of gravitational and inertial mass !!

Fundamental forces in nature

force	range	macroscopic static force [r]	velocity
strong nuclear	nuclear	/	??
weak nuclear	*nuclear*	/	??
electro-dynamic	infinite	$1/r^2$	speed of light
gravity	*infinite*	$1/r^2$	*speed of light*
inertia	??	/	? ∞ ?

Can **inertia** be explained from the other forces?

Fundamental forces in nature

force	range	macroscopic static force [r]	velocity
strong nuclear	nuclear	/	??
weak nuclear	*nuclear*	/	??
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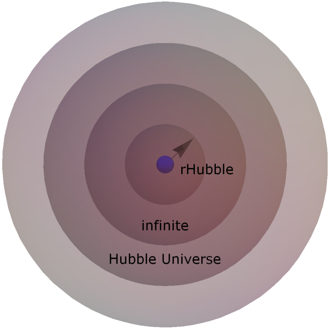
gravity	*infinite*	$1/r^2$	*speed of light*
inertia	*??*	/	

Can **inertia** be explained from the other forces?

yes: gravity of universe masses

Evolution of infinite Hubble universe

$$4\pi \rho \, G / 3 \, H^2 = 1$$



Study small sphere in infinite Hubble universe:

with constant total mass $M = 4/3\pi \, \rho \, r^3$

using: $H(t) = (dr \, / \, dt) \, / \, r$

results in: $(dr \, / \, dt) - \sqrt{M \, G \, / \, r} = 0$

which solves as the Einstein-deSitter mass filled, expanding universe:

$$r(t) = r_0 \, (1 + \sqrt{3 \, \pi \, G \rho_0} \; t)^{2/3} = r_0 \, (1 + 3/2 \, H_0 \, t \,)^{2/3}$$

Red shift in infinite Hubble universe

- The infinite homogeneity implies that no net gravitational force exists when moving from one place to another.
- Therefore observed red shifts from far away galaxies are not due to gravitational effects, but originate purely from velocity-Doppler effects, due to Hubble expansion.
- For a pure motion away from the observer, the red shift z is given by:

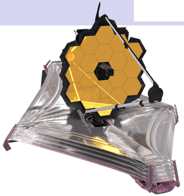
$$z = \sqrt{1 + v/c} \,/\, \sqrt{1 - v/c} \; - 1$$

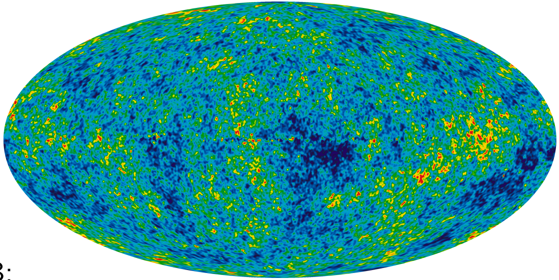
With relativistic Hublle expansion velocity law, red shift:

$$z(r) = e^{r/r_{Hubble}} - 1$$

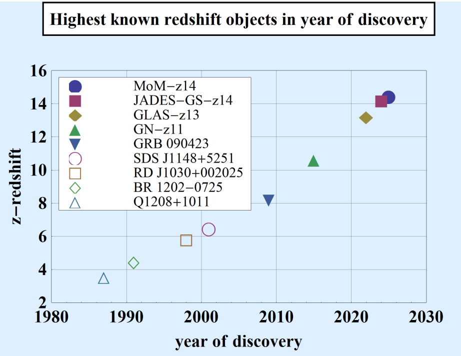
Red shift in infinite Hubble universe

Red shift increases exponentially with distance.
Therefore, with ever improving observation techniques,
we will find ever increasing red shifted objects!

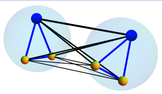




CMB:
z-redshift = 1089



Planetary orbit, low velocity (Newtonian) limit $v/c \rightarrow 0$

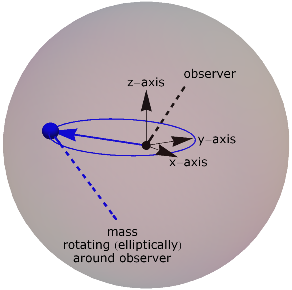


determined by balance of inertia and gravity

which are **both** proporional to G !!

Conclusion: G not important on cosmic scale !

Orbit: $\omega^2 \, r_{mass}^3 \; = \; 3 \, mass \, H^2 \, / \, (4 \, \pi \, \rho \,)$

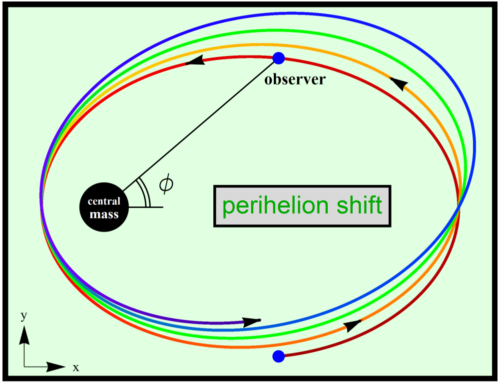


Mach's principle: orbit co-determined by 'distant masses',

with gravity as actor !

Planetary orbit, perihelion shift

Orbit calculus, starting from $\overrightarrow{F_g^{tot}}$ with v/c terms, gives proper amount of perihelion shift, but.... **OPPOSITE** sign.



Weak equivalence principle and impact of G

When only gravitational forces are involved:

$$\overrightarrow{F_g^{tot}} = \int^{all\ \ mass} d\,\vec{Fg} = \vec{0}$$

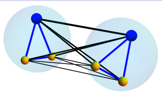
proportional to m_{obs} and G ,

which therefore both drop out of all (orbit) equations !

m_{obs} : weak equivalence principle

inertial = gravitational mass at least: for $v/c \rightarrow 0$

G : value or sign of G is not an orbit determining parameter



Gravitational and inertial mass under movement

Difference between gravitational and inertial mass under movement, when condition $v/c \to 0$ is not met:

$$\text{Gravitational mass} = m_0 \frac{\sqrt{1-(v_z/c)^2}}{1+(v_z/c)\,Cos[\theta]}$$

$$\text{Inertial mass} = \frac{m_0}{\sqrt{1-(v_z/c)^2}} \text{ and } \frac{m_0}{\sqrt{1-(v_z/c)^2}^{\,3}}$$

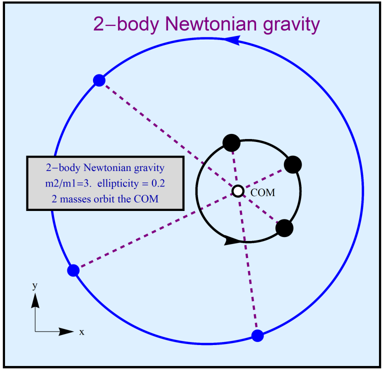
for acceleration perpendicular parallel to velocity

Gravity Poynting vector & waves

Gravitational Poynting vector $\rightarrow$ total radiated (wave) energy :

$$P_{grav}^{tot} = \frac{c^2}{4\pi G} \iint \left(\vec{E}_g * \left(\frac{\vec{r}}{r\,c} * \vec{E}_g \right) \right) \bullet \left(\frac{\vec{r}}{r} \right) dA = \frac{38\, G\, m_1^2\, r_\omega^4\, \omega^6}{5\, c^5} \left(1 + \frac{m_1}{m_2} \right)^2$$

in full analogon of electro-dynamical Poynting vector.



In electro-dynamics:

+ and - charge can move independently

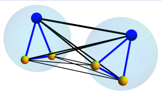
$\Longrightarrow$ di-pole radiation

In gravity:

2 masses orbit a 'Common Center of Mass"

$\Longrightarrow$ di-pole radiation not possible

$\Longrightarrow$ quadrupole radiation !



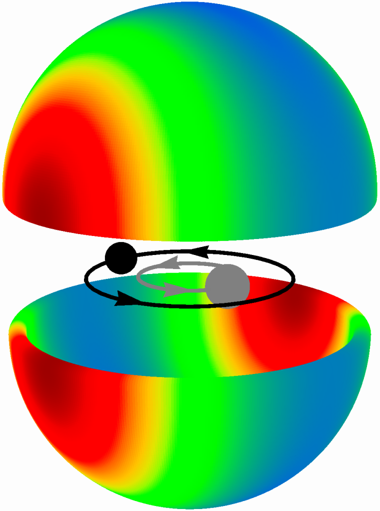
Gravity Poynting vector of binary system

Amount of radiated energy over sphere:

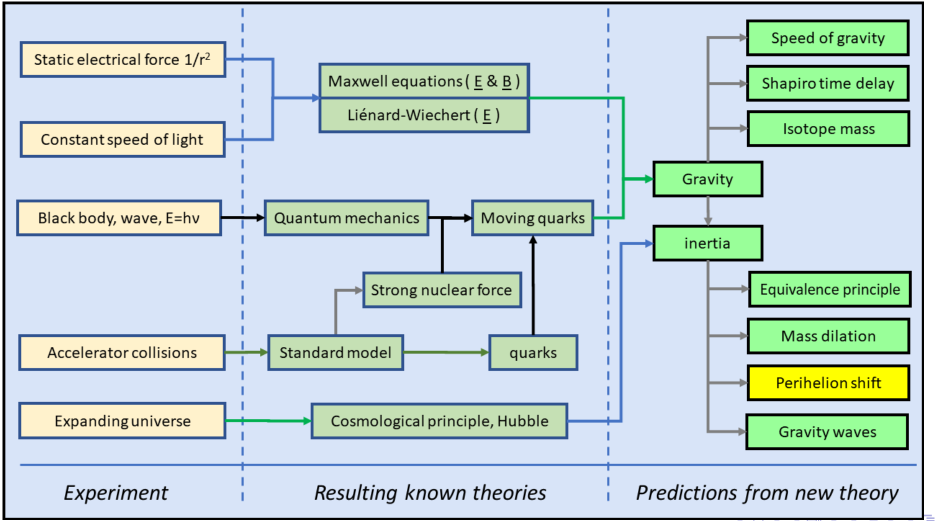
Blue = zero Red = max

Most energy is radiated near plane of orbits.

During 1 orbit, radiated energy has 2 maxima and 2 minima, in plane of orbit



Summary : origins of **GRAVITY** and **INERTIA** .

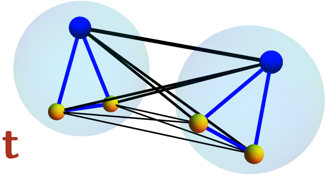


Fundamental forces in nature

force	**range**	**macroscopic static force [r]**	**velocity**
strong nuclear	nuclear	/	??
weak nuclear	*nuclear*	/	*??*
electro-dynamic	infinite	$1/r^2$	speed of light
gravity	*infinite*	$1/r^2$	*speed of light*
inertia	*??*	/	*? ∞ ?*

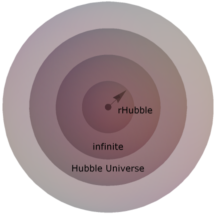
Conclusions - 1

Gravity is due to the electro-dynamical impact of moving quarks in the nuclei

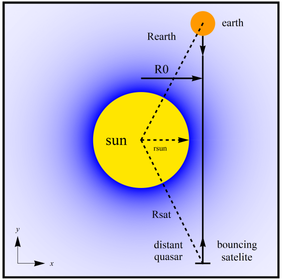


Inertia is due to the gravitational impact of all masses of the infinite, expanding universe

From the fundmental forces, only the **strong nuclear** and **electro-dynamical** forces remain.



Conclusions - 2



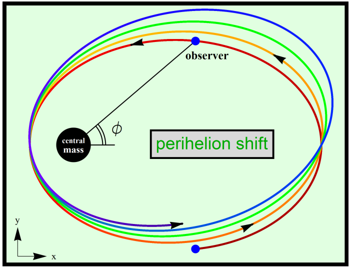
- Quark-gravity reduces the speed of light
  $\Longrightarrow$ bending of light & Shapiro time delay.
- Einstein-deSitter expanding universe model follows from inertial condition: $4\pi\rho\, G/3\, H^2 = 1$.
- Mass dilation is a gravitational effect.
- Universe **is**, **was** and **will always be** infinitely sized.
- Mach's principle (*inertia is due to the 'distant stars'*) is made explicit.
- Gravitational constant G is **NOT** an orbit determining factor.
- Cosmological red shift is purely Doppler: $z(r) = e^{r/rHubble} - 1$
- Gravity waves are quadrupoles, as masses orbit around each other.

Follow up - challenges

Gravitational impact of **electron** and anti-matter

High velocity inertial impact of expanding universe

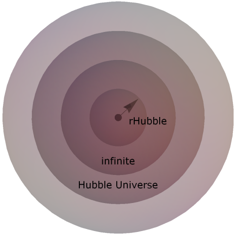
requires relativistic 3D-velocity addition,
insert into Liénard-Wiechert equations,
followed by analytic integration......



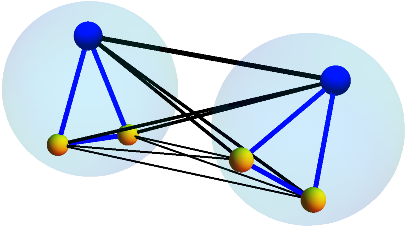
Accelerating universe
& Inflation

Perihelion shift

Epilog



Thank you
for your attention



What is the the speed of gravity and **WHY**?

speed of light, as gravity is electro-dynamically induced

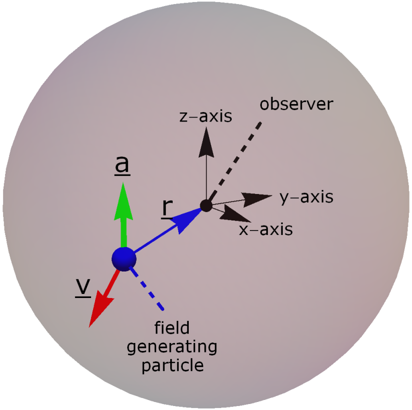
Is gravitational constant G important for planetary trajectories?

No

Field theory: retarded, dynamic Liénard-Wiechert

$$\frac{\vec{F}}{q_{obs}} = \vec{E} + \frac{\vec{v}}{c} * \left(\frac{\vec{r}}{r} * \vec{E}\right)$$

For fundamental physics, the magnetic field is a superfluous concept!



Intro to problem definition: absolute space?

What is root cause of the change in water surface shape?

Netwon:

absolute space

Mach:

distant stars