General Relativity II

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Transcribed by Ron Wu

This is a graduate course. Offered in Fall 2014 at Columbia University. Reference: Wald, *General Relativity*; Weinberg, *Gravitation and Cosmology*; *The Quantum Theory of Fields: Volume 1.*

Contents

Overview

Lecture 1 (9/3/14)

Syllabus from previous years:

1-3 are fundamental

1. Lagrangian & Hamiltonian formulation of GR
2. Energy & momentum in GR
3. Necessary of GR from QFT viewpoint
4. GR as an effective field theory: People used to say GR and QM don't go together, but in fact they go perfectly in effective FT.
5. Loops correction in GR. This has nothing to do with what we don't know about QFT
6. Weinberg–Witten theorem. It says gravity cannot be a fundamental theory.
7. Spins in GR. This is beyond standard textbook material. It says graviton has more some structure than spin 1 Boson, e.g. spin connection
8. Causal structure (Penrose diagrams). It
9. Isometrics & Killing vectors (generator of symmetry)

Some possible choices for this year:

10. Post-Newtonian expansion. Classically take Einstein equation perturb around Newton limit, or in effective FT way, use Feynman diagram. Compute gravitational waves for e.g. binary systems.
11. Singularity theorem. It says general gravity is a complete theory.
12. Cosmology constant problem
13. Inflationary Perturbation.

10, 11 are tradition topics and 12,13 are modern topics.

1 Lagrangian & Hamiltonian formulation

1.1 Gauge Transformation