Inertia First

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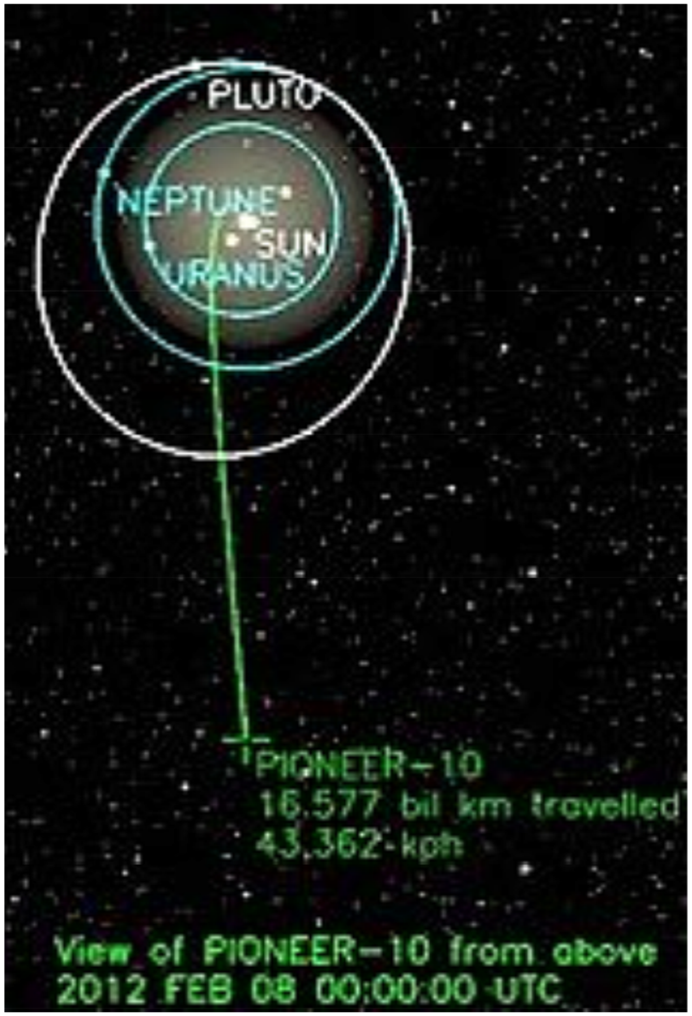
A Natural Explanation of Dark Energy, Flat Space-Time, and Quantum Gravity

Within the Solar System & Galaxy Inertia is stronger than gravity

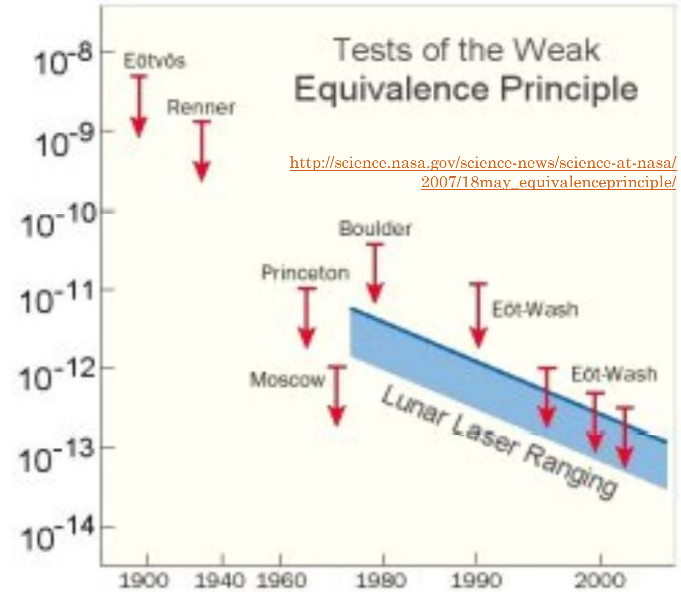


http://en.wikipedia.org/wiki/Pioneer_10

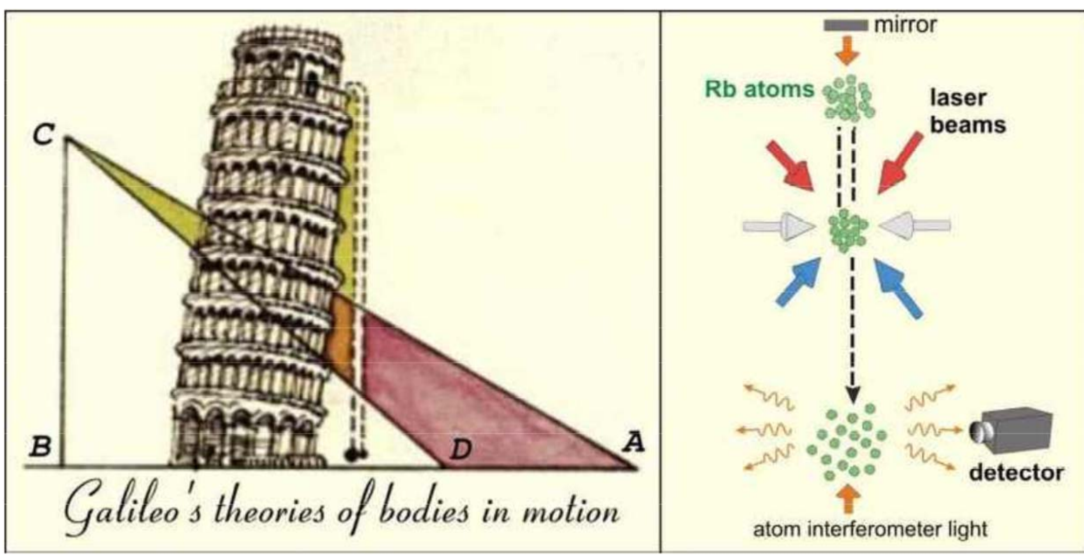
- Gravity of the SUN has already been overcome by rocketry
- The inertia of a much smaller spacecraft (Pioneer 10) is *too great for it to achieve significant interstellar speed*
- A perspective:
  - Here on Earth, it is easy to be preoccupied with gravity
  - But only a short way off, it is less important than inertia

Gravity & Inertia are closely related

- Known as the *Equivalence Principle*
- Verified by Galileo and many others
- $\Rightarrow$ Action by a force is implausible
  - Must act on all types of matter & energy

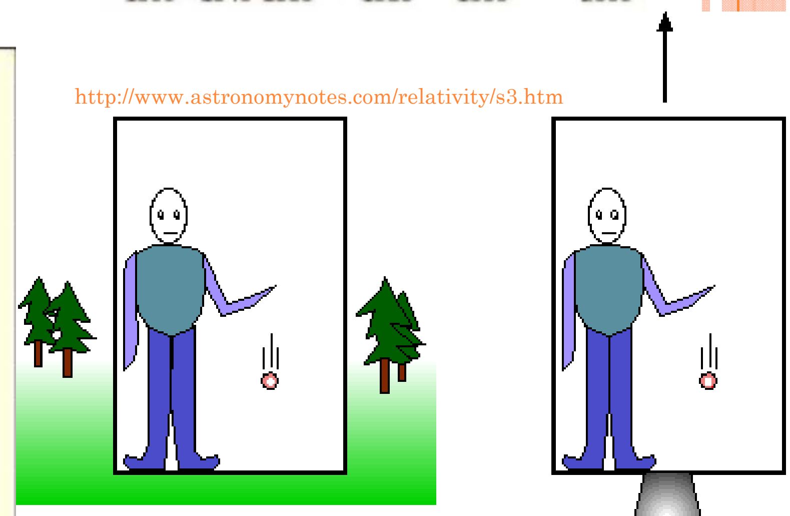


http://science.nasa.gov/science-news/science-at-nasa/2007/18may_equivalenceprinciple/



http://www.mpg.de/512907/pressRelease20041217

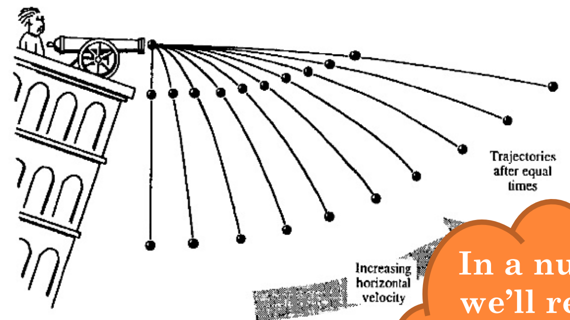
http://www.astronomynotes.com/relativity/s3.htm

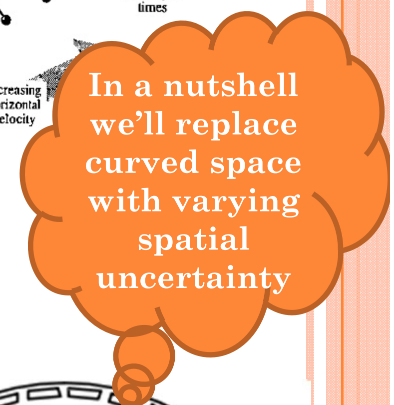


Things move the same way in a gravity field as those in a reference frame accelerating upward with the same magnitude.

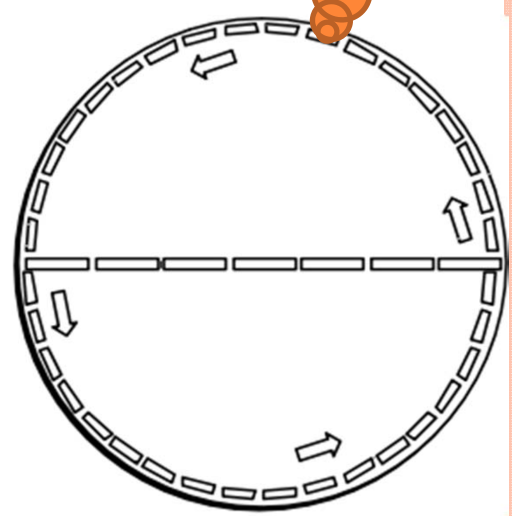
Special Relativity was very Successful But caused a Problem with Gravity

- 1907 Einstein was dissatisfied with modifications to make gravity non-instantaneous (for Special Relativity)
  - Discovered when writing a review article on physics in space-time of SR
  - Maxwell's EM already fit, but gravity was thought to be instantaneous, needed delay
  - All solutions resulted in slightly less falling distance for moving objects





- 1913 Gravity based only on time dilation didn't work out
- Concluded from rotating disk analysis that space may be "curved"
  - Using Lorentz contraction of circumference
    - Led to empirically correct equations in 1915
    - Loosely based on equivalence (centripetal acceleration = gravity)
    - Never published any formal argument
  - This argument has some problems
    - Unlike gravity, depends on direction of motion
    - Uses SR analysis and ignores acceleration of the measuring rods
      - Severe problem not appreciated until 1960 (Swann on Twin Paradox)
    - Developed without QM or Uncertainty Principle

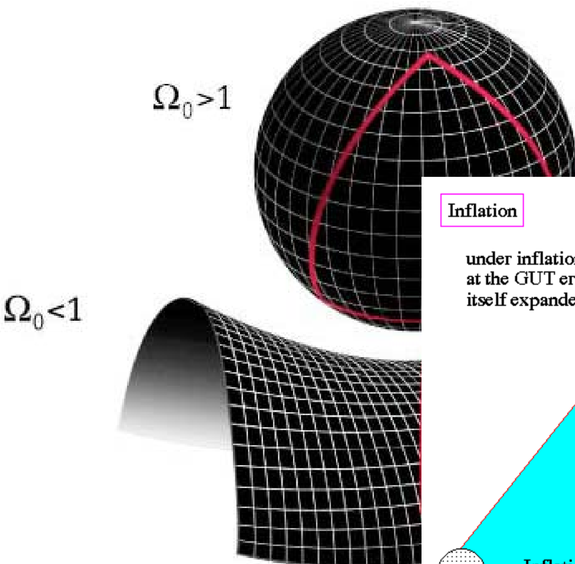


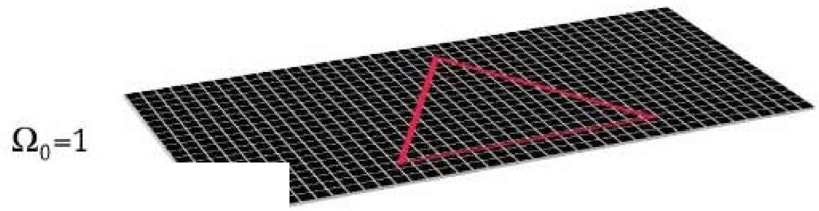
COSMOLOGICAL OBSERVATIONS CAUSED FURTHER PROBLEMS WITH GRAVITY

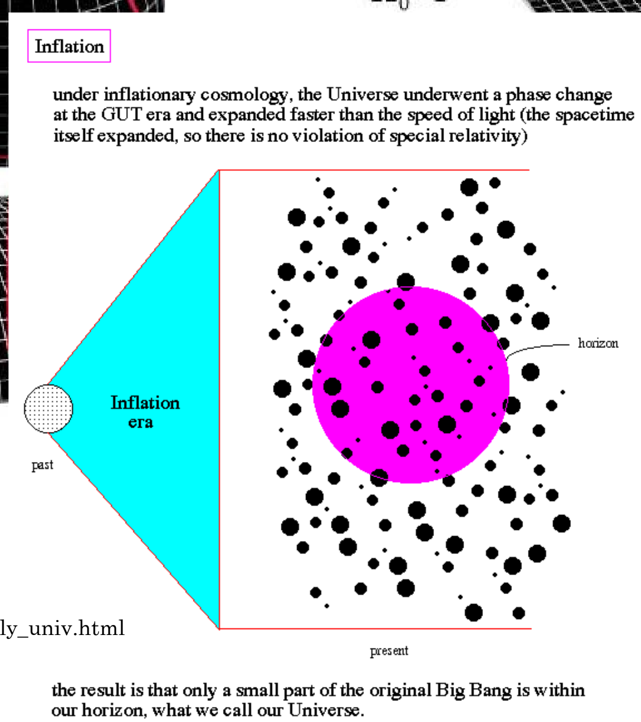
Expected space-time:

Observed space-time:

http://map.gsfc.nasa.gov/universe/bb_concepts.html







Ω should change with time, so finding it near 1 should not be stable. Solution was to assume inflation.

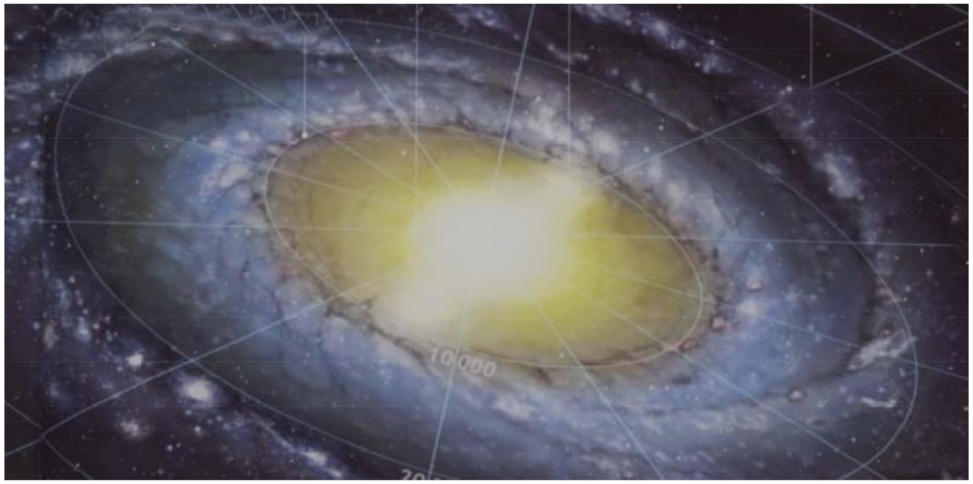
http://abyss.uoregon.edu/~js/lectures/early_univ.html

Attempts to Explain Inertia

Inertia from Gravity

Analogous to Induction Reaction in an EM field

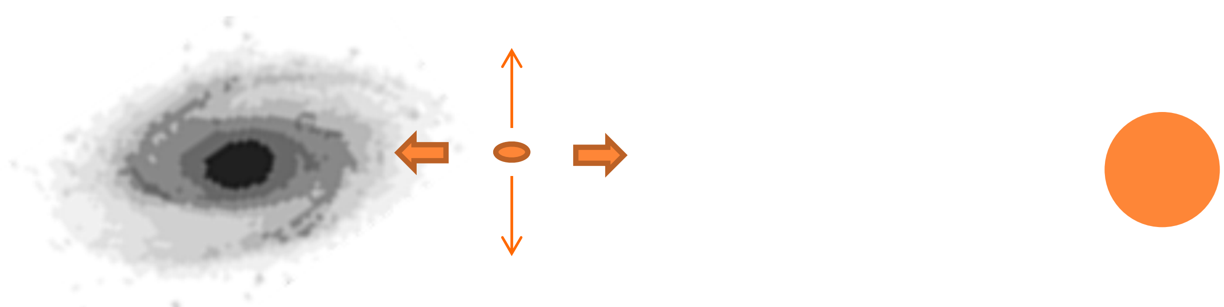
- Electromagnetic analogy theories of gravity
  - Maxwell disliked negative potential & lack of field model
    see http://mathpages.com/home/kmath613/kmath613.htm
  - Heaviside, Poincare, et. al. did publish such theories
- Einstein argued General Relativity explained inertia
  - Induction "analogy" 1912 sum of gravitational potentials
  - de Sitter 1917 "missing matter" (Universe ≈ Milky Way)



http://www.universetoday.com/65601/where-is-earth-in-the-milky-way/

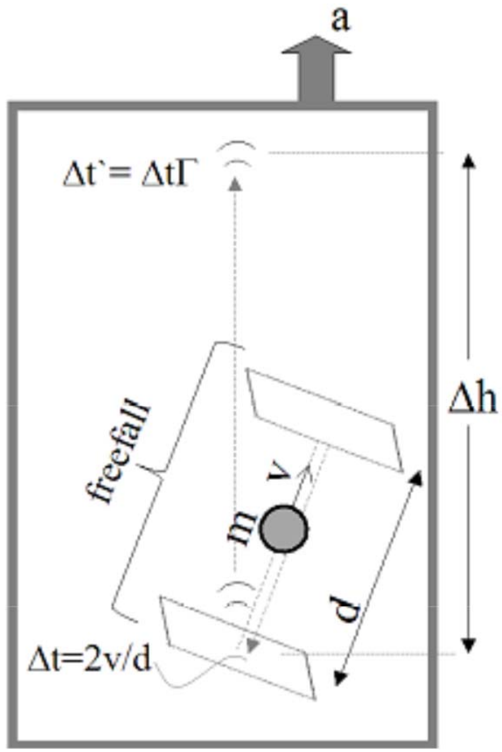
Fixing one Problem Creates Another

- Sciama 1953 again used electromagnetic induction
  - Derived similar potential formula, did not cite Einstein 1912
  - Predicted more mass would be found
  - Limited to visible horizon, eliminating boundary problems
- Suspicion arose such inertia would be anisotropic
  - Experiments showed inertia is isotropic
  - Physicists divided over whether inertia arises from matter *like gravity*
  - *This idea is called Mach's Principle*
  - But in General Relativity (GR) even an empty universe has inertia

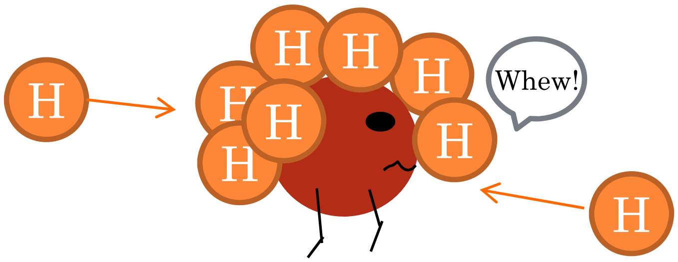


Classical Issues Resolved

- Ghosh 2000, enough mass has *now been found*
  http://www.amazon.com/Origin-Inertia-Principle-Cosmological-Consequences/dp/096836893X
- Shuler 2010, inertia from mass *should be isotropic*
  http://physicsessays.org/doi/abs/10.4006/1.3637365 or http://mc1soft.com/papers/2010_Laws_2col.pdf
  - Free falling mass clock in accelerated frame shows inertia is
    - dependent on gravitational potential
    - *and* isotropic
  - Note: due to time dilation…
    - an observer *never detects his or her own* mass increase or decrease
    - $\Rightarrow$ in limit approaching empty universe inertia appears to remain



The Higgs Boson



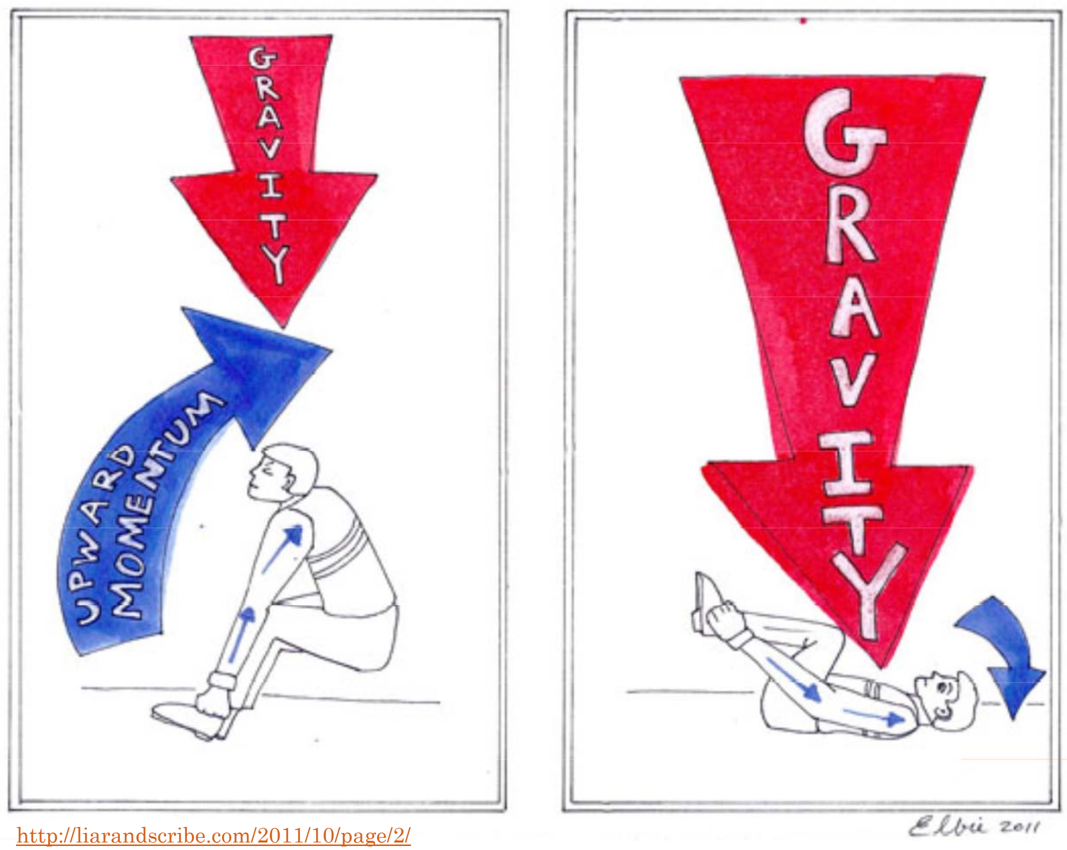
- Has energy and mass, therefore inertia, which it shares
- What it is . . .
  - Most fields do not exist without sources [e.g. electrons or protons]
  - Higgs field settles to non-zero, allowing un-sourced virtual bosons
  - These are attracted to W and Z bosons and certain other particles, giving them higher masses than otherwise predicted, thus "saving" the Standard Model of particle physics
- Is widely misunderstood by non-physicists
  - Questions like "does the Higgs cause gravity" on blogs *(occasionally with replies of denial from physicists)*
  - Websites/Papers/Theses devoted to Higgs gravity
    on ARXIV - M.S. thesis – website – *numerous others . . .*

For a discussion of the mass of an atom and the Higgs boson contribution see: http://physicsessays.org/doi/abs/10.4006/1.3637365

Inertia First Conjecture

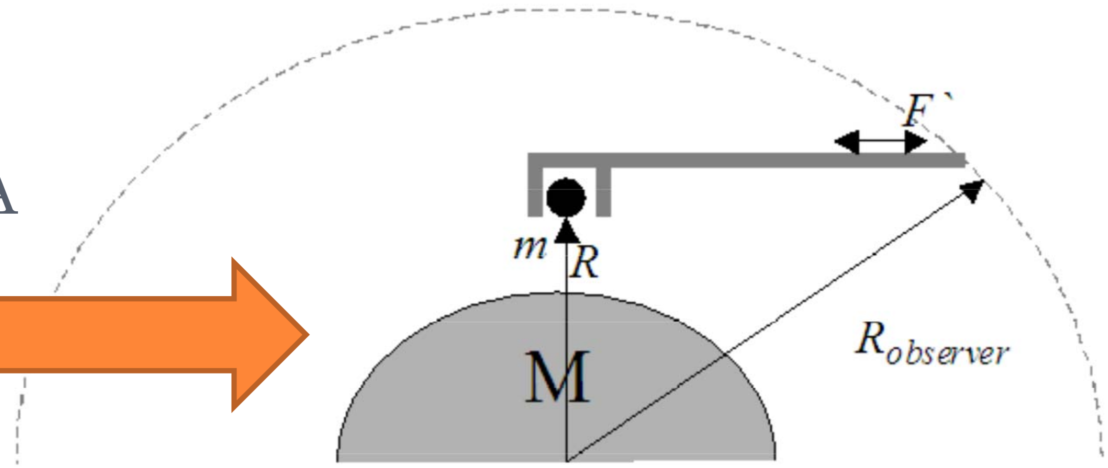
No-Bootstrap Principle:

- Inertia is equivalent to energy $E = mc^2$
- $\Rightarrow$ A particle, field or process which *has* energy cannot be the *primal* cause of inertia
- Must look beyond "energy field"
  - $\Rightarrow$ we won't be using gravitons



http://liarandscribe.com/2011/10/page/2/

Time & Inertia



- In SR time and mass transforms follow Lorentz γ factor
- In GR proper time & mass (in frame of object) are invariant
- But cross-frame we see and speak of *time dilation*
  - Solar spectral shifts – Pound-Rebka experiments – GPS timing compensation
  - GR predicts infinite dilation at event horizon of a black hole
- If momentum is conserved then cross-frame inertia *increases*
  - By equivalence to falling velocity clock
  - If untrue we could easily remove objects from near an event horizon
- Narrow conclusions:
  - Masses M & m (illustration above) are moved together with inertia *M + m*
  - Object m resists motion relative to M with larger inertia *m’* (inertia dilation)

Broad Conclusions:

- Inertia from proximity to other masses
  - Inertia *could* be conferred by other masses much as described in Einstein's 1912 paper – isotropic and based on sum of potential
  - No one has made this argument *probably* because of
    - Intractability of cross-frame measurements of mass
    - Preference for computation in "proper frame" of the object
  - Applies *anywhere that time dilation applies in any theory*
- Cross-frame transformations
  - "Laws of inertia" that follow using Γ as dilation factor:

for large Δh depends on metric → $\Gamma = 1 + a\Delta h / c^2$ *

$\Delta t_x' = \Delta t_x \Gamma$

$v_x' = v_x / \Gamma$

$m' = m\Gamma$

$\rho' = \rho$

$\mathbf{F}' = \mathbf{F} / \Gamma$ ← new

$\mathbf{A}' = \mathbf{A} / \Gamma^2$ ← hard to find

$L' = L$ ← implies nothing about length

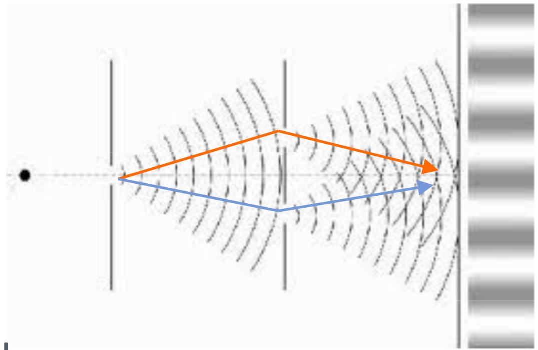
$E' = E / \Gamma$ ← well known

$G' = G / \Gamma^2$ ← new

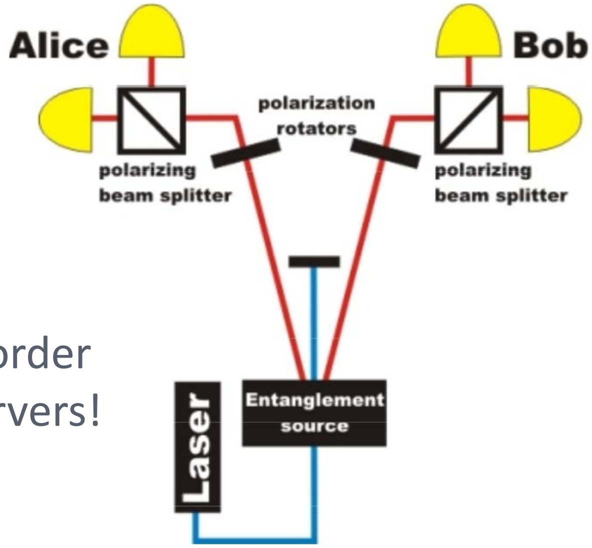
*If Δv use Γγ

"Proximity" in Quantum Mechanics

- Momentum-position uncertainty: $\Delta\rho\Delta x > h/4\pi$
  where $\rho = mv$
- Non-locality
  Double slit interference works with
  ONE particle at a time in device . . .
  But *not* if it is possible to *know the path taken!*
  Demonstrated with *Buckyballs [C_{60}]*
  $\Rightarrow$ particle knows configuration of path it doesn't take



- Remote correlation (entanglement)
  Alice observes more correlations with Bob's
  polarizer setting than explainable by statistics
  (Bell Theorem) . . . $\Rightarrow$ results at B affect A
- Apparent causality violation
  The above can be done in either order *and* the order
  may be different for relativistically moving observers!



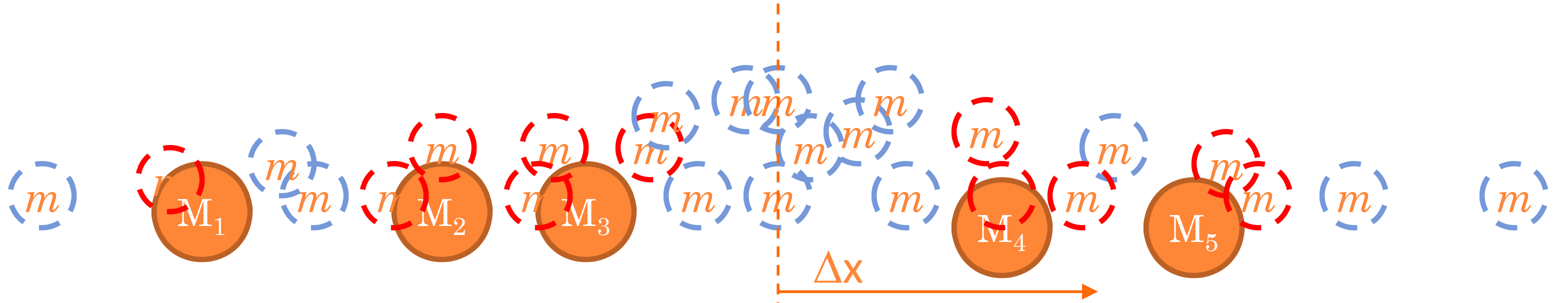
http://www.tumblr.com/tagged/double%20slit%20experiment
http://www.physicsforums.com/showthread.php?t=687294

Position Field Hypothesis

- Use momentum-position (instead of time-energy)
  - Assume measurements are optimal: $\Delta\rho\Delta x \approx h/4\pi$
  - Factor mass as the unknown:
    $(m\Delta v)\Delta x \approx h/4\pi \Rightarrow \mathbf{m} \approx h/4\pi\Delta v\Delta x$
  - Eliminate Δv
    - Velocity and position are redundant, as velocity yields future position and is essentially a reference frame transformation
    - Δv is factored from a quantum conjugate of position uncertainty and will be randomized if we try to measure Δx precisely
    - Let it be randomized and take the average value Δv_{avg}
    - Treat Δv_{avg} as a constant
    - Group all constant terms into $\mathbf{k} = h/4\pi\Delta v_{avg}$
  - => $m \approx k/\Delta x$ => $\Delta x \approx k/m$

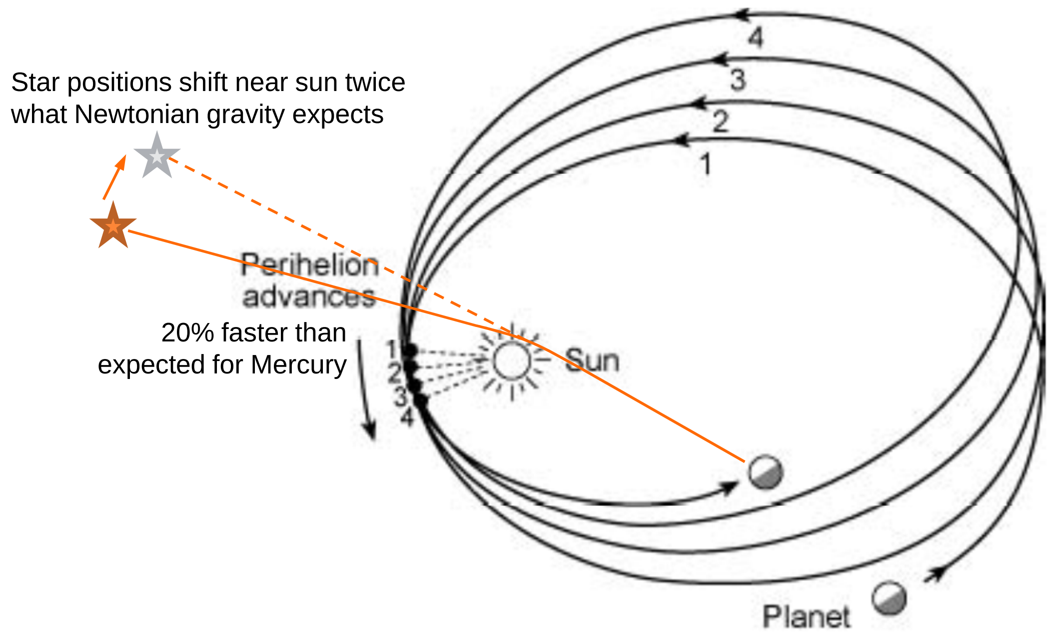
Position Field Mechanism

- Object ***m*** interacts with a group of objects $\boldsymbol{M_i}$
  - Assume ***m*** has no inertia (mass) without interaction
  - Initially ***m*** has unlimited scope of interaction $\Delta\mathbf{x} \to \infty$
- Interactions convey information about ***m's*** position, restricting Δ**x** and increasing mass **m** $m \approx k/\Delta x$
- Restricting Δ**x** reduces interactions until no more increase **m**



No implication interactions occur in time, because "time" does not exist without mass & position

How Quantum Position Fields lead to Solar System Non-linear Dynamics



"On dynamics in a quasi-measurement field" – J. of Mod. Phys. – Jan 2013
http://www.scirp.org/journal/PaperInformation.aspx?PaperID=27250

Image credit: http://ase.tufts.edu/cosmos/view_picture.asp?id=1096

Reduction to Classical Form

- Note the similarity of m ≈ k/Δx to the classical expression for inertia used by Einstein, Sciama et. al.:

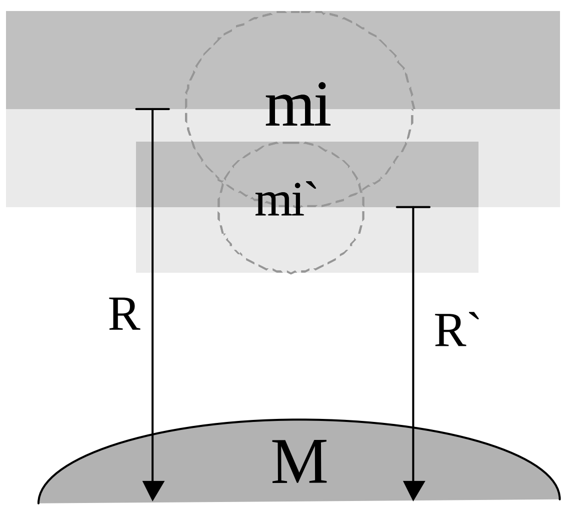
$$m_i = m \sum_x GM_x / c^2 R_x$$

  - m_i is the observed mass of particle *i*
    m is some kind of mass-causing property of the particle *i*
    G is the gravitational coupling constant
    M_x's are other particles' mass causing properties
    c is the local velocity of light constant
    R_x*'s* play the role of Δx
  - The quantum constant ***k*** is replaced by measureable classical parameters of the universe's matter distribution
- Note this is *neither* an energy field *nor* retarded potential

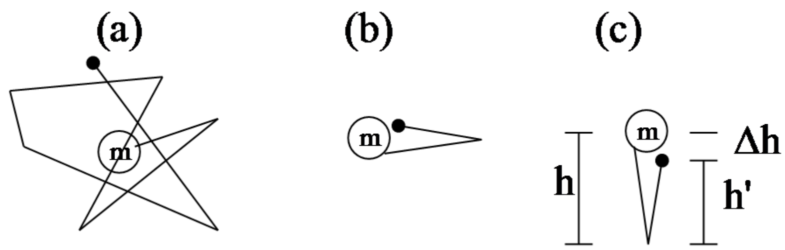
Note – this formulation obscures the object-to-object relative nature of inertia!

Relativistic Gravity from Inertia

- Trajectory Theorem: Classical inertia does not change the SHAPE of orbits or trajectories, only the TIMING
  - If a quantity (e.g. acceleration '*a*') does NOT classically transform $\Rightarrow$ shape must change
  - 2010 paper showed *a* untransformed => Mercury precession
  - But '*a*' is a property of gravity, and we don't have gravity yet
- In quantum inertia, proximity decreases position uncertainty:



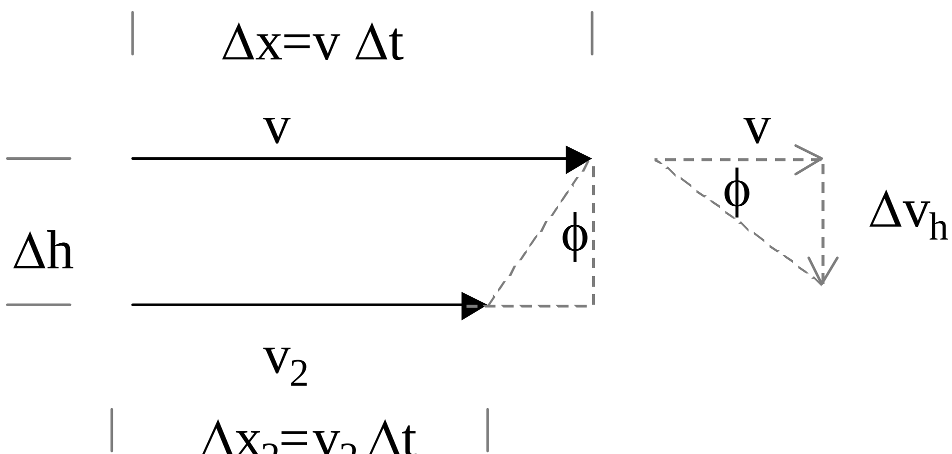
Gravity cont'd



- Assume "discovery" due to quantum inertia interactions at a successive positions
  - Discard lateral components (a-b) as inertia does not change
  - Δh is the average expected "unrecovered" height
  - Assume a discovered displacement is "conserved" as momentum
  - Rate of discovery is a free parameter – a purely imaginary velocity v_E used to "time" the discoveries
  - Solving for acceleration: $a = g v_E^2 / 2c^2$ (h, Δt & Γ's cancel out)
  - Assume *all* the acceleration of gravity is produced this way (a=g)
  - Solving for the parameter: $v_E = c\sqrt{2}$ (note: $\gamma = 1/i$)
  - *The particle's mass was not needed to deduce acceleration*
    - $\Rightarrow$ Equivalence is not only upheld but derived & explained
- Acceleration is untransformed $\Rightarrow$ relativistic precession!

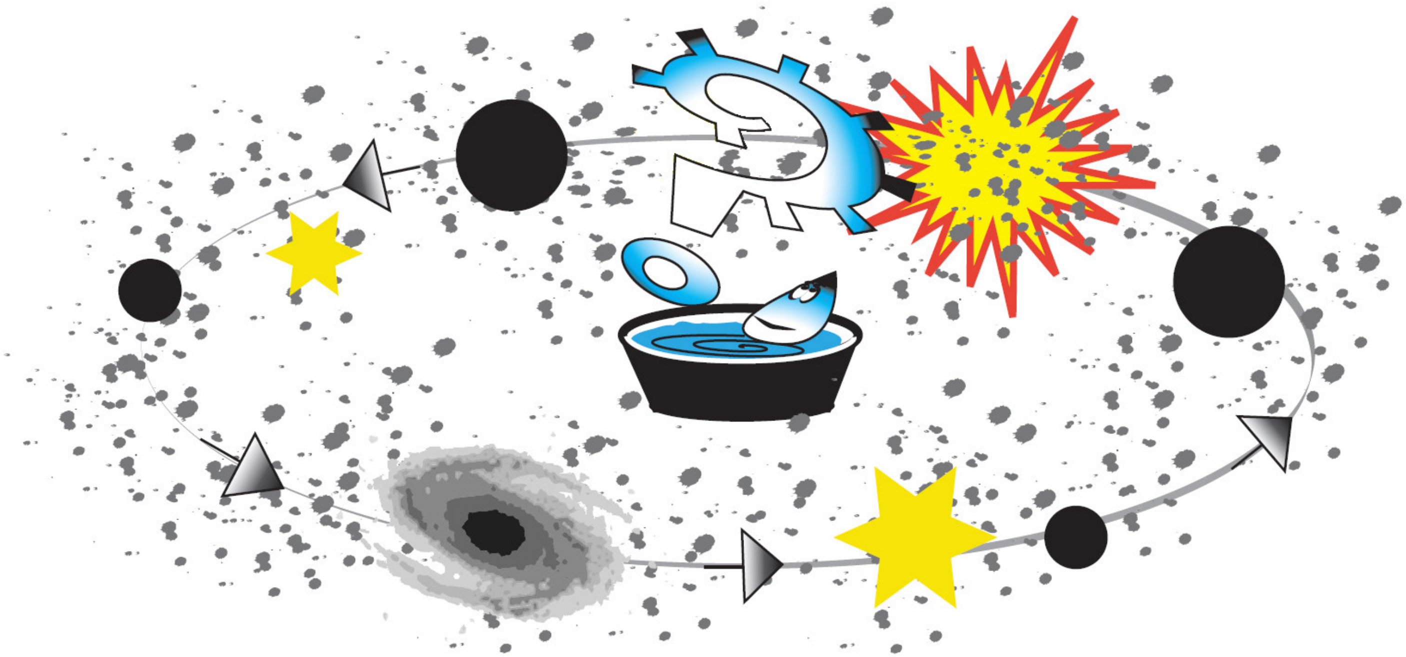
Light Bending

- Inertial velocity reduction => speed gradient refraction



- $$\Rightarrow \frac{\Delta v_h}{\Delta t} \approx \frac{v^2}{c^2} g$$
- This is additional "acceleration" which must be added
- For light *v=c* therefore *a=g*, which when added gives *2g*

Cosmological Aspects of Quantum Inertia



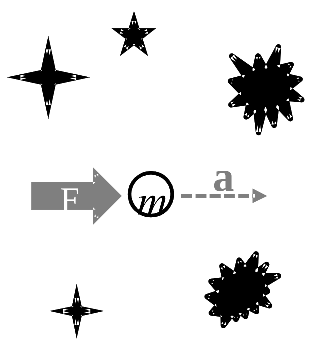
A drop in Mach's (Newton's) bucket ponders which way it should go

From "Mach vs. Newton: A Fresh Spin on the Bucket"

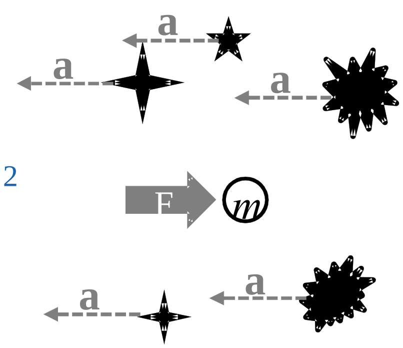
Image credit: Crystal Wolfe – artist@crystalwolfe.com

Frame Dragging in Quantum Inertia

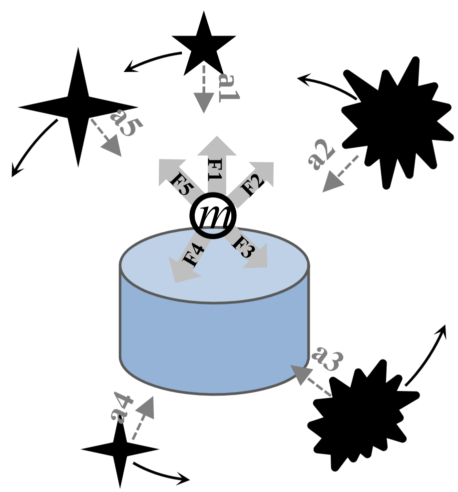
- In a multi-body problem, it does not matter who accelerates



$$\mathbf{F}_0 = m_0 \sum_i \mathbf{a}_i G m_i / R_i c^2$$



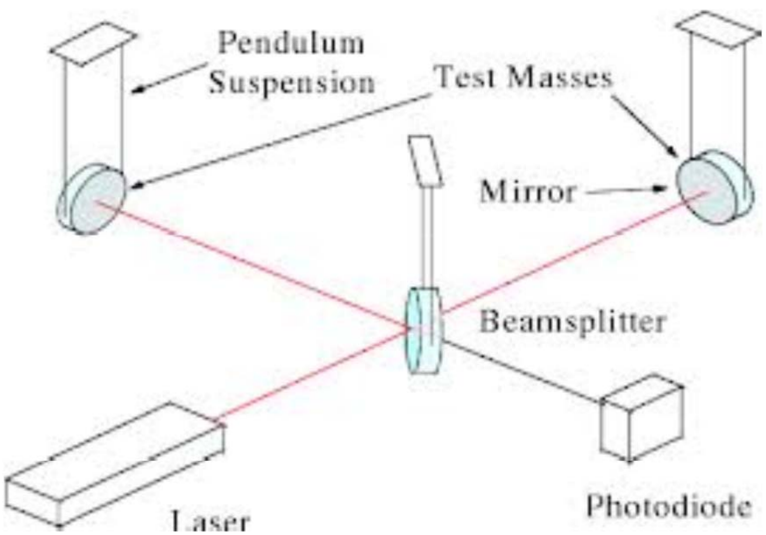
- Surprise result for Newton-Mach bucket:



Frame dragging seems to be *different* in QI. Possible experimental test?

QUANTUM INERTIA & GENERAL RELATIVITY

- Very close agreement in solar system
  - At 2 million miles from the sun, predicted time dilations differ in the 13th decimal place, significant differences near gravitational radius R_0
  - We have only observed black holes at resolutions of 1000x their R_0
- QI supports undetected "gravity waves"
  - Frame drag transfers energy - BUT
  - Difficult to detect inertia, must wait for signal from outside affected area
    - No detection yet
    - Detectors have enough sensitivity to detect the waves predicted by GR

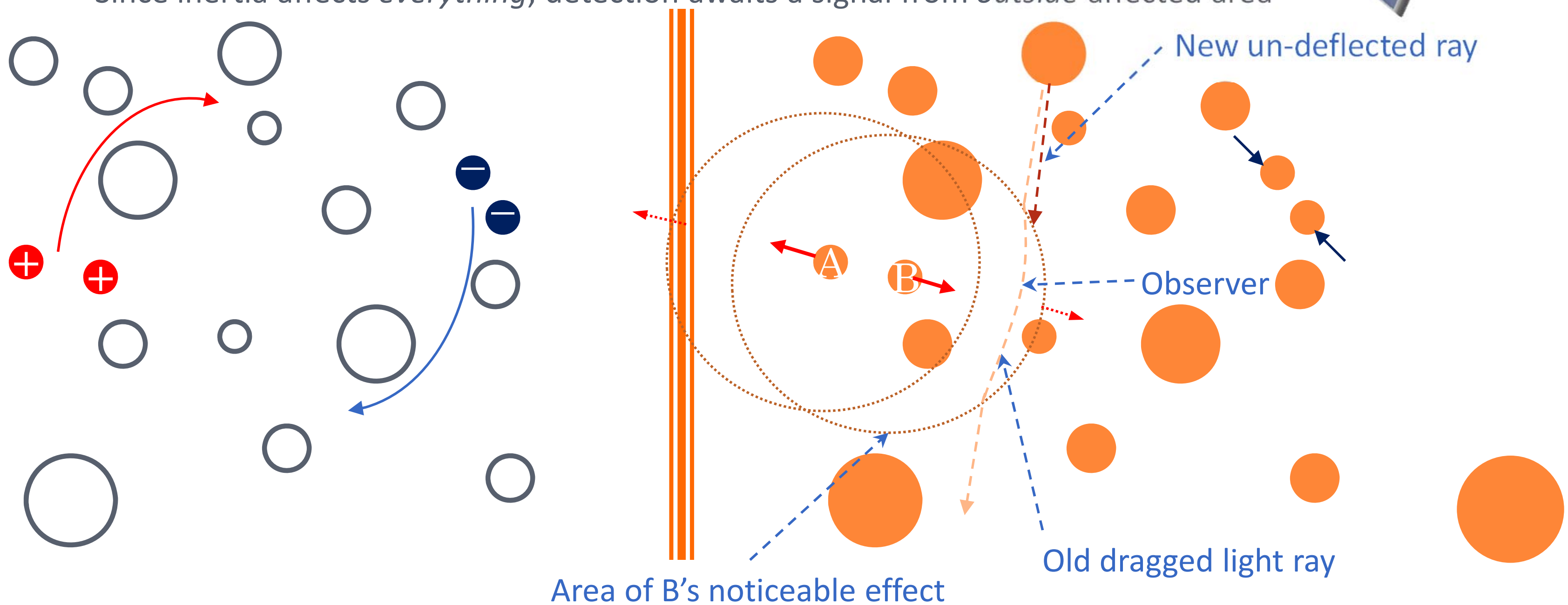


http://hermes.aei.mpg.de

Detection of Inertia Changes

- Near electrical balance in universe – a few charges create observed fields
  - Radiation occurs from the acceleration of the few unbalanced charges
  - High Signal to Noise Ratio (SNR) – radiated energy is easily detected
- Severe limitations on acceleration of inertial masses
  - Acceleration of a few masses *might* radiate energy through frame dragging, but…
  - Inertia is *all positive mass* . . . the most important mass is very distant
  - The *center of mass* of accelerating objects cannot move!
  - Since inertia affects *everything*, detection awaits a signal from *outside* affected area

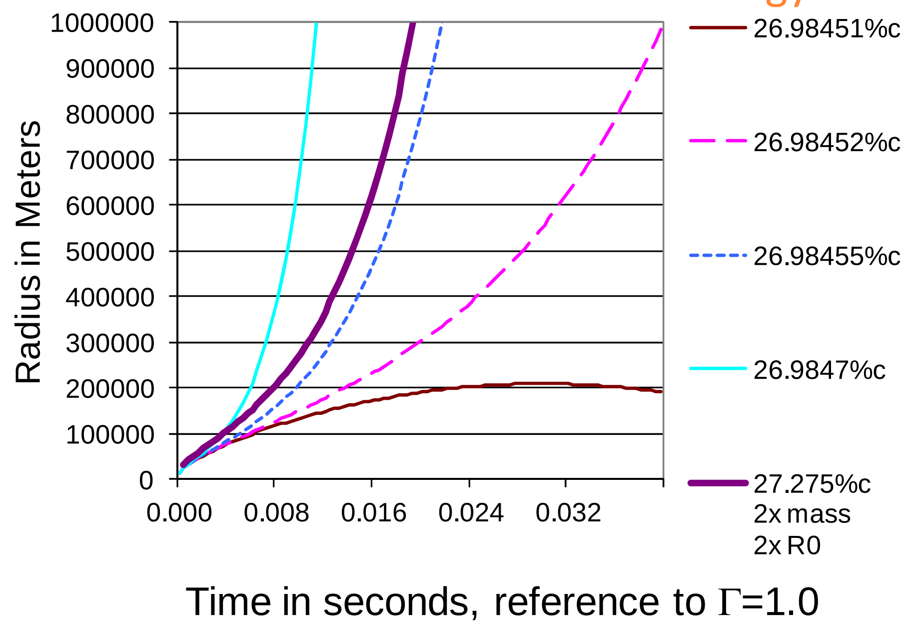
Useful work can only be done by *differences* in potential & mass creates potential over a broad area – detection must come from outside that area.



Quantum Inertia & Cosmology

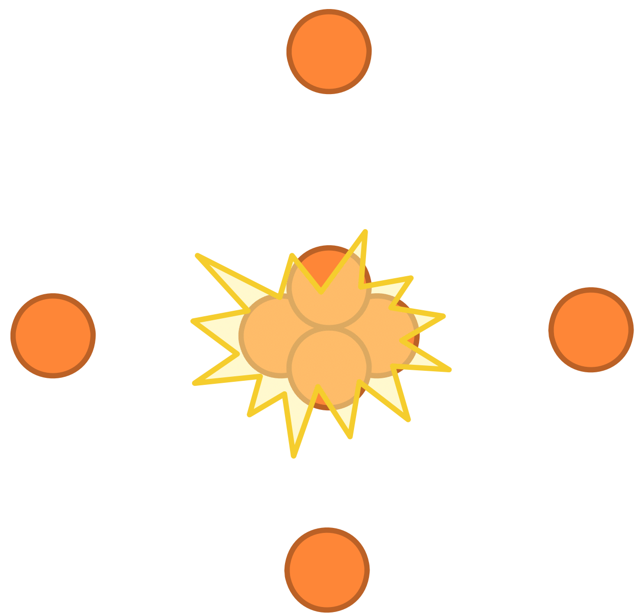
- Dark matter may not be a gravity issue
  - ISS providing preliminary indications of detecting WIMPs
- Space is always “flat” in QI
  - careful tuning of cosmological constants is not necessary
- As matter spreads out, R’s increase and inertia decreases
  - All clocks run faster
  - “Old” light emitted from slow clocks is red shifted
  - If “escape velocity” is achieved, expansion accelerates
    $\Rightarrow$ dark energy unnecessary

Six element solar mass cosmology:



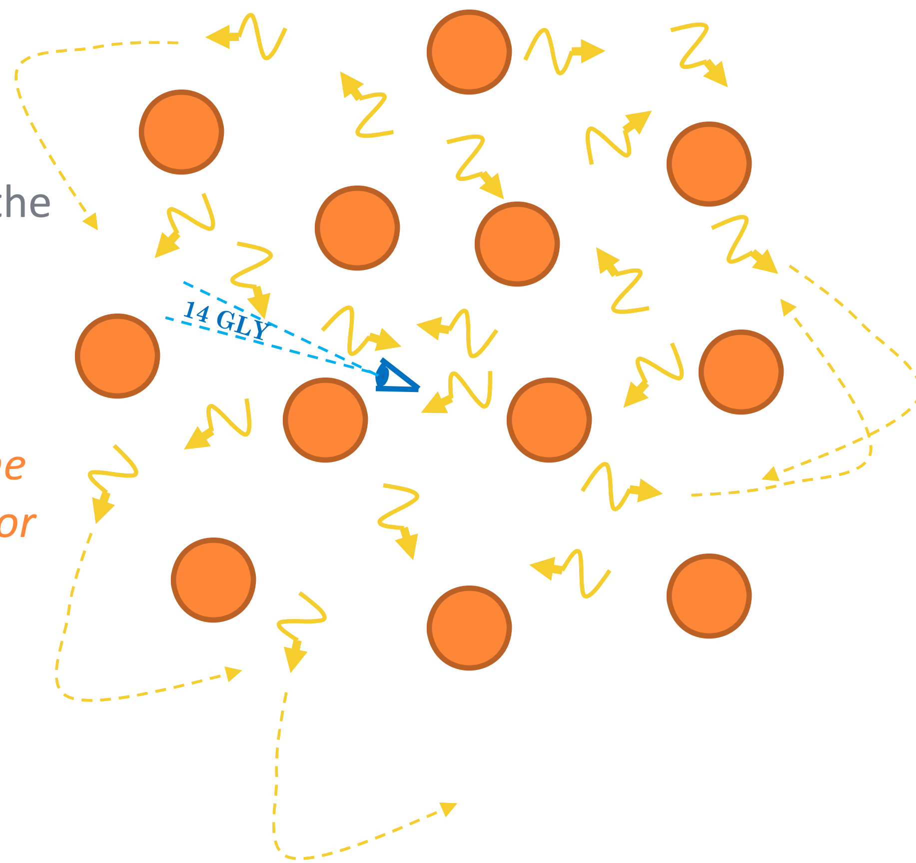
Inertia Cosmology Animation

4 masses which barely achieve escape velocity



Flat Space & Cosmic Microwave Background

- Post-scattering photons have random velocity vectors
- Boundary photons bent back, motion paths distorted (CMB)
- Apparent edge may be behind the CMB

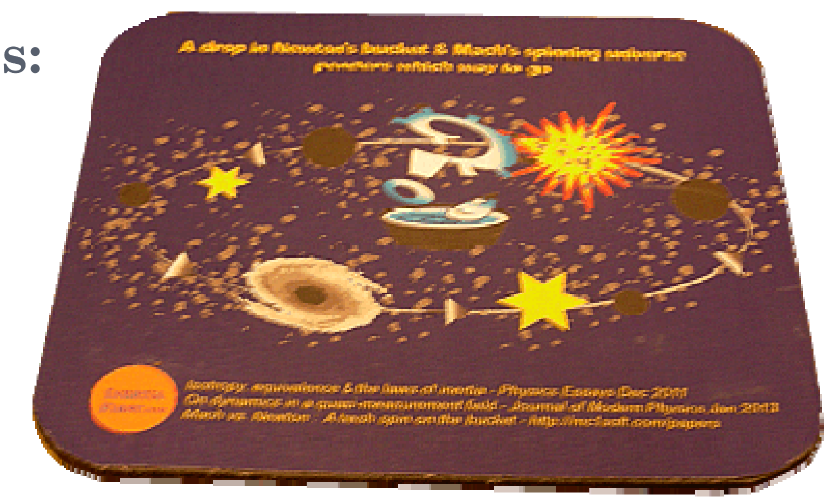


- *GR with flat space has the edge problem also – physicists assume the universe is not old enough for us to see it*

Quantum Inertia Summary & Conclusion:

- **Fully relativistic** with observed precession, light bending, etc.
  - *Time is variable much as in General Relativity*
  - *Spatial curvature is replaced by spatial uncertainty "curvature"*
- **Derives mass & gravity without using energy** (bootstrap)
- **Explains the following puzzles:**
  - *Weakness of gravity (secondary effect of inertia)*
  - *Flat space-time (natural, to tweaking)*
  - *Dark energy (expansion due to decreasing inertia)*
  - *Lack of observation of gravity waves*
  - *Equivalence principle*
- **Compatible with cosmology observations & QM**
  - *Though it does not use an energy field (gravitons)*

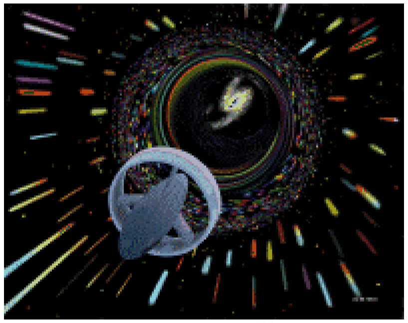
Conversation starters:



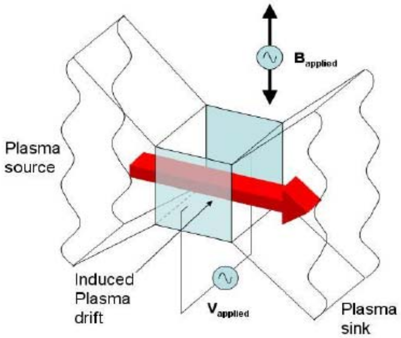
Implications for Space Travel

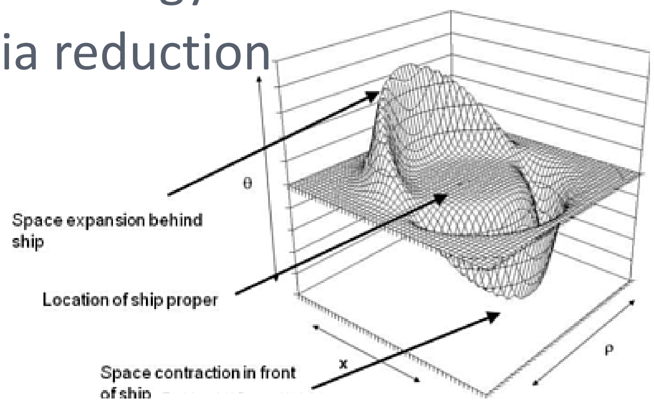
NASA Studies of Esoteric Space Travel

Artist's depiction of a hypothetical *Wormhole Induction Propelled Spacecraft*, based loosely on the 1994 "warp drive" paper of Miguel Alcubierre.



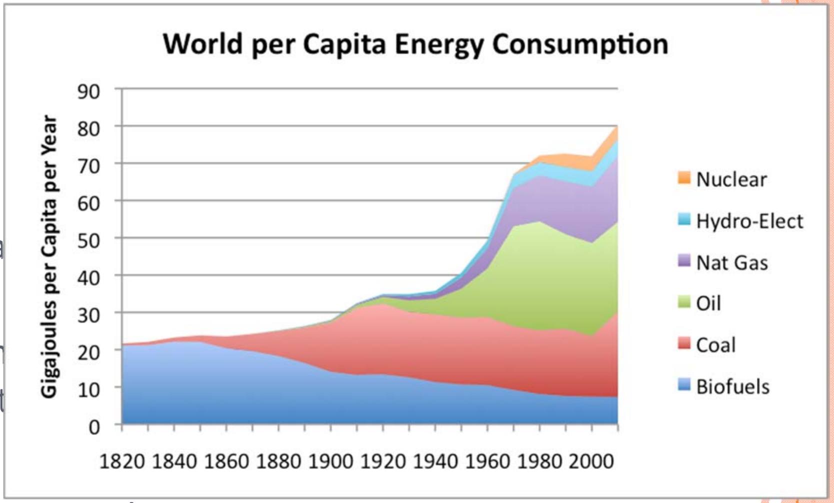
- NASA Breakthrough Propulsion Physics
  http://www.grc.nasa.gov/WWW/bpp/index.html
- JSC's Harold (Sonny) White
  http://en.wikipedia.org/wiki/Harold_Sonny_White_(NASA_Scientist)
  - Vacuum propulsion based on Casimir effect
  - Alcubierre metric "warp field"
- Analysis:
  - No impact on vacuum propulsion idea
  - "Warp" & "wormhole" concepts in GR all require huge amounts of "negative energy"
  - Negative energy also allows inertia reduction
  - Unfortunately there is no theory suggesting it exists
    $\Rightarrow$ no impact here either





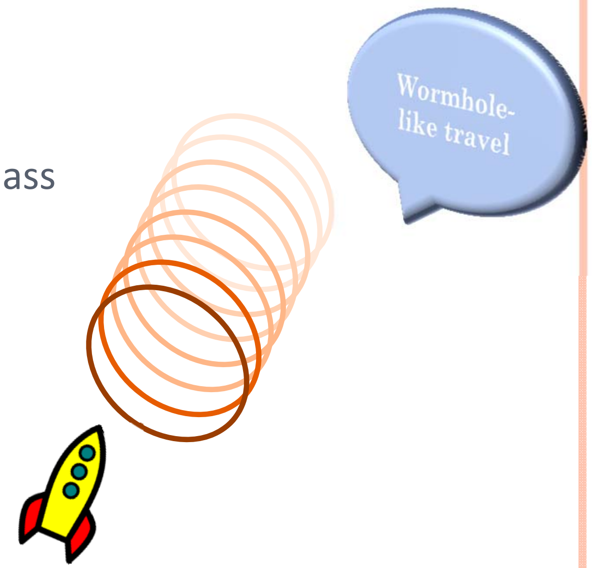
Star Travel without Negative Energy

- Conditions of plausibility
  - Robots which are oblivious to time factors
  - Information traveling by light signals
    - Robotic entities (again)
    - Measurement reference for Quantum Teleporta
  - Near speed of light for organic life
    - Requires several “tons” of mass converted to en
    - Requires solution to biological cross-contaminat
- Getting a feel for the energy required
  - Acceleration of 1g for 8000 hours (approx. 1 year)
  - 30 doublings from per capita annual energy use today
    - 2000 years at 20th century growth rates (which are not continuing)
    - Compare to other 2000 year events:
      - Horsepower ~ 4000 BCE
      - Wheel ~ 2000 BCE
      - Paved roads ~ 0 BCE
      - Natural resource power (age of sail 1500 AD, steam 1800, nuclear 1955)
      - Expected interstellar age ~ 3000 to 4000 AD (sail + 1500 to nuclear + 2000)



Evaluation of Alternatives

- Carry fuel and energy
  - Fusion is about .4% efficient
  - Difficult to go much faster than .4% C
  - Hard to imagine anti-matter more than a few % of total mass
  - Fuel for stopping and return journey
  - $\Rightarrow$ Need advance infrastructure at destination
- Re-fuel along the way
  - Fuel supplies at various positions and velocities
  - Essentially a very large infrastructure problem
- Externally supplied energy
  - Mass driver
    - In principle would work like a star gate or wormhole (interstellar subway)
    - @ 1g would need to extend half a light year, with another for slowdown
  - Circular mass driver impractical (10%C needs 600g's at 1AU)
  - Concentrated solar beam might be usable (sun converts 10^6 kg/sec to energy)
  - Use neutron stars as switching hubs
- Ideally, find & connect with a pre-existing transportation infrastructure
  - Proposed by Carl Sagan, though in fiction



Backup Charts

Trajectory Theorem

We will show that equivalence has enforced a set of transformations so that a change in inertia, or relative potential, does not in itself alter trajectory, only time. This will guarantee that all clocks, no matter the mechanism, slow at the same rate, and that the shape of all trajectories is the same, although their timing is modified.

Consider a particle at coordinate position **X** and describe its motion according to a local observer, and a remote observer who uses a Γ transformation factor and whose measurements are noted with primes. For convenience we assume the coordinate origin and axes are superimposed such that **X**\`=**X**. The equations of motion for the particle in its own frame are

$$\begin{aligned}\mathbf{v}_2 &= \mathbf{v} + \mathbf{A}dt \\ \mathbf{X}_2 &= \mathbf{X} + \mathbf{v}dt\end{aligned}$$

The subscript "2" indicates the new position, not a selection of coordinates. In the remote observer's frame we have

$$\begin{aligned}&\mathbf{v}_2\text{\`} = \mathbf{v}\text{\`} + \mathbf{A}\text{\`}dt = \mathbf{v}/\Gamma + (\mathbf{A}/\Gamma^2)d(t\Gamma) \\ &\Leftrightarrow\ \mathbf{v}_2\text{\`} = (\mathbf{v} + \mathbf{A}dt)/\Gamma = \mathbf{v}_2/\Gamma \\ &\mathbf{X}_2\text{\`} = \mathbf{X}\text{\`} + \mathbf{v}\text{\`}dt = \mathbf{X} + (\mathbf{v}/\Gamma)d(t\Gamma) \\ &\Leftrightarrow\ \mathbf{X}_2\text{\`} = \mathbf{X} + \mathbf{v}dt = \mathbf{X}_2\end{aligned}$$

Therefore the position coordinates in the trajectory will not be modified by the transforms. (If length contraction and the associated time displacement are added, these transformations can be applied to special relativity and are sufficient to explain the "fly-by principle," i.e. that a relativistic test particle passing through a solar system does not change the planetary orbits.)

Derivation of Gravity from Inertia (free parameter derivation)

Let all measurements including time be made at the original particle position, so that for the two excursions $\Delta t_1 = \Delta t_2 = \Delta t$. One can now solve for acceleration by first finding *Δh*. We have $h = v_E \Delta t$ and $h' = v_E' \Delta t$. We have $v_E' = v_E / \Gamma$ from [the velocity transformation], giving:

$$\Delta h = h - h' = v_E \Delta t (1 - 1/\Gamma)$$

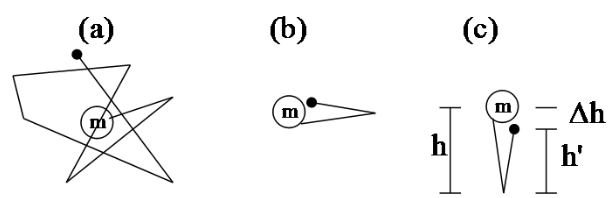
Since $\Gamma = 1 + gh/c^2$ is very close to 1 for small *h*, we use the approximation that for $x \ll 1$, $1/(1+x) \approx 1 - x$, giving:

$$\Delta h \approx g h v_E \Delta t / c^2$$

An expression can now be written for the velocity *v* imparted to the particle *m* over the interval of the entire excursion pair *2Δt*. This will yield the average velocity Δv_{avg} over that interval. Assume that the velocity at the end of the interval will be double the average velocity.

$$\Delta v_{avg} = \Delta h / 2\Delta t = g h v_E / 2c^2$$

$$\Delta v = 2\Delta v_{avg} = g h v_E / c^2$$



Now solving for the acceleration *a* :

$$a = \Delta v / 2\Delta t = g h v_E / 2\Delta t c^2$$

and substituting for *h* :

$$a = g {v_E}^2 \Delta t / 2\Delta t c^2 = g {v_E}^2 / 2c^2 \qquad (1)$$

It turns out that the height *h* of the excursion does not matter. It cancels out of the equations. So does the time period *Δt* within which each half of the excursion takes place. With the restrictive assumptions above, that leaves only v_E. This one parameter rolls up all the other various parameters. The free parameter can now be chosen as $v_E = c\sqrt{2}$ giving $a = g$.

Orbital predictions page 1 of 2

For a comparison baseline of gravitational effects the Schwarzschild metric will be used, which is known to give a correct result for planetary orbits in the solar system. Taking the form given by Brown [12]:

$$d^2r/d\tau^2 = -m/r^2 + \omega^2(r-3m) \qquad (1)$$

and re-writing using our notation and units, we have

$$a = -GM/R^2 + (v^2/R^2)(R - 3GM/c^2)$$

$$\Leftrightarrow a = -GM/R^2 + (v^2/R)(1 - 3GM/Rc^2) \quad (2)$$

For $3GM/Rc^2 \ll 1$ we can use the small x approximation, $1-x \approx 1/(1+x)$, thus:

$$a = -GM/R^2 + (v^2/R)/(1+3GM/Rc^2) \quad (3)$$

Since (3) is in the frame of the object, which is free falling, $a = 0$. What we have left is the balance of gravitational acceleration and centripetal acceleration. The Newtonian centripetal acceleration is reduced by $(1+3GM/Rc^2)$ which can be factored, ignoring high order terms, as $(1+GM/Rc^2)^3 = \Gamma^3$, where $\Gamma = (1+GM/Rc^2)$. We can rewrite (3) as

$$GM/R^2 \approx (v^2/R)/\Gamma^3 \qquad (4)$$

Whenever equations of orbital motion in the frame of the orbiting object can be reduced to this form, the observed value of planetary precession will be obtained.

We can derive a relation between the gravitational relativistic factor for weak fields, Γ, and the lateral velocity Lorentz factor $\gamma = 1/(1-v^2/c^2)^{.5}$. For circular orbits, tangential velocity is given by:

$$v = \sqrt{GM/R} \qquad (5)$$

This is a good approximation to average velocity for near circular planetary ellipses if R is taken as the semi major axis. Substituting for v in the Lorentz factor formula and using the usual approximations for operations on $1 \pm x$ for $x \ll 1$ we have:

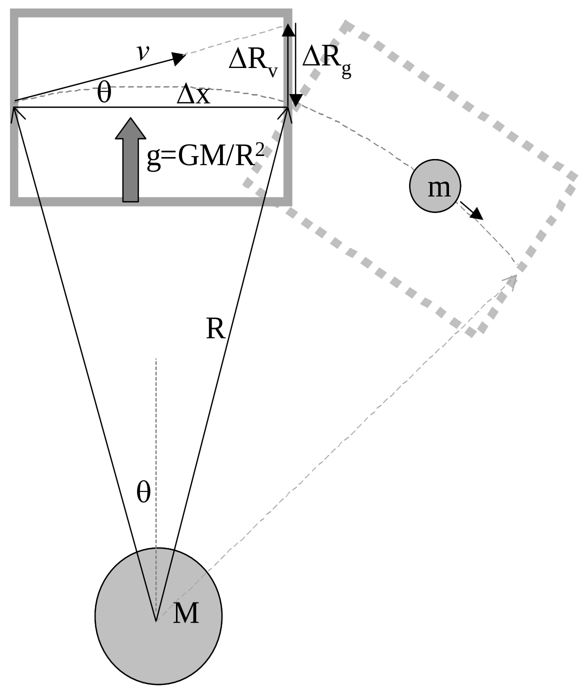
$$\gamma = 1/(1-GM/Rc^2)^{0.5} \approx \Gamma^{0.5} \qquad (6)$$

The total relativistic transformation factor for an orbiting mass will then be

$$\Gamma\gamma = \Gamma^{1.5} \qquad (7)$$

Orbital predictions page 2 of 2

For simplicity, a circular orbit is assumed, which allows the orbiting object to enter and leave local accelerated frames conveniently at the same height R. In the limit as $\Delta x \rightarrow 0$ an accurate representation will be obtained.

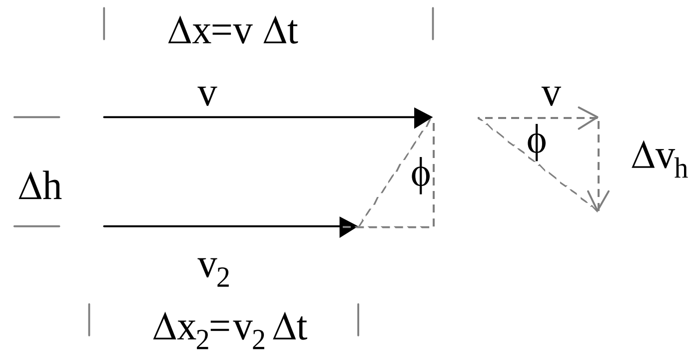


Setting the radial displacement due to gravity ΔR_g equal to the radial displacement outward ΔR_v due to inertial continuation of v gives the expected result for balanced gravitational and centripetal force, $g = GM / R^2 = v^2 / R$. This equation has been derived so far without regard to relativistic factors. Accounting for *m's* relativistic motion, notice that centripetal acceleration v^2/R doesn't change. A new Δx is marked using *m's* coordinates, leaving the diagram of the accelerated frame unchanged. The number of Δx*'s* that *m* finds in an orbit is not a factor since neither R nor v changes. However, the constant gravitational acceleration will be perceived through *m's* time dilation and must be transformed by the inverse of [the time formula] giving:

$$
\begin{aligned}
&(GM / R^2)(\Gamma\gamma)^2 = v^2 / R \\
&\Leftrightarrow GM / R^2 = (v^2 / R) / \Gamma^3
\end{aligned}
\qquad (1)
$$

This has exactly the same form as our benchmark (4).

Light path derivation



Setup for speed gradient refraction

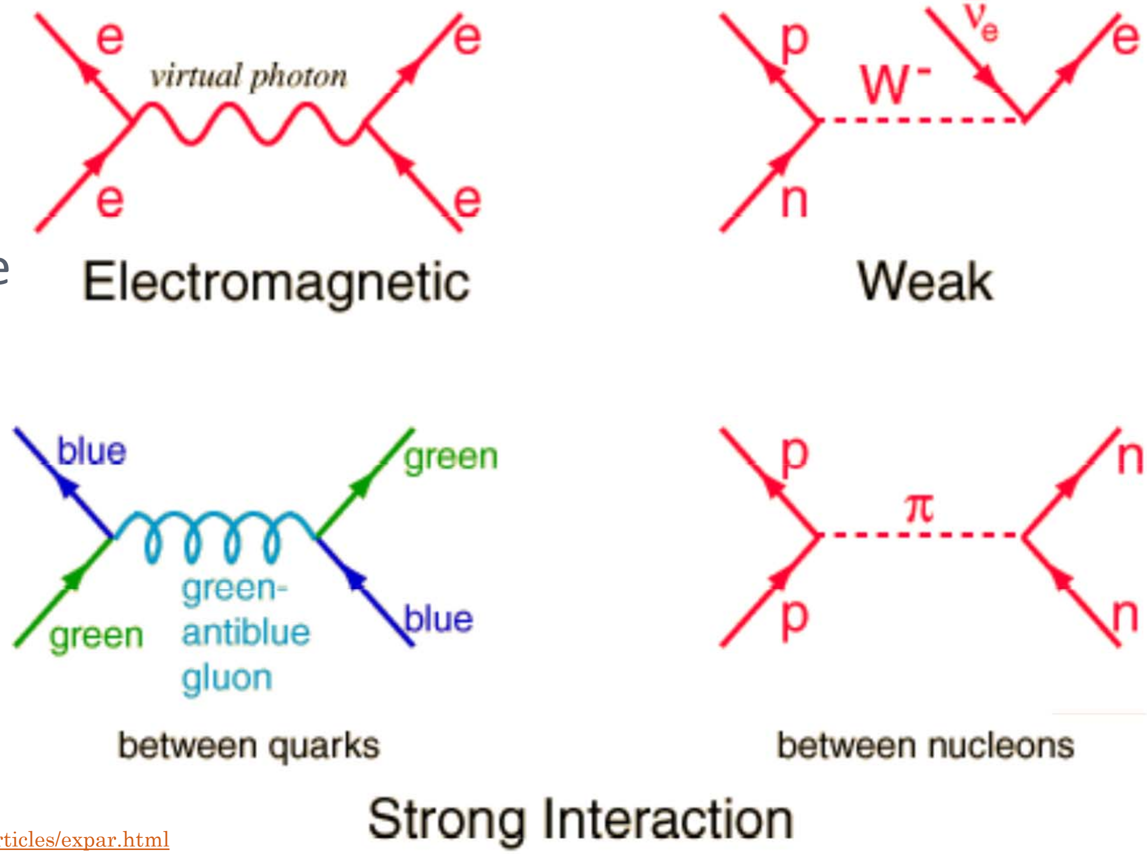
After a horizontal interval Δx we have $\Delta x = v\Delta t$, and we assume $\Delta x_2 = v_2\Delta t = (v/\Gamma)\Delta t$. Two formerly vertical points on the object will be turned at an angle ϕ such that $\tan\phi \approx \phi \approx (\Delta x - \Delta x_2)/\Delta h = (v - v/\Gamma)\Delta t/\Delta h$. The velocity vector **v** will be turned by this same angle ϕ so that a vertical velocity component Δv_h is added, where $\tan\phi \approx \phi \approx \Delta_h / v$. Equating the two expressions for ϕ we have $\phi \approx \Delta_h / v = (v - v/\Gamma)\Delta t/\Delta h$. We can rearrange this into an expression $\Delta_h / \Delta t = v^2(1 - 1/\Gamma)/\Delta h$. This value $\Delta v_h/\Delta t$ is aligned with the gravitational acceleration g (assumed to be vertical in the figure). Substituting for Γ, using for $x \ll 1$, and simplifying we have:

$$\frac{\Delta v_h}{\Delta t} \approx v^2(1-(1-g\Delta h/c^2))/\Delta h = \frac{v^2}{c^2}g \qquad (1)$$

For light, we have $v = c$ and therefore $\Delta v_h / \Delta t = g$. Since $\Delta v_h / \Delta t$ is added to the explicit acceleration g as already noted, we have a total apparent acceleration of $2g$. This value is well known to agree with observations of stellar deflection in the vicinity of the sun.

Overview of Quantum Fields

- Fields act through the uncertainty principle
- All fields in common usage are energy fields
  - $\Delta E \Delta t > h/4\pi$
  - In a small time interval, energy uncertainty is large
  - Virtual particles (bosons) arise and do the work of the field
  - Interactions are momentum based



http://hyperphysics.phy-astr.gsu.edu/hbase/particles/expar.html

HIGGS FEYNMAN DIAGRAMS [SAMPLES]