Title: Gravitational collapse, shock waves and white holes

Speakers: Viqar Husain

Collection/Series: Lee's Fest: Quantum Gravity and the Nature of Time

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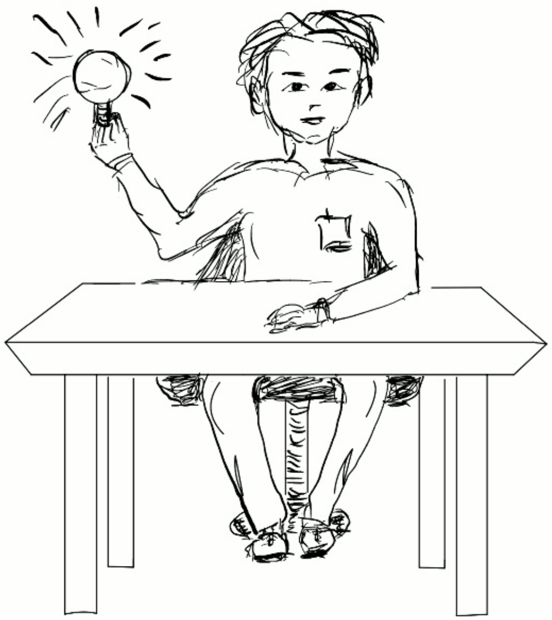
Abstract:

I will describe an effective quantum gravity model for dust collapse that predicts a shock wave as the end point of a black hole, and smooth metrics for black hole to white hole transitions.




NEEDS WORK!

Quantum gravity on a lattice

Lee Smolin *

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Abstract

A formulation of quantum gravity with a gauge-invariant cutoff is given by transcribing MacDowell and Mansouri's formulation of general relativity onto Wilson lattice. The weak coupling and strong coupling expansions are develop The strong coupling expansion reveals a typical strong coupling phase with short range order, confinement (of spin) and asymptotic freedom. If the lattice theory has a second-order phase transition, then the continuum theory may be well-defined.

DERIVATION OF QUANTUM MECHANICS FROM A DETERMINISTIC NONLOCAL HIDDEN VARIABLE THEORY. 1. THE TWO-DIMENSIONAL THEORY

Lee Smolin (Princeton, Inst. Advanced Study)

Jul, 1983

48 pages

Report number: PRINT-83-0802 (IAS,PRINCETON)

Quantum Gravity and the Statistical Interpretation of Quantum Mechanics

Lee Smolin[1]

Received September 9, 1985

Three independent arguments are given for the conclusion that the distinction between quantum fluctuations and real statistical fluctuations in the state of a system will not be maintained in a theory that gives a correct description of phenomena in which quantum and gravitational effects are both important. As this distinction is absolute in terms of the orthodox interpretation of the quantum state something in either the interpretation of the quantum state or the interpretation of the thermodynamic state will have to be altered to construct a theory which describes both quantum and gravitational phenomena. I propose that we pursue the simplest possibility, which is to adopt the statistical interpretation of the wave function in which quantum fluctuations are understood to be ordinary statistical fluctuations in an ensemble of individual physical systems.

General Relativity and Gravitation, Vol. 17, No. 12, 1985

Space-Time Foam as the Universal Regulator[1]

Louis Crane[2] and Lee Smolin[3]

A distribution of virtual black holes in the vacuum will induce modifications in the density of states for small perturbations of gravitational and matter fields. If the virtual black holes fill the volume of a typical spacelike surface then perturbation theory becomes more convergent and may even be finite, depending on how fast the number of virtual black holes increases as their size decreases. For distributions of virtual black holes which are scale invariant the effective dimension of space-time is lowered to a noninteger value less than 4, leading to an interpretation in terms of fractal geometry. In this case general relativity is renormalizable in the $1/N$ expansion without higher derivative terms. As the Hamiltonian is not modified the theory is stable.

Does String Theory Solve the Puzzles of Black Hole Evaporation?[1]

M. J. Bowick,[2] L. Smolin,[2] and L. C. R. Wijewardhana[2]

We point out that the massive modes of closed superstring theories may play a crucial role in the last stages of black hole evaporation. If the Bekenstein–Hawking entropy describes the true degeneracy of a black hole—implying loss of quantum coherence and the unitary evolution of quantum states—it becomes entropically favorable for an evaporating black hole to make a transition to a state of massive string modes. This in turn may decay into massless modes of the string (radiation) avoiding the naked singularity exposed by black hole evaporation in the semiclassical picture. Alternatively, quantum coherence may be maintained if the entropy of an evaporating black hole is much larger than that given by the Bekenstein–Hawking formula. In that case, however, the transition to massive string modes is unlikely. String theories might thus resolve the difficulty of the naked singularity, but it appears likely that they will still involve loss of quantum coherence.

VOLUME 61, NUMBER 10 PHYSICAL REVIEW LETTERS 5 SEPTEMBER 1988

Knot Theory and Quantum Gravity

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and

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(Received 13 June 1988)

A new representation for quantum general relativity is described, which is defined in terms of functionals of sets of loops in three-space. In this representation exact solutions of the quantum constraints may be obtained. This result is related to the simplification of the constraints in Ashtekar's new formalism. We give in closed form the general solution of the diffeomorphism constraints and a large class of solutions of the full set of constraints. These are classified by the knot and link classes of the spatial three-manifold.

PACS numbers: 04.60.+n, 02.40.+m

Did the universe evolve?†

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Received 9 May 1991

Abstract. A new type of explanatory mechanism is proposed to account for the fact that many of the dimensionless numbers which characterize particle physics and cosmology take unnatural values. It is proposed that all final singularities 'bounce' or tunnel to initial singularities of new universes at which point the dimensionless parameters of the standard models of particle physics and cosmology undergo *small* random changes. This speculative hypothesis, plus the conventional physics of gravitational collapse, together comprise a mechanism for natural selection, in which those choices of parameters that lead to universes that produce the most black holes during their lifetime are selected for. If our universe is a typical member of the ensemble that results from many generations of such reproducing universes than it follows that the parameters of our present universe are near a local maximum of the number of black holes produced per universe. Thus, modifications of the parameters of particle physics and cosmology from their present values should tend to decrease the number of black holes in the universe. Three possible examples of this mechanism are described. In inflation models I show that, given the hypotheses, there is selective pressure for the very small values of scalar field self-coupling required for inflation. The second concerns the effect on changing the proton–neutron mass difference on the rate of black hole formation in our galaxy. I argue that changing the sign of the mass difference results in a large decrease in the number of black holes produced. Whether raising it results in a decrease or an increase in black hole production is difficult to determine because of the intricate physics of the star formation process. The third mechanism is that in cold, or tepid, big bang models, changes in the proton–neutron mass difference could strongly effect the evolution of the universe as a whole.

A QG theory should

* Resolve curvature singularity

* Matter bounce / Matter lump in place of singularity.

The big question:

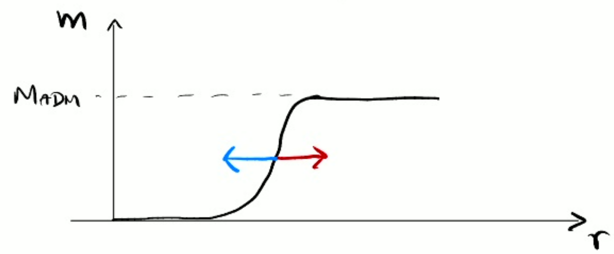
Describe gravitational collapse, BH formation & subsequent evolution in QG

Basic idea: "follow the matter"

$$ds^2 = -\left[1 - (N^r(r,t))^2\right] dt^2 + 2N^r(r,t)dtdr + dr^2 + r^2 d\Omega^2$$

$$N^r(r,t) = \sqrt{\frac{2m(r,t)}{r}}$$

$$\theta_\pm = \frac{2}{r}(-N^r \pm 1).$$



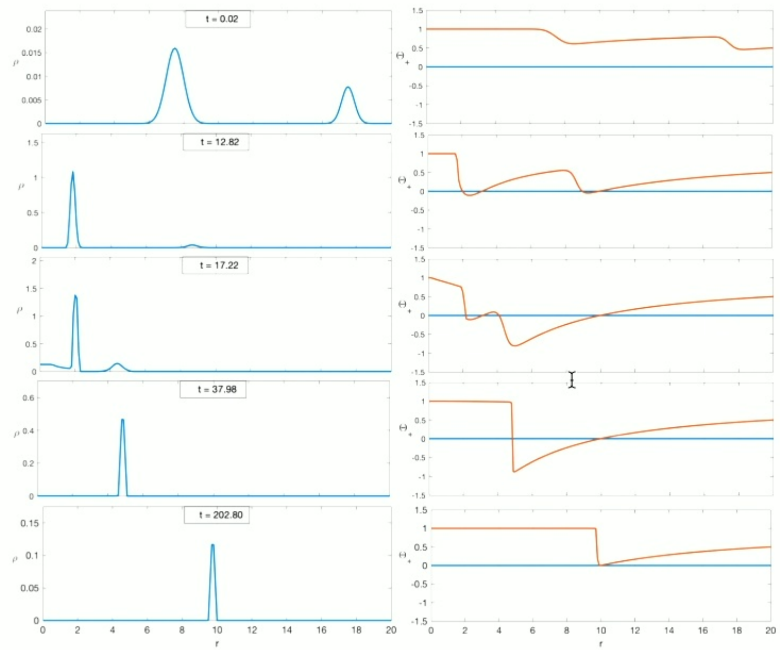
m(r,t) such that

- singularity avoidance
- adjustable speed.

Dust collapse

1. Effective constraints
2. Fix time: Time is dust
   → physical hamiltonian
3. Solve eom

w. Jared Kelly, Robert Santacruz
Ed Wilson-Ewing



* Smooth initial data evolves to outgoing 'shock wave'
* BH lifetime $\sim M^2$

Metric Engineering I

$$ds^2 = -\left[1-(N^r(r,t))^2\right]dt^2 + 2N^r(r,t)dtdr + dr^2 + r^2 d\Omega^2$$

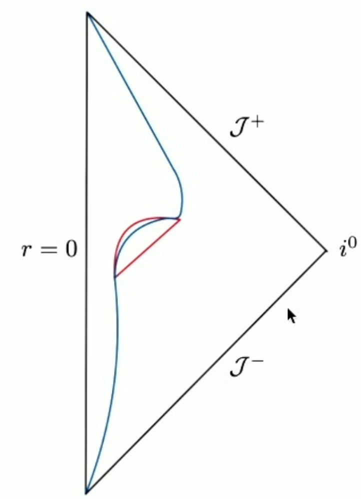
$$N^r(r,t) = \sqrt{\frac{2m(r,t)}{r}}$$

$$m(r,t) = M_0\left[1+\tanh\left(\frac{r-r_0-v(r,t)t}{\alpha\, l_0}\right)\right]^a \tanh\left(\frac{r^b}{l_0^b}\right).$$

$$v(r,t) = \frac{A}{(1+r)^n}\tanh\left(\frac{t-t_0}{l_0}\right)$$

BH lifetime

$\sim M^{n+1}$



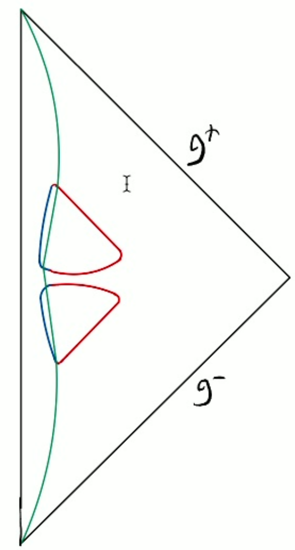
w/ S. Hergott, S. Rastgoo

Metric Engineering II

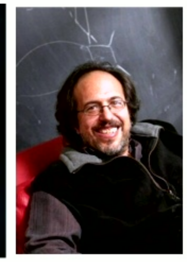
BH → WH transition

$$N^r(r,t) = -\tanh[\lambda(t-t_0)]\sqrt{\frac{2m(r,t)}{r}}$$

$$m(r,t) = M_0\left[1+\tanh\left(\frac{r-r_0-v(r,t)t}{\alpha\, l_0}\right)\right]^a \tanh\left(\frac{r^b}{l_0^b}\right).$$



$|\Psi\rangle$

$= \frac{1}{\sqrt{2}} \Big(\Big|$   $\Big\rangle$

$+ \Big|$   $\Big\rangle \Big)$

Thanks Lee !