The General Theory of Relativity, Seminars

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These seminars give you the necessary background to conquer more advanced hot topics in the field of high energy physics such as: cosmology, string theory, alternative theories of general relativity, and quantum gravity.

By the end of the seminar, you will acquire skills of:

- knowing the gravitational differences between the Special Theory of Relativity and the General Theory of Relativity.
- implementing Einstein equations and other laws of physics on different curved spacetimes.
- exploring the "problem of time" after generalizing the Lagrangian and Hamiltonian mechanics on curved spacetime.
- applying more advanced geometrical techniques on curved spacetimes to solve gravitation problems from perspective of the General Theory of Relativity or that of an alternative theory to general relativity.

Prerequisites:

Previous exposure to the Special Theory of Relativity is NOT assumed. Yet, it is strongly recommended you review it before the seminar begins (e.g., W. G. V. Rosser, "An Introduction to the Theory of Relativity" or any reference at the same level). Being acquainted with finite-dimensional vector spaces and multivariable calculus is assumed.

Main Syllabus:

1. Prelude to the Special Theory of Relativity & Lorentzian spacetime.
2. Equivalence Principle(s) & *curved* spacetime.
3. Manifolds & tensor structures.
4. Covariant derivative, curvature structure, and diffeomorphisms.
5. Einstein equations & Laws of physics in curved spacetimes.
6. Linearized gravity, Newtonian approximation & gravitational waves.
7. Lagrangian & Hamiltonian formulations of the General Theory of Relativity.
8. Special curved spacetimes: black holes, wormholes, and/or Alcubierre warp drive.
9. Differential forms & calculus on manifolds OR projects on some gravitation problems (tentative).

References:

- Standard: M. Hobson, G. Efstathiou, A. Lasenby, "General Relativity: An Introduction for Physicists", CUP, 2006.
- Standard: H. Stephani, "Relativity: An Introduction to Special and General Relativity", CUP, 2004.
- Standard: R. d'Inverno, J. Vickers, "Introducing Einstein's Relativity: A Deeper Understanding", OUP, 2022.
- Advanced: R. Wald, "General Relativity", The University of Chicago Press, 1984.
- Encyclopedic: C. Misner, K. Thorne, J. Wheeler, "Gravitation", W. H, Freeman and Company, 1970.