Lecture 9

Gravity as self-consistent theory of "spin-2" field

Two papers Linear + General 1957 Rev Mod Phys;
Gupta 1952 I; Deser 1970

[Presentation directly with these papers]

Gupta:

- Start with $\phi_{\mu\nu}$ → flat Minkowski space 2nd rank tensor field
- Write a linear Laplacian equation for it with no source
- Now require a source on the right hand side
  → conserved for consistency of the Laplacian on LHS.
- Conserved $\theta_{\mu\nu}$ requires that

$$\Theta_{\mu\nu} = T_{\mu\nu}^{\text{matter}} + t_{\mu\nu}^{\phi\text{-field}}$$

$\partial_\mu \Theta^{\mu\nu} = 0$ will not hold if $t_{\mu\nu}$ is not included.

Then modify the Lagrangian of $\phi_{\mu\nu}$

This changes eqn. of motion of $\phi_{\mu\nu}$

So add more terms to get $t_{\mu\nu}$ for the enhanced Lagrangian

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Then one recovers $t_{\mu\nu} \to$ L&L pseudo-tensor of $g_{\mu\nu} = \eta_{\mu\nu} + \phi_{\mu\nu}$

i.e. one recovers G.R.

In Gupta's ('52 & '57 Rev Mod. Phy.
the purpose is "flat space theory
of gravity" equiv to GR.

$$\Box U_{\mu\nu} = \kappa (T_{\mu\nu} + t_{\mu\nu})$$

$$\left[\left({}^{(1)}R_{\mu\nu} - \frac{1}{2}\eta_{\mu\nu}\, {}^{(1)}R \right) = 8\pi (T_{\mu\nu} + t_{\mu\nu}) \right.$$

$$\left. \text{By def, } t_{\mu\nu} = G_{\mu\nu} - {}^{(1)}G_{\mu\nu} \right]$$

Difference in philosophy

Gupta + HEP PPL

Flat space $\mathbb{R}^4$
+ perturbative
theory of graviton

Relativists

pseudo-Riemannian manifold

↓

includes singularities
& not necessarily $\mathbb{R}^4$

Deser (1970)

Instead of infinite series for $t_{\mu\nu}$, one can adopt Palatini variational method with

$g_{\mu\nu}$ as well as $\Gamma^{\mu}_{\nu\sigma}$

treated as indep. d.o.f.

Then one set of e.o.m. set

$\Gamma \rightarrow$ compatible with $g_{\mu\nu}$

The other set becomes Einstein's eqn.s.