Evidence of a 6.12×10^{18} GeV particle: Detection and mathematics

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Plan

Tuesday - Section 1:

1. Current difficulties with physics
2. Proposing a new way of looking at the problem
3. Evidence to support the proposition of a spactime-particle
4. Diffraction patterns of gravitons
5. Explaining galactic haloes

Wednesday - Section 2:

1. The expanding Universe
2. Mathematics of the spacetime-particle
3. Young's two slit experiment
4. Summary and concluding remarks

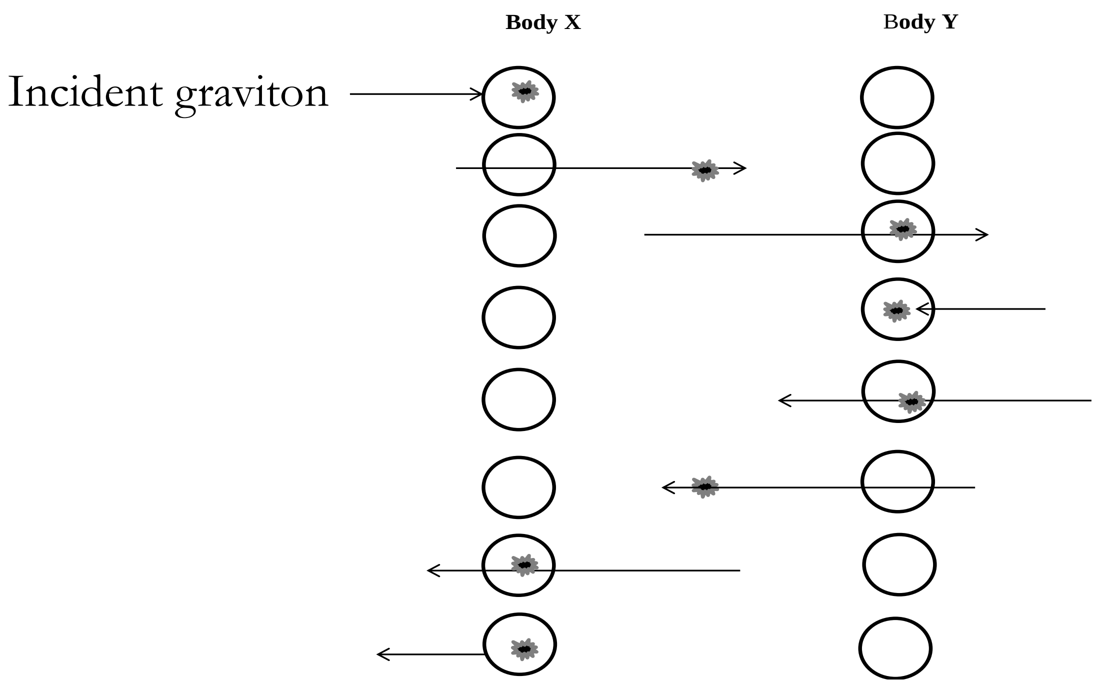
Part 1. Current difficulties

- All quantum particles are influenced by curved spacetime (i.e., gravity), but…..
- The cosmological constant G is missing from quantum theory.
- The graviton is poorly understood - "mediator of gravitational effects".
- The graviton is not in the standard cosmological model.
- The "vacuum catastrophe" … relativity versus quantum physics.
- Dark matter and dark energy?
- The two pillars of modern physics are incompatible?
- Young's two-slit interference experiment needs a mechanism

Part 2. Proposing a mechanism for spacetime

1. Let the graviton be redefined as the spacetime-particle - gravitons do not just "mediate gravity", they provide the mechanism for spacetime.
2. Gravitons link matter in space and time.
3. Incident gravitons provide space and time in equal measure.
4. Sets of gravitons share in carrying photons & quantum particles.
5. Because of 1, 2 and 3, gravitons are at **c** and form the spacetime continuum.
6. The "sea of gravitons" does not provide a preferred reference frame.

A simple view … gravitons carrying a quantum of energy: $X \to Y \to X$



Notes: 1. Because of gravitons, changes take place in space and time.
2. Actually **sets of incident gravitons** carry the quantum.

- **Postulate #1:**

  The dimensions of time and space are provided by gravitons, the quantum field particles of spacetime, which link points at **c** and carry the energy of other quantum particles in the time dimension.

- Implications
  - The quantum vacuum is teeming with gravitons at **c** linking points in the Universe.
  - The spacetime continuum began when gravitons formed.
  - Gravitons provide the experience of spacetime on an ongoing basis.

- **Postulate #2**:

  The elastic encounter between incident gravitons and mass produces a red-shift <u>and</u> scattering of emitted gravitons. Gravitons transfer energy to the mass during these encounters: the source of the energy-content of mass.

- Implication – the graviton is the mechanism underpinning the energy-content of bodies:

$$E^2 = (pc)^2+(mc^2)^2$$

Gravitational red-shift and scattering of gravitons by mass

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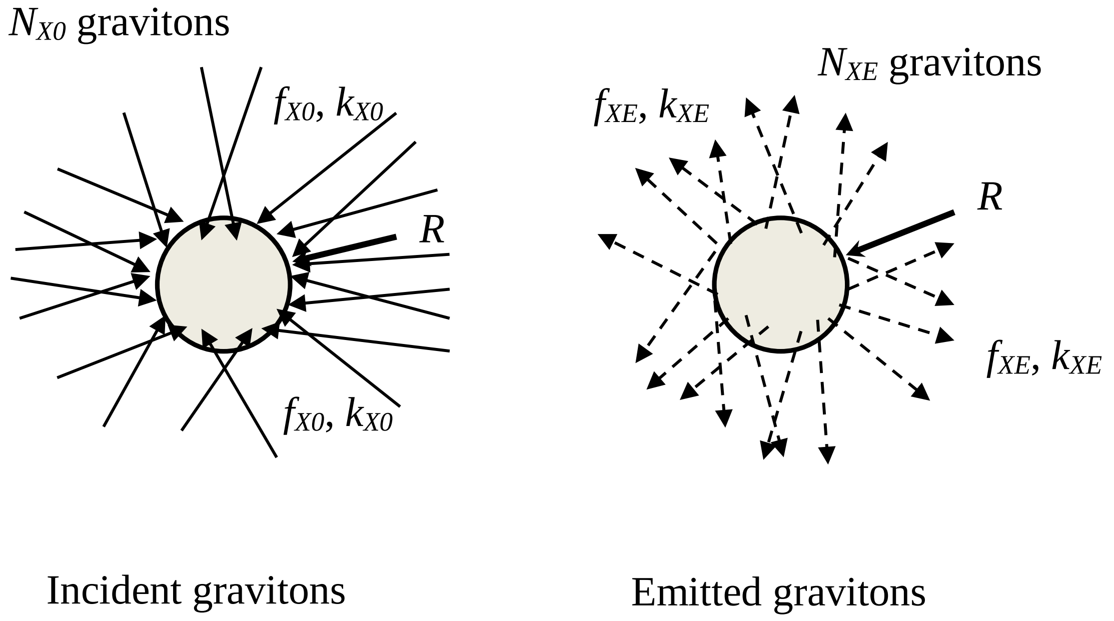

- Energy transferred E_X from gravitons is given by:

$$E_X = (hf_{X0}k_{X0}l - hf_{XE}k_{XE}l)$$
$$\Rightarrow \frac{E_X}{l} = (hf_{X0}k_{X0} - hf_{XE}k_{XE})$$

- Equate to the energy-content E_M of a body with radius r :

$$\frac{d(\frac{E_x}{l})}{dr} = \frac{E_M}{4\pi r^2}$$

- Treat as a separable equation and integrate (R to ∞) :

$$(hf_{X0}k_{X0} - hf_{XE}k_{XE}) = \frac{E_M}{4\pi R}$$

- Rearrange and divide both sides by $(h.f_{X0}.k_{X0})$ to give:

$$\frac{f_{XE}k_{XE}}{f_{X0}k_{X0}} = (1 - \frac{E_M}{hf_{X0}k_{X0}4\pi R})$$

- Given that $f_X = c.k_X$ we have:

$$\frac{f_{XE}}{f_{X0}} = \sqrt{(1 - \frac{E_M}{hf_{X0}k_{X0}4\pi R})}$$

- This equation is of the form of redshift of general relativity:

$$\frac{f_{\infty}}{f_{*}} = \sqrt{(1 - \frac{2GM}{c^2R})}$$

- For these two equations to be equivalent, the following holds true:

$$\frac{Mc^2}{4\pi h f_{X0} k_{X0} R} = \frac{2GM}{c^2 R}$$

- Which simplifies to the **unification** equation:

$$G = \frac{c^4}{8\pi h f_{X0} k_{X0}}$$

- Therefore, G is a function of quantum constants. In other words ….

- The unification equation shows that G is based on the properties of the spacetime particle (i.e., the graviton).

- By substituting the values for h and c into the unification equation, the properties of incident gravitons are:

  Frequency: f_{X0}= 1.48 x 10^{42} s^{-1}

  Wavenumber: k_{X0}= 4.92 x 10^{33} m^{-1}

  Force of gravitons: $hf_{X0}k_{X0}$= 4.85 x 10^{42} J m^{-1}

Note:

- These magnitudes are similar to the Planck scale, but here the values are derived (i.e., not obtained by dimensional analysis).

The energy of incident gravitons

- Based on $f_{X0} = 1.42 \times 10^{42}\ s^{-1}$, the energy of the graviton is:

$$E_X = hf_{X0} = 6.626 \times 10^{-34} \times 1.42 \times 10^{42}$$

$$\Rightarrow E_X = 9.41 \times 10^{8} \text{ joul.} = 6.12 \times 10^{18} \text{ GeV}$$

- Therefore, the graviton is a very, very high-energy particle. It is the most energetic quantum particle of all.
- This finding is the opposite to current thinking and may seem wrong, but…
- It is consistent with our understanding of the action of a probe which can interact with every other quantum particle.

Part 3: Supporting the proposition

- In general relativity the spacetime constant κ is given by:

$$\kappa = \frac{8\pi G}{c^4}$$

- Based on the unification equation we can replace $\boldsymbol{G}$ as follows:

$$\kappa = \frac{8\pi}{c^4}\left(\frac{c^4}{8\pi h f_{X0} k_{X0}}\right) = \frac{1}{h f_{X0} k_{X0}}$$

- So, the Einstein equation of general relativity can be re-written as follows:

$$R_{\alpha\beta} - \frac{1}{2} g_{\alpha\beta} R = \kappa T_{\alpha\beta} \quad \Rightarrow \quad R_{\alpha\beta} - \frac{1}{2} g_{\alpha\beta} R = \frac{1}{h f_{X0} k_{X0}} T_{\alpha\beta}$$

- Curvature of spacetime is a function of matter density on the force of gravitons.

- Accordingly, curvature of spacetime is caused by factors such as gravitational red-shift of gravitons and Doppler shift of gravitons.
- So, mass and motion can cause changes in incident gravitons which produce curvature of spacetime.
- In the void of empty space, the frequency and wavenumber of gravitons do not change. So the existence of a cosmological fluid made of high-energy gravitons at **c** does not, by itself, produce curvature of spacetime. (i.e., so there is no “vacuum catastrophe”).

What about scattering of gravitons?

- Scattering of gravitons has previously been irrelevant, but now we should incorporate scattering of gravitons to **extend general relativity**.
- We will see that scattering of the spacetime particle gives an explanation of galactic haloes, flat rotation curves and the accelerating expansion of the Universe (i.e., the inventions of “dark matter” and “dark energy”).

An analogy of scattering of gravitons:

Exploding fireworks represent the diffraction patterns of gravitons of two galaxies

Another analogy: A diffraction pattern of photons with a laser

Predicting the scattering angle at the critical distance

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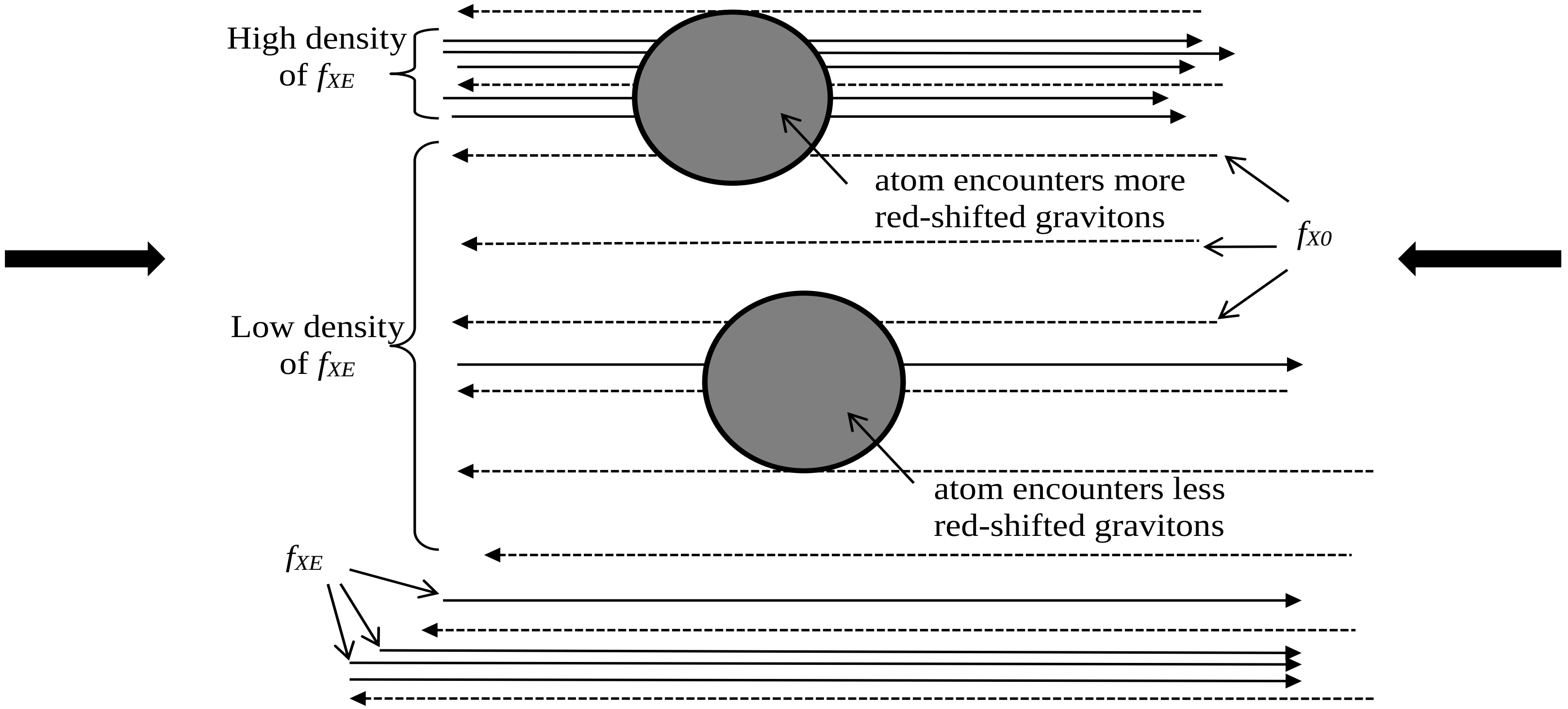
Gravitons coming from a mass are redshifted and scattered



Gravitons from the void

Calculating the scattering angle of gravitons

- From Compton scattering (and ignoring magnitudes of fourth order or more):

$$\lambda_{XE} - \lambda_{X0} = \frac{h}{Mc}(1 - cos\phi) \quad \Rightarrow \quad \delta\lambda_X = \frac{h\phi^2}{2Mc}$$

- We can determine $\delta\lambda_X$ from the red-shift of gravitons as follows:

$$(hf_{X0}k_{X0} - hf_{XE}k_{XE}) = \frac{E_M}{4\pi R} \quad \Rightarrow \quad \left(1 - \frac{{k_{XE}}^2}{{k_{X0}}^2}\right) = \frac{E_M}{4\pi hf_{X0}k_{X0}R}$$

$$\Rightarrow \frac{k_{XE}}{k_{X0}} = \frac{\lambda_{X0}}{\lambda_{XE}} = \sqrt{(}1 - \frac{E_M}{4\pi hf_{X0}k_{X0}R}) \approx (1 - \frac{E_M}{8\pi hf_{X0}k_{X0}R})$$

- Now using $\frac{\lambda_{X0}}{\lambda_{XE}} = (1 - \frac{\delta\lambda_X}{\lambda_{XE}})$ and $E_M = Mc^2$ in weak fields to give:

$$\left(1 - \frac{\delta\lambda_X}{\lambda_{XE}}\right) \approx \left(1 - \frac{Mc^2}{8\pi hf_{X0}k_{X0}R}\right) \quad \Rightarrow \quad \delta\lambda_X \approx \frac{\lambda_{XE}Mc^2}{8\pi hf_{X0}k_{X0}R}$$

$$\phi^2 = \frac{\lambda_{XE}M^2c^3}{4\pi h^2 f_{X0}k_{X0}R} \quad \Rightarrow \quad \phi = \sqrt{(}\frac{M^2c^3}{4\pi h^2 f_{X0}k_{X0}k_{XE}R})$$

- **Predicted scattering angle**: Using the derived equation, the scattering angles ϕ of gravitons by bodies made of hydrogen atoms or hydrogen nuclei, are predicted:

Particle	Mass M (kg)	Radius R (m)	Scattering angle ϕ (radian)
Hydrogen atom	1.67×10^{-27}	0.53×10^{-10}	8.5×10^{-32}
Hydrogen nucleus	1.67×10^{-27}	1.2×10^{-15}	1.8×10^{-29}

- **Measuring the scattering angle**: From rotation curves, the deviations from Newtonian mechanics occur at approximately 0.1-1.0 kpc, which implies that:

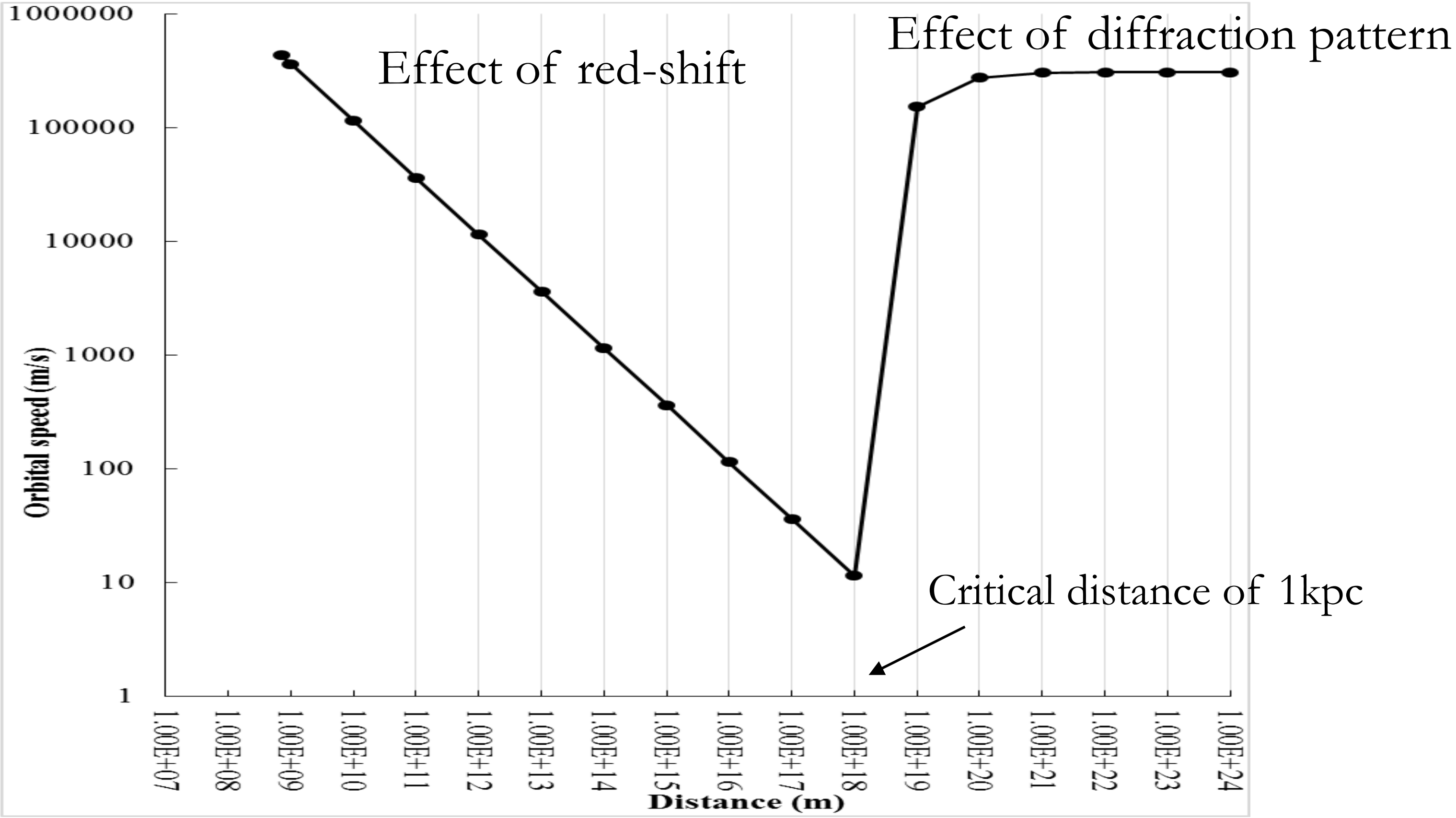
$$\phi = 3 \times 10^{-29} \text{ to } 3 \times 10^{-30} \text{ radian.}$$

- **⇒ The predicted and measured values for the scattering angle are of similar magnitude.**

Predicting the orbital speed in the galactic halo

- Calculations based on missing gravitons in a diffraction minimum:
    - the energy density of a diffraction minimum is ½ the energy density at the surface of the ponderous mass, and
    - Beyond the critical distance, the orbital speed is $\sqrt{½}$ times the speed of a surface orbit.
- So for Sun-like stars, the equations predict that for a distances greater than 1 kpc:
    - Diffraction patterns start having an effect on orbital speed at about 1-10 kpc,
    - The orbital speed is 3×10^5 m s^{-1},
    - The orbital speed is constant with distance, and
    - The diffraction pattern is roughly spherical.
- These predictions fit with cosmological observations of rotation curves and galactic haloes.

The effect of distance on orbital speed
(for bodies orbiting Sun-like stars)



⇒ Diffraction patterns of gravitons explain galactic haloes and galactic rotation curves.

End of Section 1

Thank you

Questions, Comments and Discussion.

Section 2:

Plan:

1. The expanding Universe
2. Mathematics of the spacetime-particle
3. Young's two slit experiment
4. Summary and concluding remarks

Part 1: Explaining the expanding Universe

- Gravitational red shift of gravitons causes a reduced frequency and reduced wavenumber for a body at a fixed distance. For example, for a sun-like star the change in frequency and wavenumber of gravitons, according to the red shift formula, is:

$$\frac{f_{XE}}{f_{X0}} = 0.999997879$$

- Mass also produces an equivalent scattering of gravitons which gives expansion of space (i.e., reduced pressure).

- The reduced pressure due to scattering causes bodies to free fall towards incident gravitons (i.e., Doppler blue shift of incident gravitons). As a result free falling bodies find that:

$$|\text{gravitational red shift}| = |\text{blue shift caused by scattering}|$$

- As a result, frequency f_{X0} and wavenumber k_{X0} of incident gravitons are constant for free falling bodies in the evolving Universe.

- Accelerated expansion is due to the evolution of denser stars (i.e., increase in $\frac{M}{R}$ of stellar bodies), since the scattering angle $\phi \propto \sqrt{\frac{M^2}{R}}$.

- The unification equation is composed of constants:

$$G = \frac{c^4}{8\pi h f_{X0} k_{X0}}$$

- The energy density ε_{X0} of the void for a free falling body is constant:

$$\varepsilon_{X0} = h f_{X0} {k_{X0}}^3 = 1.17 \times 10^{110} \text{ joul m}^{-3}$$

- **Note**: The cosmic background radiation is Doppler red-shifted because of the free falling of today's bodies towards the expanding space (i.e., the Hubble recession velocity).

Part 2: Mathematics of the graviton

Based on our approach to the graviton as the spacetime-particle, we make the following claims:

- The graviton provides space and time in equal measure, therefore **c** is constant.
- There is no preferred reference frame in the sea of gravitons
- The graviton is a boson which has a dual mechanism for space and time, that is best represented as an ordered pair or, better still, as a complex number.
- The dual mechanism of gravitons provides orthogonal space and scalar time. Thus the graviton provides two different mathematical methods for providing space and time.
- Each point in the Universe encounters a set of incident gravitons, which means that a point is best represented as three complex numbers:

$$\vec{Q} = \begin{pmatrix} x + ict_x \\ y + ict_y \\ z + ict_z \end{pmatrix}$$

Linking points in the Universe

- Let one point be defined as the origin, $0 = \begin{pmatrix} 0 \\ 0 \\ 0 \end{pmatrix}$, then the link to another point is given by: $\overrightarrow{0Q} = \begin{pmatrix} x + ict_x \\ y + ict_y \\ z + ict_z \end{pmatrix}$.
- The norm (i.e., magnitude) of this link is obtained by the inner product:

$$|\overrightarrow{0Q}|^2 = \langle \overrightarrow{0Q} | \overrightarrow{0Q} \rangle = \begin{pmatrix} x - ict_x \\ y - ict_y \\ z - ict_z \end{pmatrix} \begin{pmatrix} x + ict_x \\ y + ict_y \\ z + ict_z \end{pmatrix} = (x^2 + y^2 + z^2) + c^2\left({t_x}^2 + {t_y}^2 + {t_z}^2\right)$$

$$\Rightarrow \left|\overrightarrow{0Q}\right|^2 = l^2 + (ct)^2 = 2(ct)^2$$

Projecting links onto orthogonal subspaces

- So, the linking of points by gravitons can be treated as a complex vector, but note that this link is more than a vector because it provides the connection in space and time.

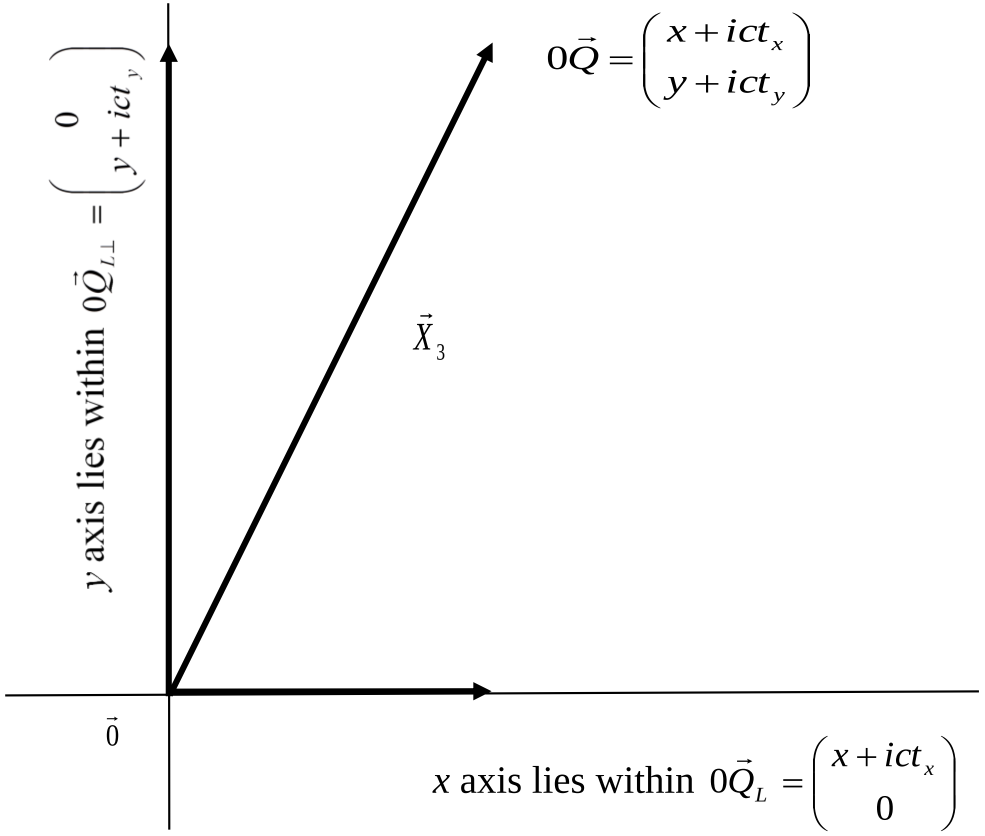
- A link in complex space can be projected onto orthogonal subspaces. For example, subspaces containing perpendicular x and y axes:

$$\left|\overrightarrow{0Q}\right|^2 = 2(ct)^2 \text{ and } \left|\overrightarrow{0Q_L}\right|^2 = (ct)^2 \text{ and } \left|\overrightarrow{0Q_{L\perp}}\right|^2 = (ct)^2$$

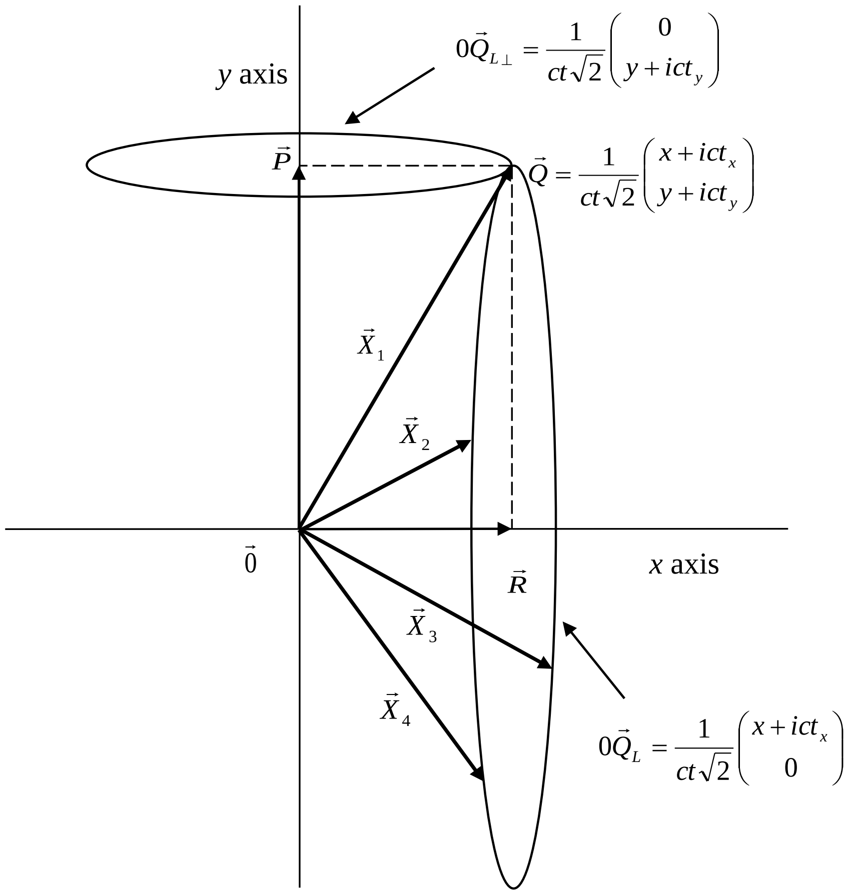
- Also, in $\mathbb{C}^2$ space the orthogonal subspaces are:

$$\overrightarrow{0Q_L} = \begin{pmatrix} x + ict_x \\ 0 \end{pmatrix} \text{ and } \overrightarrow{0Q_{L\perp}} = \begin{pmatrix} 0 \\ y + ict_y \end{pmatrix}$$

Representing projections provided by gravitons



Normalizing and orthogonal projections



Motion along the x axis - Einstein's time dilation

- Successive sets of gravitons carry a body with kinetic energy along the x axis.

- In C^2 space, the inner product of the subspace containing the x axis is:

$$\langle \overrightarrow{0Q_L} | \overrightarrow{0Q_L} \rangle = \begin{pmatrix} x - ict_x \\ 0 \end{pmatrix} \begin{pmatrix} x + ict_x \\ 0 \end{pmatrix} = x^2 + c^2 {t_x}^2$$

$$\Rightarrow (ct)^2 = x^2 + c^2 {t_x}^2$$

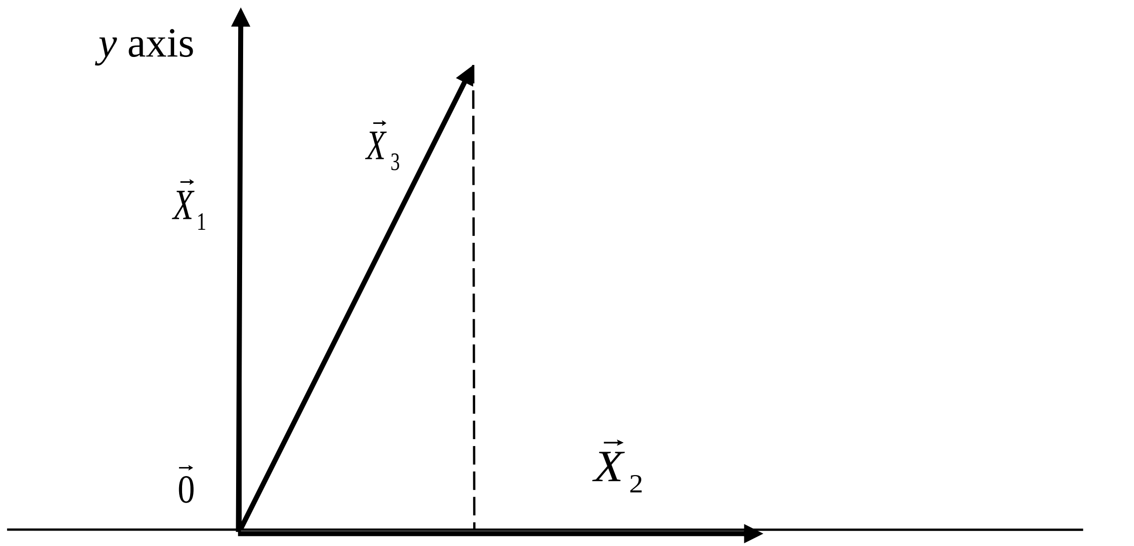
and since along the x axis, $|x| = |ut|$

$$\Rightarrow t^2 \left(1 - \frac{u^2}{c^2}\right) = {t_x}^2$$

and $t = \gamma t_x$

Similarly, Einstein's length contraction can be found for $t^2 = \left(\frac{xc}{c^2 - u^2}\right)^2$.

Projecting subspaces containing the x axis (i.e., $y = 0$)



$$0\vec{Q}_{L1} = \begin{pmatrix} 0 + ict_{x1} \\ 0 \end{pmatrix} \quad 0\vec{Q}_{L3} = \begin{pmatrix} x_3 + ict_{x3} \\ 0 \end{pmatrix} \quad 0\vec{Q}_{L2} = \begin{pmatrix} x_2 + ict_{x2} \\ 0 \end{pmatrix}$$

$$\Rightarrow \left|0\vec{Q}_{L1}\right|^2 = (ct_1)^2 \quad \Rightarrow \left|0\vec{Q}_{L3}\right|^2 = (ct_3)^2 \quad \Rightarrow \left|0\vec{Q}_{L2}\right|^2 = (ct_2)^2$$

Note: There are no preferred reference frame

Lorentz boosts

- Let a point is at rest on the x axis of one subspace (i.e., $\overrightarrow{0Q_{Lk}}$) move at $+u$ along the x axis in the other subspace (i.e., $\overrightarrow{0Q_{Lj}}$):

$$\Rightarrow x_j = x_k + ut_j \qquad \text{and} \qquad x_k = x_j - ut_j$$

- From the perspective of $\overrightarrow{0Q_{Lk}}$ the x axis is at rest so $t_{xk} = t_k$, and divide x_k by **c** to obtain:

$$t_{xk} = \frac{x_k}{c} = \frac{x_j - ut_j}{c} \Rightarrow t_{xk} = x_j - \frac{ux_j}{c^2}$$

- By substitution, the inner product of the subspace is:

$$\left\langle \overrightarrow{0Q_{Lk}} \middle| \overrightarrow{0Q_{Lk}} \right\rangle = \begin{pmatrix} x_k - ict_{xk} \\ 0 \end{pmatrix} \begin{pmatrix} x_k + ict_{xk} \\ 0 \end{pmatrix}$$

$$\Rightarrow (ct_k)^2 = {x_k}^2 + (ct_{xk})^2 = (-ut_k)^2 + c^2 \left(t_j - \frac{ux_j}{c^2}\right)^2$$

$$\Rightarrow {t_k}^2 \left(1 - \frac{u^2}{c^2}\right) = \left(t_j - \frac{ux_j}{c^2}\right)^2$$

$$\therefore {t_k}^2 = \gamma^2 \left(t_j - \frac{ux_j}{c^2}\right)^2 \quad \text{and} \qquad t_k = \gamma \left(t_j - \frac{ux_j}{c^2}\right)$$

- And by a similar approach, all Lorentz coordinate transformation equations can be obtained.

Minkowski's spacetime-interval

- The inner product of the projected subspace of a representative graviton, $\overrightarrow{X_j}$, in C^2 space gives the squared lengths:

$$\langle\overrightarrow{0Q_{Lj}}|\overrightarrow{0Q_{Lj}}\rangle = \begin{pmatrix} x_j - ict_{xj} \\ 0 \end{pmatrix}\begin{pmatrix} x_j + ict_{xj} \\ 0 \end{pmatrix} = {x_j}^2 + \left(ct_{xj}\right)^2$$

$$\Rightarrow \left(ct_j\right)^2 = {x_j}^2 + \left(ct_{xj}\right)^2$$

$$\Rightarrow \left(ct_{xj}\right)^2 = \left(ct_j\right)^2 - {x_j}^2$$

- We can generalize by considering changes in lengths in C^3 and rotations to obtain Minkowski's spacetime interval:

$$(ds)^2 = (ct)^2 - (dx^2 + dy^2 + dz^2)$$

Where the left side is based on change in time on the moving point, while the right side is based on changes in time and space in the coordinates of the projected subspace.

Notes about relativity and spacetime

- When gravitons are used, points are represented by complex space. However, the length between points is obtained via the inner product, which gives a real number.
- Relativity does not use complex numbers, but relies on lengths obtained via the inner product or such like (i.e., by variants of the Pythagorean theorem).
- Therefore, relativity is based on a simplifying process which eliminates the differences in the mathematical properties of space and time (imaginary part).

Euler's Formula

- A point on the x axis can be described:

$$\overrightarrow{0Q_L} = \begin{pmatrix} x + ict_x \\ 0 \end{pmatrix} \qquad \text{so: } (ct)^2 = x^2 + (ct_x)^2$$

$$\Rightarrow \overrightarrow{0Q_L} = \frac{1}{ct}\begin{pmatrix} x + ict_x \\ 0 \end{pmatrix} = \begin{pmatrix} \frac{u}{c} + i\,\frac{t_x}{t} \\ 0 \end{pmatrix} \text{ (for normalized case).}$$

- Equally, the point can be described:

$$\overrightarrow{0Q_L} = \begin{pmatrix} ctcos\emptyset + ictsin\emptyset \\ 0 \end{pmatrix}$$

$$\text{so: } (ct)^2 = (ctcos\emptyset)^2 + (ctsin\emptyset)^2 = (ct)^2$$

$$\Rightarrow \overrightarrow{0Q_L} = \begin{pmatrix} cos\emptyset + isin\emptyset \\ 0 \end{pmatrix} \text{ (for normalized case).}$$

- Therefore: $(x + ict_x) = ct(cos\emptyset + isin\emptyset)$

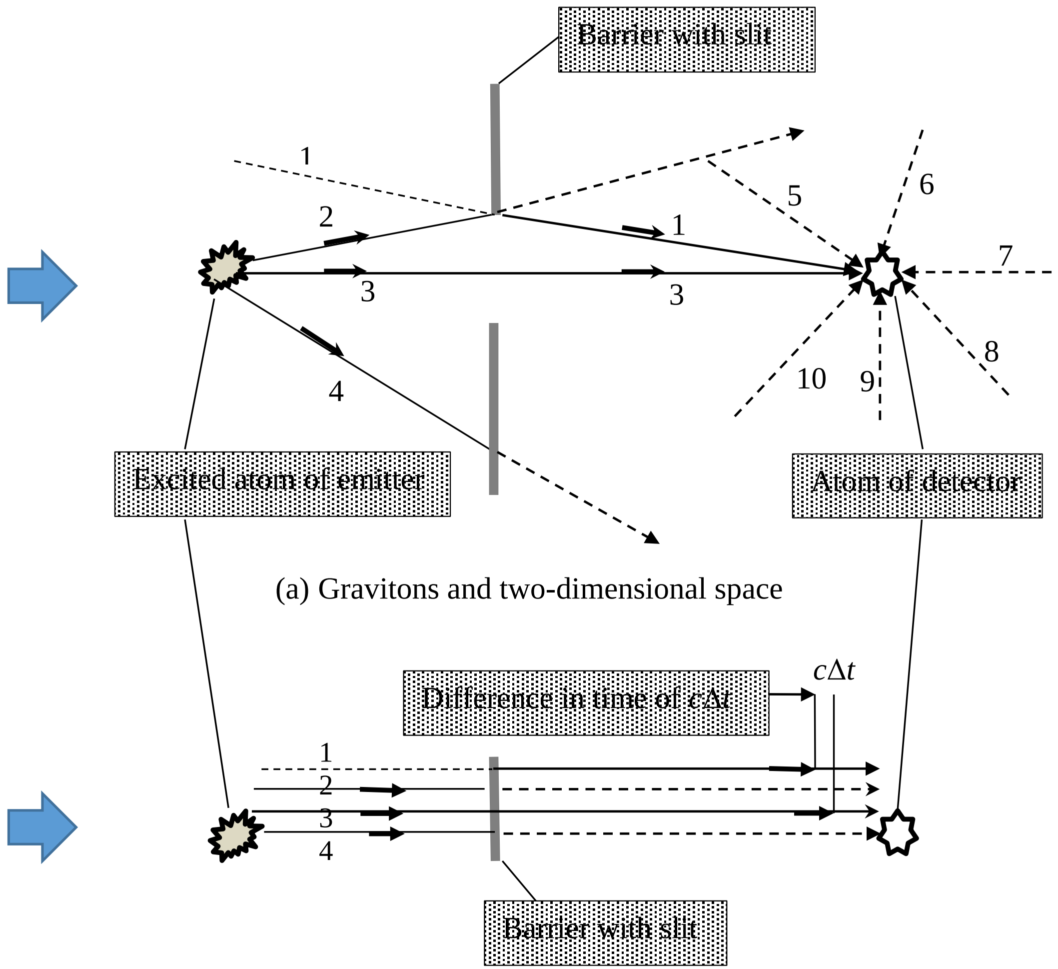
- And generalize to obtain Euler's formula:

$$z = x + icy = R(cos\emptyset + isin\emptyset) = Re^{i\emptyset}$$

Part 3: Gravitons carrying an emitted quantum

Representing gravitons providing space

Representing gravitons providing time



(a) Gravitons and two-dimensional space

(b) Gravitons and one-dimensional time

Calculating Young's two slit interference

- In an ideal experiment, let one carrier-graviton from each slit carry the quantum to the point of detection, $\vec{Q}$. For two gravitons carrying the quantum through slit 1 and slit 2, the total pathlenght is:

$$\overrightarrow{0Q} = \overrightarrow{0Q_1} + \overrightarrow{0Q_2} = \begin{pmatrix} x_1 + ct_{x1} \\ y_1 + ct_{y1} \end{pmatrix} + \begin{pmatrix} x_2 + ct_{x2} \\ y_2 + ct_{y2} \end{pmatrix} = \begin{pmatrix} ct_1 cos\phi + ct_1 sin\phi \\ ct_1 cos\theta + ct_1 sin\theta \end{pmatrix} + \begin{pmatrix} ct_2 cos(\phi+\delta) + ct_2 sin(\phi+\delta) \\ ct_2 cos(\theta+\epsilon) + ct_2 sin(\theta+\epsilon) \end{pmatrix}$$

$$\Rightarrow \overrightarrow{0Q} = \begin{pmatrix} ct_1 e^{i\phi} + ct_2 e^{i(\phi+\delta)} \\ ct_1 e^{i\theta} + ct_2 e^{i(\theta+\epsilon)} \end{pmatrix}$$

- The squared length of spacetime due to these the two carrier-gravitons is determined as follows:

$$\left|\overrightarrow{0Q}\right|^2 = 2(ct_1)^2 + 2(ct_2)^2 + 2c^2 t_1 t_2 cos(\delta) + 2c^2 t_1 t_2 cos(\epsilon)$$

For $\delta = \epsilon$ then:

$$\left|\overrightarrow{0Q}\right|^2 = 2\left\{c^2 {t_1}^2 + c^2 {t_2}^2 + 2c^2 t_1 t_2 cos(\delta)\right\}$$

- And for $t_1 = t_2$ and $\delta = 0$, we have $\left|\overrightarrow{0Q}\right|^2 = 8c^2 {t_1}^2$, and for $\delta = \pi$ we have $\left|\overrightarrow{0Q}\right|^2 = 0$.

Explaining Young's two slit interference

- Each quantum that arrives at the detector is carried by sets of gravitons through the slits, and the gravitons provide pathways of different lengths.
- The inner product gives the measure of spacetime at the detector, and it is the sum of the spacetime provided by the carrier-gravitons.
- Variation in the measure of spacetime at detection points, which is generally understood in terms of probability of detection, produces the interference phenomenon.

Summary and conclusion

- Defined the graviton as the quantum field particle of spacetime.
- Provided a mechanism for space and time which extends GR and QT.
- Derived for gravitons the equation for gravitational red-shift of general relativity.
- Derived the unification equation which shows G is based on the graviton's properties.
- Calculated that a free-falling body finds incident gravitons are 6.12×10^{18} GeV and:

  $f_{X0} = 1.48 \times 10^{42}$ s^{-1} and $k_{X0} = 4.92 \times 10^{33}$ m^{-1}.
- Showed that diffraction patterns of gravitons can account for flat rotation curves and rapid orbital speeds within galactic haloes (i.e. alternative to dark matter).
- Explained that scattering of gravitons produces a reduced pressure which gives a Doppler blue shift of gravitons that precisely counters gravitational red shift. So bodies today fall towards gravitons, which maintains the quantities in the unification equation as constants.
- Calculated that the energy density of the cosmological vacuum is constant at:

  $\varepsilon_{X0} = hf_{X0}{k_{X0}}^3 = 1.17 \times 10^{110}$ J m^{-3}.

- Showed that the mathematics of special relativity can be obtained with gravitons, i.e., by way of the inner product of projected subspaces of links in complex space.
- Derived representative equations with gravitons: Einstein’s time dilation, Lorentz boosts and Minkowski’s spacetime interval.
- Obtained Euler’s formula with gravitons.
- Explained Young’s two slit interference with gravitons.
- Found that the graviton is the mechanism which reveals the mathematics of:
    - Quantity: numbers and algebra.
    - Structure: sets and group theory.
    - Space: orthogonality, geometry and trigonometry.
    - Change: functions and calculus.
- Find that the properties of the graviton give the Universe the rules which unify physics and mathematics.

Thank you

Books:

- Smith, P.T. *Unravelling the Great Mysteries of the Universe*. VNS: Sydney. (2013, 2014 2nd edn).
- Smith, P.T. *Gravitons: Discovering Frequency and Scattering*. VNS: Sydney. (2013, 2015 2nd edn).
- Smith. P.T. *Gravitons at Work*. VNS: Sydney. (2017).

  www.greatmysteriesoftheuniverse.com

Refereed journal paper:

- Smith, P.T. 2017. *Reporting new evidence of gravitons*. Japanese Physics Society Conf. Proc. **14**, 020101 (2017).