

# GR after 100 Years

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- Much ahead of its time – at least 50 Years!

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- GR should have been born in 1980 rather than in 1916!
- This is what makes Einstein different

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- Time is homogeneous
- Characterizes Force-free state of space and time

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- Homogeneity is a universal property, Must always be respected
- Make them match!
- Required universal velocity,  $c : x \leftrightarrow ct$

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- Homogeneity binds Space and Time into space-time
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- Obviously homogeneous; curvature must be homogeneous - constant

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- Minkowski (flat) is a *prescription*
- Free – homogeneous spacetime is thus characterized by constant curvature  $\Lambda \rightarrow$  dS/AdS

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- (i) Universal Velocity ,  $c$  & (ii) Universal Length ,  $\Lambda$

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- It has to be determined empirically by observation

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- What else, the curvature,  $R_{abcd}$

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- Similarly Bianchi Derivative of  $R_{abcd}$  vanishes
- Bianchi identity :  $R_{ab[cd;e]} = 0$ . Taking trace

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

$$G_{a;b}{}^b = 0, \quad G_{ab} = R_{ab} - \frac{1}{2} R g_{ab}$$

# Einstein gravity : GR

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- Then this is the **GR** : **Einstein Gravity**

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- Spared of the great confusion, persisting over 100 years and still no sign of abetting

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- *Constant curvature spacetime though maximally symmetric has dynamics!*
- There is a break/discontinuity from flat to curved, zero to non-zero!



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- No Force  $\Rightarrow$  Universal Force : Homogeneity *Rightarrow* Inhomogeneity

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

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

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- *So must do vacuum energy , and NOT by  $\Lambda g_{ab}$*

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- **Not only GR was principle driven, so is journey beyond it!**

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- Thus inclusion of VE in gravitational interaction
- Would need enlarged framework of *Quantum Gravity*
- This is the principle that asks for new theory

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- VE could gravitate :  
via higher dimensions, or micro-structure, or both!

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- Enlargement should keep GR intact and VE should get automatically incorporated
- Possible avenues :
  - (i) High energy effects  $\Rightarrow$  Higher dimensions
  - (ii) Space bending like a wire  $\Rightarrow$  discrete micro-structure – *"atoms of space"*
- VE could gravitate :  
via higher dimensions, or micro-structure, or both!
- Won't know until QG emerges

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- Monumental embarrassment to a perceptive insight  
**In terms of Planck area the Universe measures  $10^{120}$  units!**

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- *Isn't this sublime elegance, **Greatest feat of human thought!***

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- Light doesn't, what bends is space on which light freely floats

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- Negative charge, non-localized, spread over whole space, when summed would exactly balance positive charge ( $T_{ab}$ )

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- This completion would be the greatest enlargement  
*Rightarrow* **Quantum theory of spacetime/gravity**

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- **That would be the greatest synthesis : Quantum space-time/gravity**
- *That's the challenge?*

