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Quantum Gravity in Relativistic Phase Space

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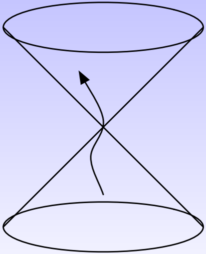
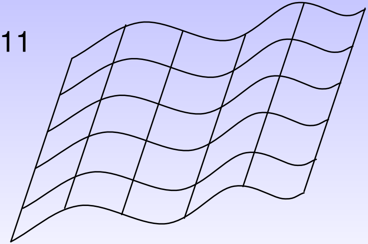


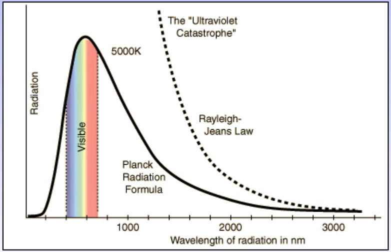


Why *Quantum* Gravity?

1. All the other fundamental interactions are quantized.
2. The Einstein Field Equation has matter in it.

Spacetime Curvature = Matter

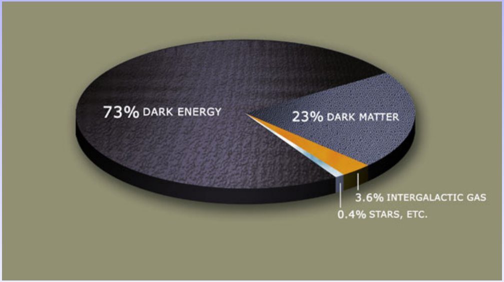
3. Singularities of Black Holes and the Big Bang
(Compare to UV divergence of Rayleigh-Jeans)

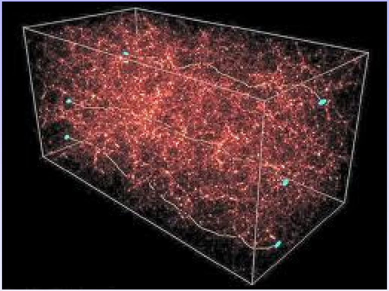


Why *Quantum* Gravity?

Dark Matter and Dark Energy

4. Unexplained gravitational phenomena
   - Dark Energy
   - Dark Matter





Quantization Necessities

What is needed for the quantization process?

Canonical Quantization, *à la* Dirac

$$\{x,\ p\} = 1 \rightarrow [\hat{x},\ \hat{p}] = i\hbar$$

1. Multiply by $i\hbar$.
2. Phase space dynamical variables become operators.
3. Change the Poisson Bracket to a commutator.

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So what is needed?

- Phase Space
- Canonically Conjugate Fields
- Relativistic geometry

Quantization Necessities

Usually taken care of with *Hamiltonian Dynamics*

- $H = H(x,\ p)$
- Poisson Brackets {A, B}
- *Canonically Conjugate* if $\{A,\ B\} = 1$
- All over in QM $\rightarrow \hat{H}\Psi = i\hbar\frac{\partial}{\partial t}\Psi$ (Schrödinger Eqn)
- Generalizes to relativistic fields.

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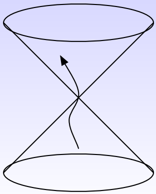
But it is not geometric

Biconformal Space

→ Relativistic Phase Space

Gravitational Gauge Theory is born from an attempt to understand gravity from a particle physics perspective and use the symmetries of spacetime measurements to construct theories of gravity.



Biconformal Space

$\rightarrow$ Relativistic Phase Space

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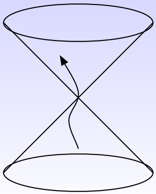
Biconformal Space: A space, formed from the symmetries of the light cone, that contains General Relativity and is special because:

- *Derive* the structures that make it a relativistic phase space.
    - Symplectic form $\rightarrow$ Poisson Bracket
    - Time is an emergent property!
- Allows direct characterization of canonically conjugate variables.



Biconformal Space

Current Calculation

- Combine general relativity result of Wehner and Wheeler with time result of Spencer and Wheeler.
- Solve the structure equations that we obtain.

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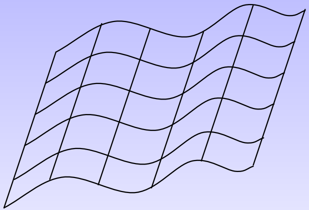
We have general relativity set in a broader framework.

Biconformal Space

Curved Phase Space

Curved Momentum space

- Principle of Relative Locality
- 2+1 Quantum Gravity (regularization)



Thank You