Λ : A Constant of Spacetime Structure

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Let's begin at the very beginning

Free : Absence of all forces

Space : homogeneous and isotropic

Time : homogeneous

Let's term it *homogeneous*

Free of *all Dynamics*

Force-free state

Homogeneity

Space : $x \leftrightarrow y$

Space and Time : $x \leftrightarrow t$?

Dimensions don't match.

Homogeneity is a universal general property

Make dimesnsions match $\rightarrow$ Universal velocity, c

$$x \leftrightarrow ct$$

Profound conclusion: Homogeneity demands

Universal velocity c or $m = 0$ particle!

Homogeneity binds Space and Time into Spacetime

What should be geometry of homogeneous free spacetime?

Obiviously homogeneous; i.e. curvature homogeneous

Homogeneous spacetime:

$$R_{abcd;e} = 0 \text{ : Constant Curvature}$$
$$\Downarrow$$
$$R_{abcd} = \Lambda(g_{ac}g_{bd} - g_{ad}g_{bc})$$

Dynamics - free spacetime is of constant curvature, Λ

Not of zero curvature, flat

Minkowski metric is a *prescription*

Natural geometry of dynamics-free spacetime is

constant curvature Λ, dS/AdS

Λ arises as a constant of spacetime structure on the same footing as **c**.

It defines a Universal Length!

c binds Space and Time into *Spacetime.*

Λ curves it - gives a constant curvature

its natural "free" state!

Homogeneity demands:

c: *Universal Velocity* & Λ: *Universal Length*

These are two the most fundamental constants as they are part of space-time structutre

No other constant can claim this degree of fundamentalness

Like **c**, Λ is free to have any value

without reference to anything else

It has to be determined empirically by observation

Now the next question:

What happens when spacetime is not homogeneous $R_{abcd;e} \neq 0$?

Inhomogeneity $\rightarrow$ Presence of force/Dynamics

What could it be?

It should follow entirely from curvature, R_{abcd}

Diff. Geometry: $D^2 \equiv 0$, Boundary of boundary is zero (*John Wheeler*)

$\nabla \times \nabla\phi = 0$, $\nabla \cdot \nabla \times \mathbf{A} = 0$

Similarly Bianchi Derivative of R_{abcd} vanishes

Bianchi identity: $R_{ab[cd;e]} = 0$, Taking trace

$$g^{ac} g^{bd} R_{ab[cd;e]} = 0$$
$$\Downarrow$$

$$\mathrm{G}^{b}_{a;b} = 0, \; G_{ab} = R_{ab} - \tfrac{1}{2} R g_{ab}$$

Integrating Bianchi identity

$$
\begin{array}{lll}
G_{ab} & +\Lambda g_{ab} = & \kappa T_{ab},\ T^{b}{}_{a;b} = 0 \\
\Downarrow & & \Downarrow \\
\nabla^2 \phi & & \rho
\end{array}
$$

T_{ab}: Source - Energy - momentum

Then this is the **Einstein Gravity**

It has simply followed from spacetime curvature.

Λ at the same footing as T_{ab}

Naturally comes as integration constant $\big($Much acrobatics by Unimodular/ Tracefree, Ellis et al and Padmanabhan$\big)$

Gravity is thus unique universal force!

When $T_{ab} = 0$, back to homogeneity

Dynamics free state with constant curvature Λ

Had Einstein followed this geometric approach, he would have recognised Λ, **not a blunder** *but a true constant of spacetime*

Perhaps would have made the greatest prediction of all times

The Universe will suffer accelerated expansion some time in future !

Had that happened, not only would it have been most remarkable

We would have been spared of the great confusion

In the conventional view

Absence of gravity $\rightarrow R_{abcd} = 0$, flat

Presence of gravity $\rightarrow R_{abcd} \neq 0$, curved

Constant curvature spacetime though maximally symmetric has dynamics !

There is a break/discontinuity from flat to curved, zero to non-zero !

In our perspective

Homogeneous R_{abcd}: No dynamics/gravity, Λ: dS/AdS

Inhomogeneous R_{abcd}: Gravitational dynamics

No break - Continuity: *homogeneity* to *inhomogeneity*

No force $\rightarrow$ *Universal Force*

Constant velocity, NOT zero, Constant curvature, NOT zero !

Force - No Force: homogeneity - inhomogeneity

How is Λ determined?

Static uniform density dust Universe : $-\rho_c r + \Lambda r = 0$

This determines as ρ_c

Observations: ρ_c is the present density!

It bears out all the observations beautifully

Most natural explanation for accelerating expansion

No need for anything *dark (and sinister)* energy!

Problem: Slated against vacuum energy (VE): $T_{ab} = \Lambda g_{ab}$

Monumental discrapemcy of 10^{120}, great embarrassment!

How does VE gravitate, *by adding* Λg_{ab} *on the right*?
No independent existence, Secondary effect

Exactly on the same footing as gravitational field energy (GFE)

How does GFE gravitate in GR, not by a stress tensor

In GR, $\phi \sim 1/r$, there is no self interaction

How is it then accounted for?

By *curving* 3-space:

Einstein is Newton with 3-space curved (arxiv:1206.0635)

General Principle for all Secondary Sources:

Gravitate by enlarging framework NOT by stress tensor

So must do vacuum energy by enlarging framework and NOT by Λg_{ab}

For VE, How do we enlarge framework?

It is a quantum creature, Won't know it until Quantum Gravity tells !

Imagine had we asked this question for GFE in 1912?

We would have done, $\nabla^2\phi \sim (\nabla\phi)^2$?

This is exactly like writing Λg_{ab} on the right?

Couldn't have thought of curving 3-space!

Drawing on GFE and GR, enlargement should keep GR intact

How about invoking extra D!

Could VE gravitate via extra D leaving 4-D GR intact?

Exactly as what happens for GFE in GR

Then Λ would be completely free of Planck's length

Observations determine it as the present energy density!

For VE, inertial density, $\rho + p = 0$

What happened when inertial mass, $m = 0$, particle?

Had a new theory to accommodate it: SR

Need a new theory to make VE gravitate!

Finally let's turn monumental embarrassment into a perceptive insight

In terms of Planck area the Universe measures 10^{120} *units !*