Holographic Space Time

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The Key Points

- General Relativity as Hydrodynamics of the Area Law - Jacobson
- The Covariant Entropy/Holographic Principle - 't Hooft, Fischler, Susskind and Bousso
- T.B. and Fischler: c.c. as boundary condition on entropy* for large time
- Scattering in terms of Asymptotic Current Algebra
- Jet State decomposition of DOF, Zero Energy Horizon DOF

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- That is *Einstein's Equations (with cosmological constant undetermined) are the hydrodynamics of any quantum system obeying the area law!*
- Implies QFT (in string theory we learn that all of QFT follows from the supersymmetric generalization of Einstein's equations in 11 dimensions) should only be quantized when discussing small fluctuations around the ground state.

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$$ds^2 = -(1 - \frac{R_S}{r} \pm \frac{r^2}{R^2})dt^2 + \frac{dr^2}{(1 - \frac{R_S}{r} \pm \frac{r^2}{R^2})} + r^2 d\Omega^2.$$

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- Leads to asymptotic energy conservation law in Minkowski ($R \rightarrow \infty$) limit.

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- Finite Diamond $Q(P,p) \rightarrow \psi^A_i(p)$: Angular momentum (Dirac spectrum) cutoff = IR cutoff .

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- Localized interactions. HST consistency conditions tie together into Feynman diagrams. Both particle vertices and black hole production.

Holographic Cosmology

- Principle that local excitations are constrained states of variables on the horizon, with a number of constraints $\sim N = R/L_P \ll N^2$ has profound implications for early universe cosmology. Explains Boltzmann-Penrose question of why the universe began in a low entropy state.

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- Leads to a finite, quantum mechanical theory of inflation, more constrained than QFT models, and with no conceptual ("trans-Planckian mode") problem.
- Holographic theory explains current data as well as QFT models, but gives different results for tensor (B mode) correlation functions. Unfortunately these are not yet measured and theory predicts them to be small.

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- Leads to $m_{3/2} \sim (M_U/m_P)^{-1/2}\Lambda^{1/4}$
- Splitting in super multiplets $\sim \sqrt{m_{3/2}M_P} \sim a\ few\ TeV$.

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- Space-time is not a fluctuating quantum variable, but instead a representation of the hydrodynamics of the underlying quantum system.
- Localized excitations are constrained low entropy states of that system.
- Implications for the early universe, tensor fluctuations in the CMB, as well as TeV scale physics and supersymmetry.