

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

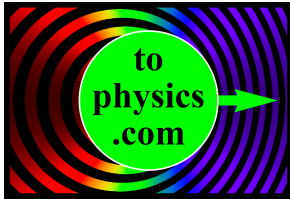
speed of light / ???

Is gravitational constant G important for planetary trajectories?

Yes / No

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

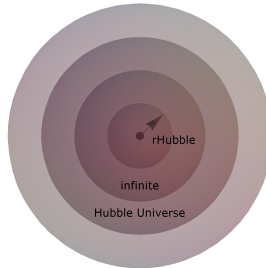
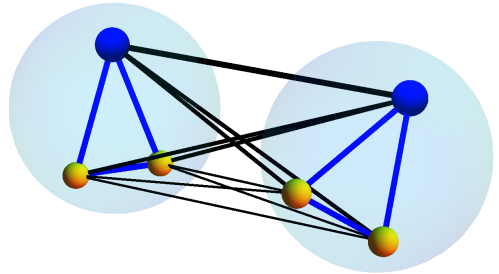
Jeroen van Engelshoven 

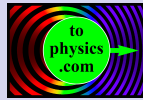


September 23, 2025

main outlines

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



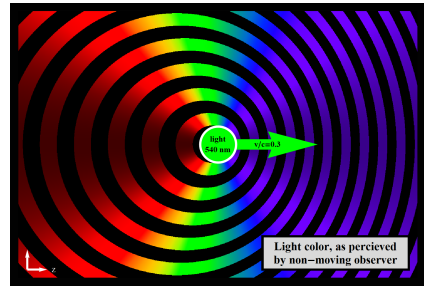
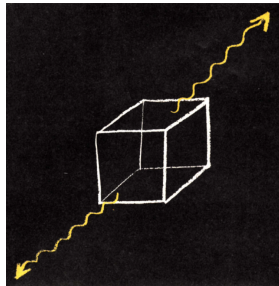


Special Relativity (1905)

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

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

- $E = mc^2$





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

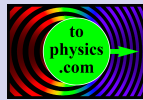
Force between 2 moving charged particles:

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

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

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

$\vec{F}$	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 $\vec{r}_{part}$ compared to observer $\vec{r}_{obs}$, in direction particle to observer: $\vec{r} = \vec{r}_{obs} - \vec{r}_{part}$. We use $\vec{r}_{obs} = \vec{0}$: observer in center.
$\vec{v} \vec{a}$	velocity $\vec{v} = d\vec{r}_{part}/dt$ 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 ($\approx 299\,792\text{ km/s}$)
s	$r - (\vec{r} \bullet \vec{v}) / c$
ϵ_0	vacuum permittivity $\approx 8.854 \times 10^{-12} \text{ F/m}$
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

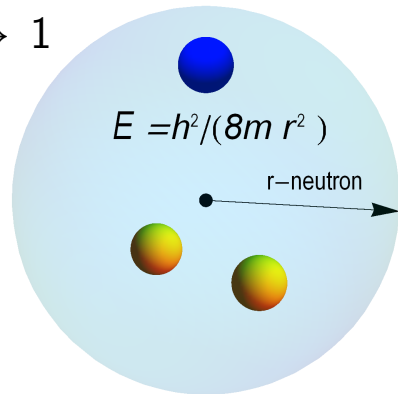
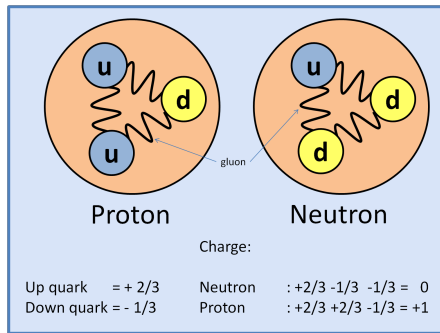


Quantum physics (± 1930) - Standard model (± 1970)

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

$\downarrow$

Standard model $\implies$ 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	??	/	? ∞ ?

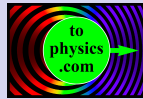


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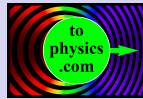


1979



Fundamental forces in nature

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Can gravity be explained from the other forces?

Force between 2 neutrons - 1

electro-dynamical

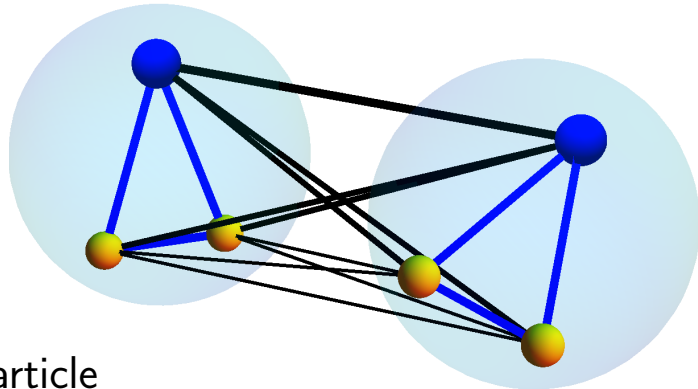
What is the force
between 2 neutrons?

that are macroscopically apart.

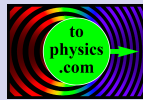
neutron

$\neq$ 1 static neutral particle

= 3 **moving** charged quarks!



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



Force between 2 oscillatory moving charges

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

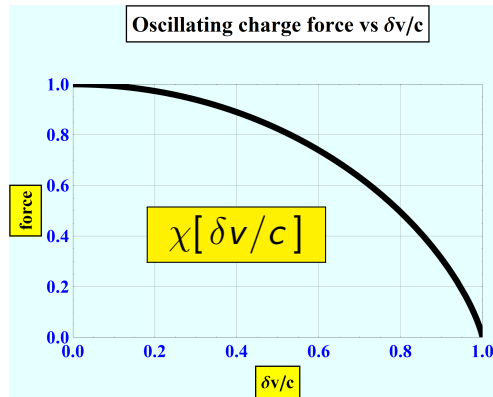
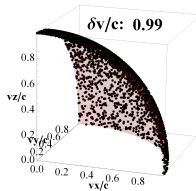
and velocity: $\vec{v} = \delta v (\cos[\phi_v] \sin[\theta_v], \sin[\phi_v] \sin[\theta_v], \cos[\theta_v])$

total LW force: integrate over all velocities.

Liénard-Wiechert

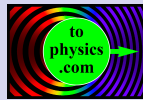
$$\overbrace{F_{q_i \leftrightarrow q_j}}^{\text{Liénard-Wiechert}} = \frac{-q_i q_j}{4 \pi \epsilon_0 r^2} \dots$$

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



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

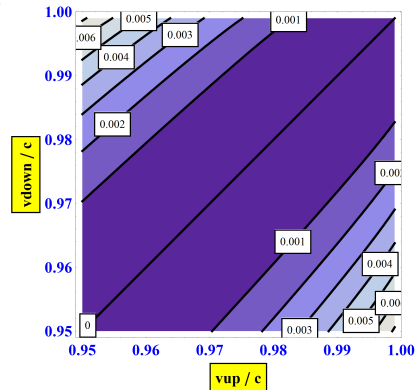
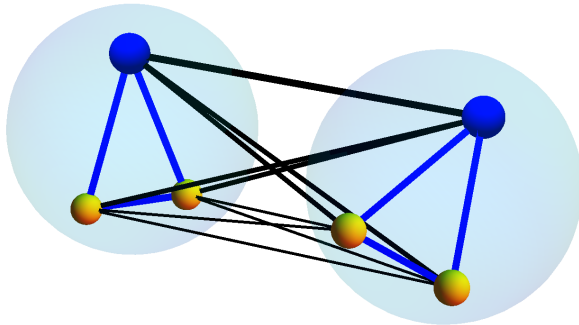
for quarks in proton/neutron

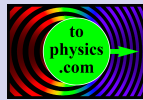


Force between 2 neutrons - 2

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

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



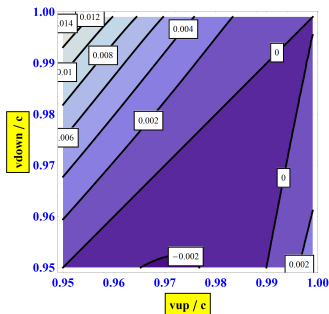


Forces proton-neutron & proton-proton

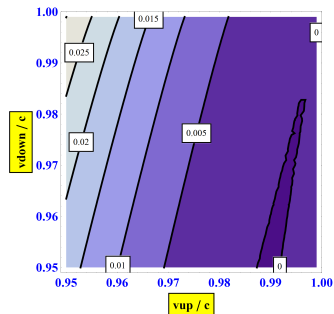
$$\overrightarrow{F_{p \leftrightarrow n}} = \left(\frac{-q_0^2}{4\pi\epsilon_0 r^2} \right) \left(\frac{1}{9} \right) (0, 0, 8\chi[\delta v_{uu}^{pn}/c] - 10\chi[\delta v_{ud}^{pn}/c] + 2\chi[\delta v_{dd}^{pn}/c])$$

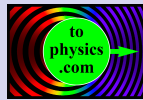
$$\overrightarrow{F_{p \leftrightarrow p}} = \left(\frac{-q_0^2}{4\pi\epsilon_0 r^2} \right) \left(\frac{1}{9} \right) (0, 0, 16\chi[\delta v_{uu}^{pp}/c] - 8\chi[\delta v_{ud}^{pp}/c] + \chi[\delta v_{dd}^{pp}/c])$$

proton-neutron



proton-proton





Conclusions on electro-dynamical forces between 2 static neutrons

Force properties:

STATIC

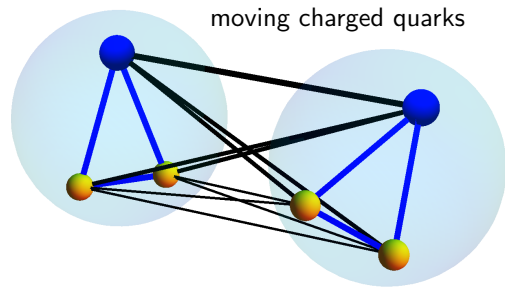
INFINITE

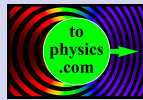
as function of distance: $1/r^2$

speed = speed of electro-dynamics = speed of light



complies to Liénard-Wiechert equation





Conclusions on electro-dynamical forces between 2 static neutrons

Force properties: **quark-gravity**

STATIC

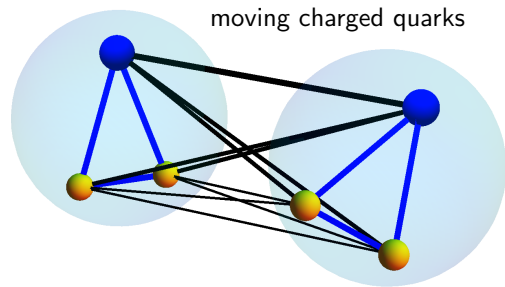
INFINITE

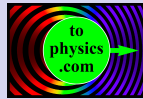
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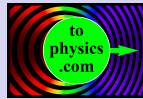




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force	range	macroscopic	velocity
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weak nuclear	nuclear	??	??
electro-dynamic	infinite	$1/r^2$	speed of light
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inertia	??	/	? ∞ ?

Can gravity be explained from the other forces?

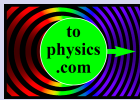


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inertia			

Can gravity be explained from the other forces?

yes: quark-gravity

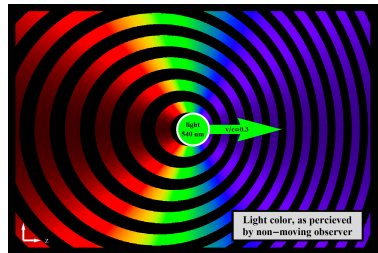
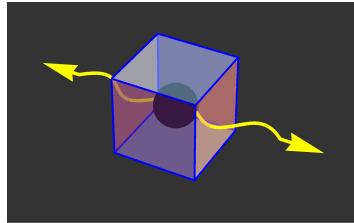


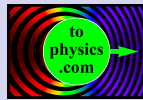
gravitational mass in motion

Gravitation is due to oscillatory charges
 $\Rightarrow$ follows Doppler law !

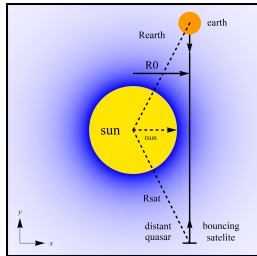
Alternatively :

$$\begin{aligned}
 mass_{grav} [v_z, \theta] &= E / c^2 = h\nu / c^2 \\
 &= \frac{h\nu_0}{c^2} \frac{\sqrt{1-(v_z/c)^2}}{1 + (v_z/c) \cos[\theta]} \\
 &= m_0 \frac{\sqrt{1-(v_z/c)^2}}{1 + (v_z/c) \cos[\theta]}
 \end{aligned}$$





Optical properties of quark-gravity



leading to a
reduction of speed of light

⇒ **refraction**

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

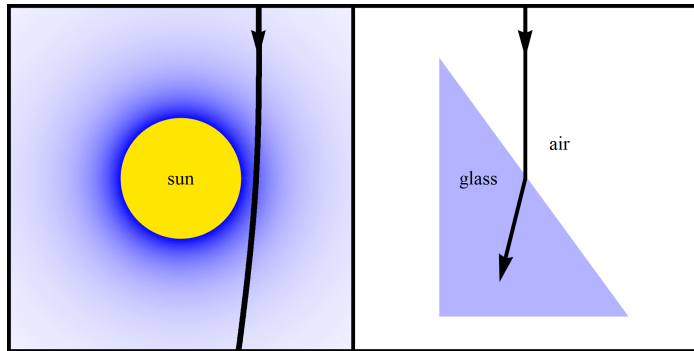


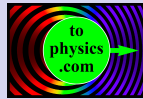
Shapiro time delay !

moving quarks
inside nucleus

moving electrons
around nucleus

influence electric fields of passing light





Refraction in Full & Linearized General Relativity

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

Full General Relativity $ds^2 = \left(1 - \frac{2GM_{\text{sun}}}{c^2 r}\right) c^2 dt^2 - \left(1 - \frac{2GM_{\text{sun}}}{c^2 r}\right)^{-1} dr^2 - r^2 (d\theta^2 + \sin^2[\theta] d\phi^2)$

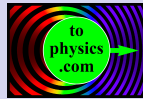
Linearized General Relativity $ds^2 = \left(1 - \frac{2GM_{\text{sun}}}{c^2 r}\right) c^2 dt^2 - \left(1 + \frac{2GM_{\text{sun}}}{c^2 r}\right) (dx^2 + dy^2 + dz^2)$

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

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

Both Full & Linearized General Relativity give as refractive index:

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



Refraction: relation General Relativity to quark-gravity

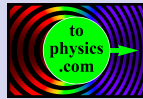
General Relativity

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

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



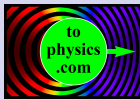
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<i>gravity</i>	<i>infinite</i>	<i>$1/r^2$</i>	<i>speed of light</i>
inertia	??	/	? ∞ ?

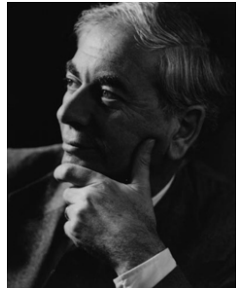
Can inertia be explained
from the other forces?



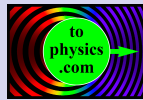
Approach

Suggestion by D.W. Sciama (1953) :

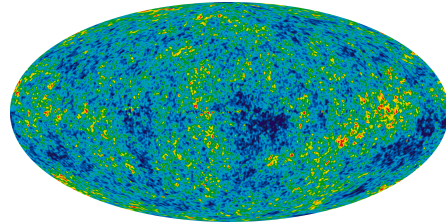
Can inertia be explained
from gravity?



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



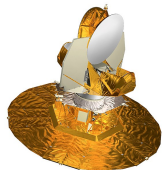
Where are all masses ? $\implies$ model of universe



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 $c/H = r_{Hubble}$.





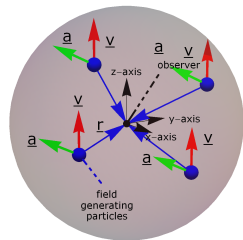
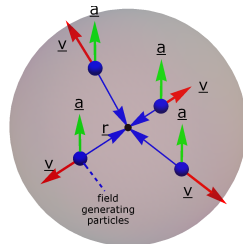
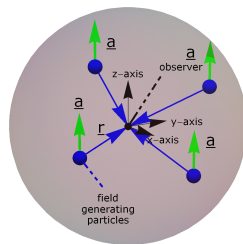
Inertia calculations for various models of universe

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'





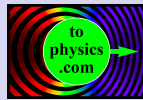
Gravitational Liénard-Wiechert force, between 2 moving masses

$$\vec{F}_g = -m_{obs} (\vec{E}_g + \vec{v} * \vec{B}_g)$$

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

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

$\vec{F}_g$	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 $\vec{r}_{part}$ compared to observer $\vec{r}_{obs}$, in direction particle to observer: $\vec{r} = \vec{r}_{obs} - \vec{r}_{part}$. For $\vec{r}_{obs} = \vec{0}$: observer in center.
$\vec{v}$ $\vec{a}$	velocity $\vec{v} = d\vec{r}_{part}/dt$ 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	$r - (\vec{r} \cdot \vec{v}) / c$
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
$\bullet$ $*$	represent the vector dot product and vector cross product



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

$$\begin{aligned}
 \vec{F}_g &= -G m_{obs} (\vec{E}_g + \vec{v} * \vec{B}_g) \\
 &= -\frac{G m_{obs} m_{part}}{r^3} (\vec{r} + (\vec{r} * (\vec{r} * \vec{a})) / c^2) \\
 &= -\frac{G m_{obs} m_{part}}{r^3} (\vec{r} + ((\vec{r} \cdot \vec{a}) \vec{r} - r^2 \vec{a}) / c^2)
 \end{aligned}$$

Integrate over all masses:

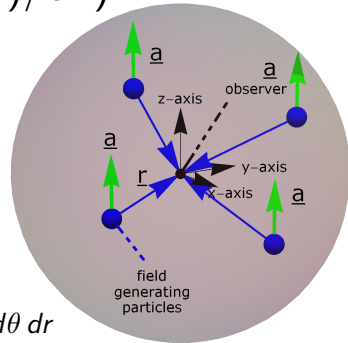
$$\vec{F}_g^{tot} = \int^{all\ mass} d\vec{F}_g$$

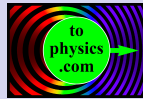
Model of static universe:

sphere with radius r_{max}

with constant mass density ρ .

$$\begin{aligned}
 m_{part} &\rightarrow d m_{part} = \\
 \rho dx dy dz &= \rho \sin[\theta] r^2 d\phi d\theta dr
 \end{aligned}$$





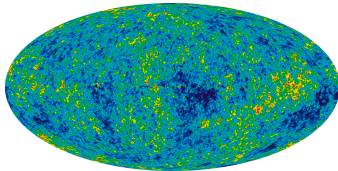
A: Impact of acceleration in static universe, $\vec{v} = \vec{0}$, $\vec{a} \neq \vec{0}$

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

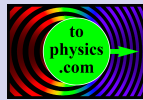
find r_{max} via Hubble law : $v = Hr \rightarrow r_{\text{max}} = c/H$

$$\vec{F}_g^{\text{tot}} = m_{\text{obs}} \vec{a} (4\pi\rho G / 3H^2)$$

WMAP : flat space $\rightarrow \Omega_{\text{tot}} = 8\pi\rho G / 3H^2 = 1.02 \pm 0.02$
 $\hookrightarrow$ Friedmann model in General Relativity (GR)

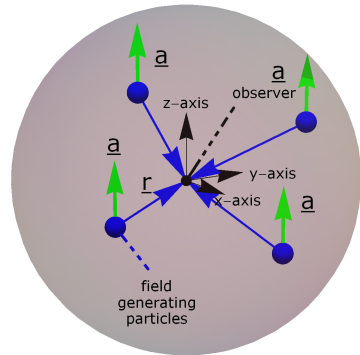


Newton's second law: $\vec{F} = m\vec{a}$!



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.

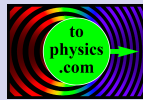


The mass of the observer attempts to join
the acceleration of all masses of the universe.

It resists the externally applied force: INERTIA.

Mach's
principle





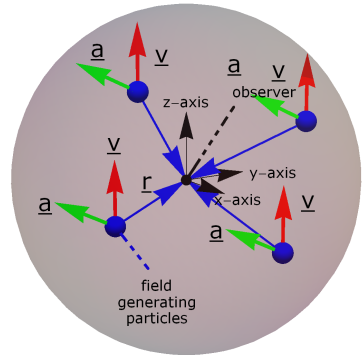
B: Impact of acceleration in static universe, $\vec{v} \neq \vec{0}, \vec{a} \neq \vec{0}$

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.



$$\begin{aligned} \vec{F}_g^{tot} &= -m_{obs} \int_0^{c/H} \int_0^\pi \int_0^{2\pi} (\vec{E}_g^* + \vec{v} * \vec{B}_g^*) \rho \frac{\sqrt{1-(v_z/c)^2}}{1+(v_z/c) \cos[\theta]} \sin[\theta] r^2 d\phi d\theta dr \\ &= m_{obs} \frac{4\pi\rho G}{3H^2} \left(\frac{a_x}{\sqrt{1-(v_z/c)^2}}, \frac{a_y}{\sqrt{1-(v_z/c)^2}}, \frac{a_z - H v_z (1-(v_z/c)^2)}{\sqrt{1-(v_z/c)^2}^3} \right) \end{aligned}$$



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

This describes the relativistic momentum change,

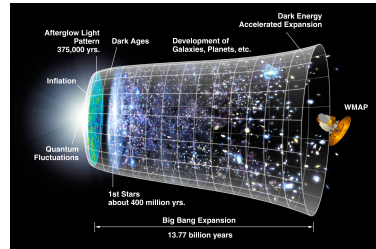
When neglecting the new term, containing $H v_z$:

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

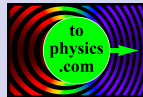
$$\vec{F}_g^{tot} = m_{obs} \frac{4\pi\rho G}{3H^2} d(\gamma[v_z/c] \vec{v})/dt$$

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 constant H , as occurred during the early phases of the universe.

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



accelerated universe?



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

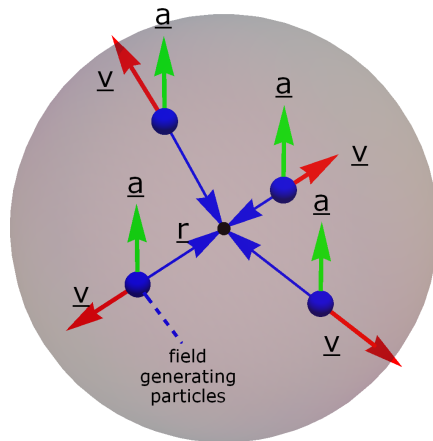
± 1930

Linear Hubble expansion law:

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

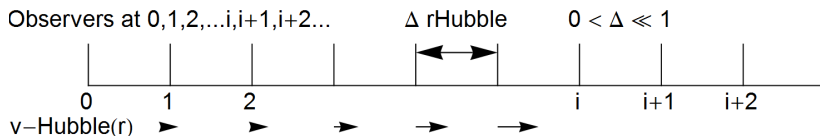
Find relativistic form of Hubble law

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 Δr_{Hubble} ,

Each observer i sees neighbor $i+1$ move with a velocity:

$$v = H * \Delta r_{Hubble} = H * \Delta * c/H = \Delta c$$

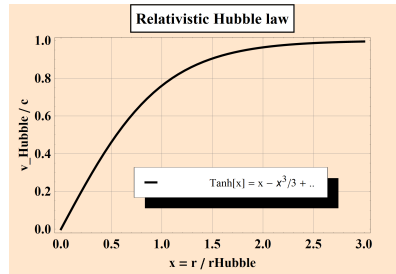
To calculate velocity of observer $i+2$ from observer i :

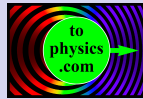
Apply recursive relativistic velocity addition, starting from:

$$v_{new}(v1, v2) = (v1 + v2)/(1 + (v1 * v2)/c^2)$$

For observer in origin this procedure can be used to obtain relativistic velocity. Final (numerical) result:

$$v(r) = c \tanh[r/r_{Hubble}] \quad \rightarrow \rightarrow \rightarrow \rightarrow$$





C: Inertia in Hubble expanding universe

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

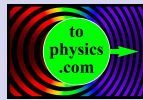
$$\begin{aligned} d\, mass &= \rho \frac{\sqrt{1-(v_{Hubble}/c)^2}}{1+(v_{Hubble}/c)} dx\, dy\, dz \\ &= \rho\, e^{-r/r_{Hubble}} \sin[\theta] r^2 d\phi\, d\theta\, dr \end{aligned}$$

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

$$\begin{aligned} \overrightarrow{F_g^{tot}} &= -m_{obs} \int_0^\infty \int_0^\pi \int_0^{2\pi} (\vec{E}_g^* + \vec{v} * \vec{B}_g^*) \rho\, e^{-r/r_{Hubble}} \sin[\theta] r^2 d\phi\, d\theta\, dr \\ &= m_{obs} \frac{4\pi\rho G}{3H^2} (a_x, a_y, a_z) \int_0^\infty x e^{-x} (1 + e^{-2x}) dx \\ &= m_{obs} \vec{a} \frac{40\pi\rho G}{27H^2} = m_{obs} \vec{a} \end{aligned}$$

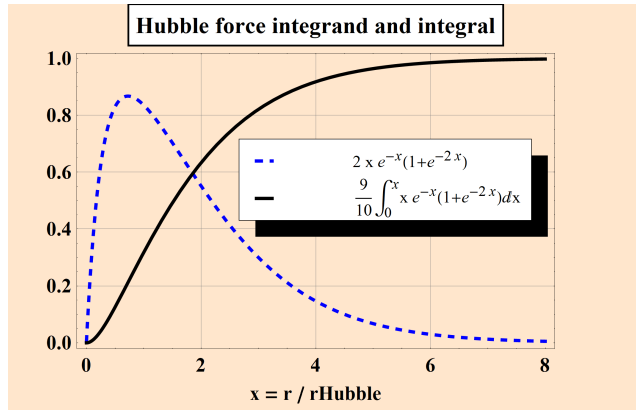
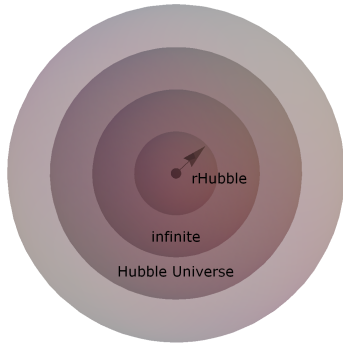
re-using WMAP (flat space) result: $8\pi\rho G/3H^2 = 1$ in Friedmann model of GR.

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 $\Rightarrow$ 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	/	??
<i>weak nuclear</i>	<i>nuclear</i>	/	??
electro-dynamic	infinite	$1/r^2$	speed of light
<i>gravity</i>	<i>infinite</i>	<i>$1/r^2$</i>	<i>speed of light</i>
inertia	??	/	? ∞ ?

Can inertia be explained
from the other forces?

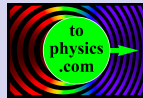


Fundamental forces in nature

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<i>gravity</i>	<i>infinite</i>	<i>$1/r^2$</i>	<i>speed of light</i>
<i>inertia</i>	<i>??</i>	/	

Can inertia be explained
from the other forces?

yes: gravity of
universe masses



Evolution of infinite Hubble universe

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

Study small sphere in infinite Hubble universe:

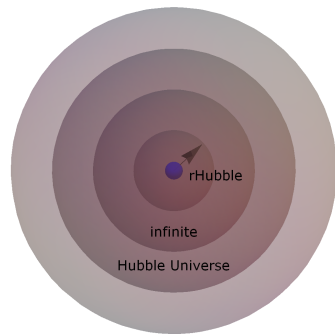
with constant total mass $M = 4/3\pi\rho r^3$

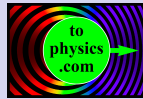
using: $H(t) = (dr/dt)/r$

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

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

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





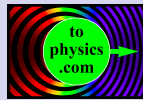
Red shift in infinite Hubble universe

- 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:

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

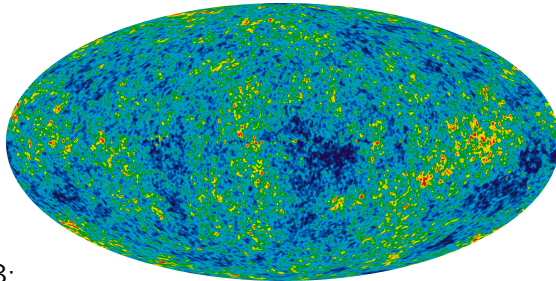
With relativistic Hubble expansion velocity law, red shift:

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

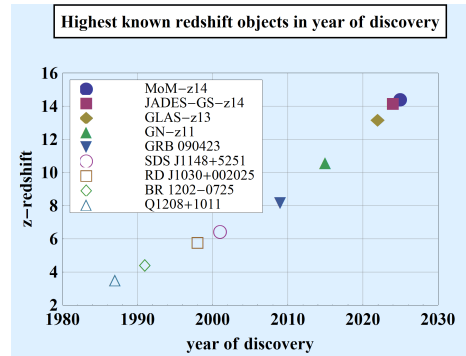


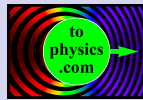
Red shift in infinite Hubble universe

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



CMB:
 $z\text{-redshift} = 1089$





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

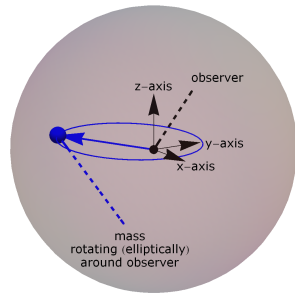
determined by balance of inertia and gravity

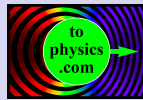
which are **both** proportional to G !!

Conclusion: G not important on cosmic scale !

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

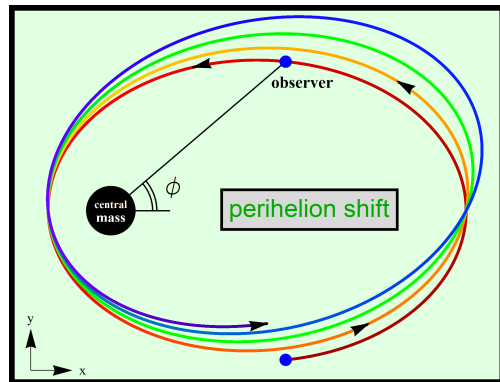
Mach's principle: orbit co-determined by 'distant masses',
with gravity as actor !

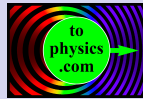




Planetary orbit, perihelion shift

Orbit calculus, starting from $\vec{F}_g^{tot}$ 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:

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

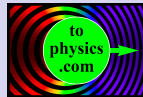
proportional to m_{obs} and G ,

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

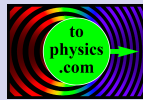


Gravitational and inertial mass under movement

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

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

$$\text{Inertial mass} = \frac{m_0}{\sqrt{1-(v_z/c)^2}} \text{ for acceleration perpendicular} \quad \text{and} \quad \frac{m_0}{\sqrt{1-(v_z/c)^2}^3} \text{ parallel to velocity}$$



Gravity Poynting vector & waves

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

$$P_{grav}^{tot} = \frac{c^2}{4\pi G} \oint \left(\vec{E}_g * \left(\frac{\vec{r}}{r c} * \vec{E}_g \right) \right) \cdot \left(\frac{\vec{r}}{r} \right) dA = \frac{76 G m_1^2 r_\omega^4 \omega^6}{15 c^5} \left(1 + \frac{m_1}{m_2} \right)^2$$

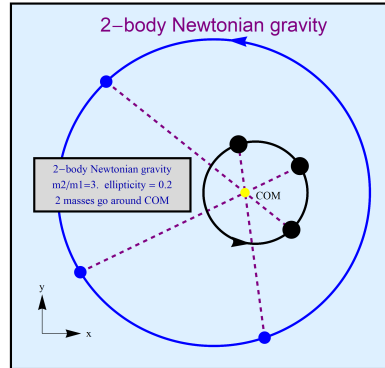
in full analogon of electro-dynamical Poynting vector.

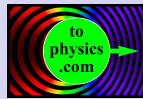
In electro-dynamics:

+ and - charge can move independently
 $\Rightarrow$ di-pole radiation

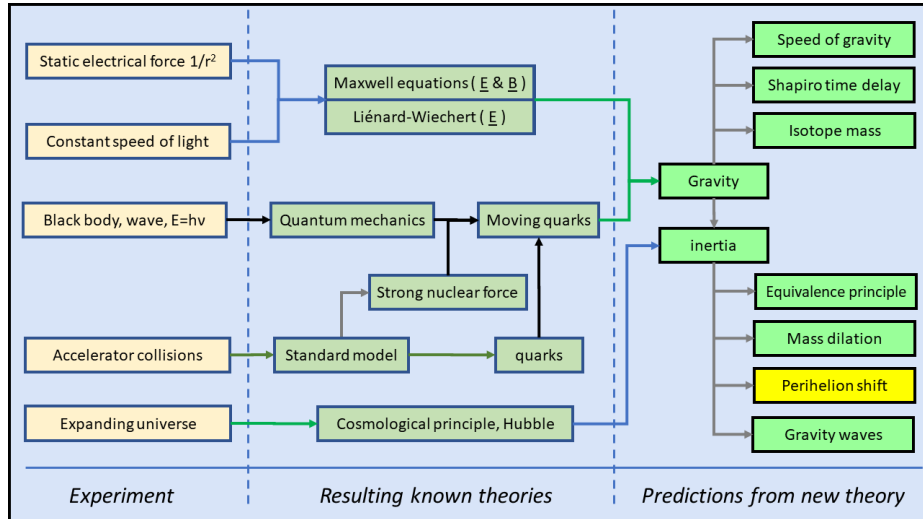
In gravity:

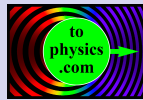
2 masses orbit a 'Common Center of Mass'
 $\Rightarrow$ di-pole radiation not possible
 $\Rightarrow$ quadrupole radiation !





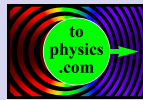
Summary : origins of **GRAVITY** and **INERTIA** .





Fundamental forces in nature

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

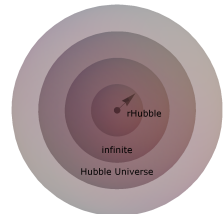
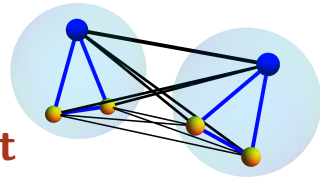


Conclusions - 1

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

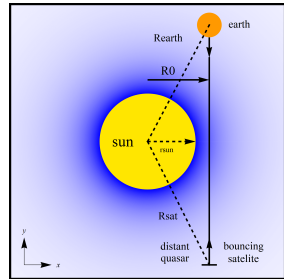
From the fundmental forces, only the **strong nuclear** and **electro-dynamical** forces remain.

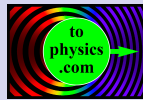




Conclusions - 2

- Quark-gravity reduces the speed of light
 $\implies$ bending of light & Shapiro time delay.
- Einstein-deSitter expanding universe model follows from inertial condition: $4\pi\rho G/3H^2 = 1$.
- 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: $z(r) = e^{r/r_{\text{Hubble}}} - 1$
- Gravity waves are quadrupoles, as masses orbit around each other.





Follow up - **challenges**

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

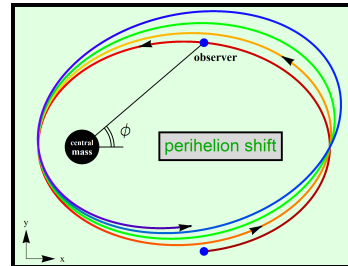
High velocity inertial impact of expanding universe

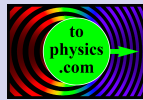
requires relativistic 3D-velocity addition,
insert into Liénard-Wiechert equations,
followed by analytic integration.....



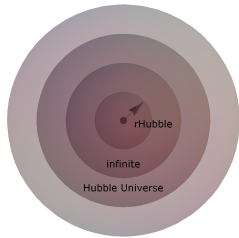
Accelerating universe
& Inflation

Perihelion shift

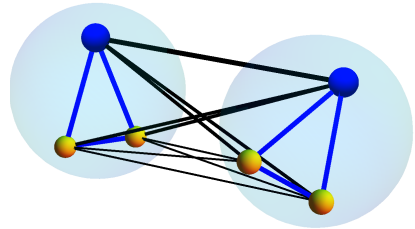




Epilog



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?

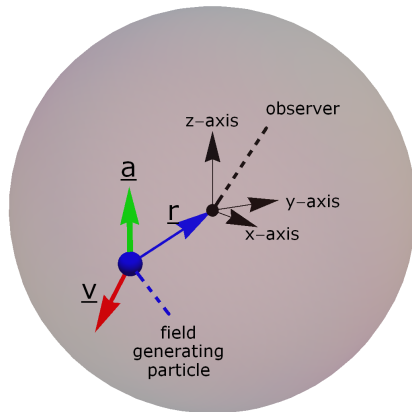
No



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!**



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

Mach:
distant stars

