

3-31-2011

# Quantum Gravity in Relativistic Phase Space

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## Recommended Citation

Hazboun, J. (2011, March 31). Quantum Gravity in Relativistic Phase Space. Presented at the Intermountain Graduate Symposium, Utah State University, Logan, Utah.

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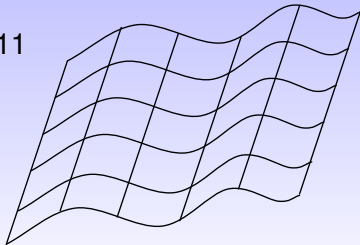
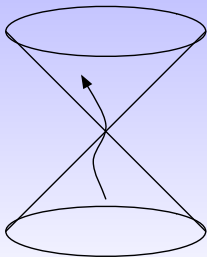


# Quantum Gravity in Relativistic Phase Space

Jeffrey Hazboun

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31 March 2011

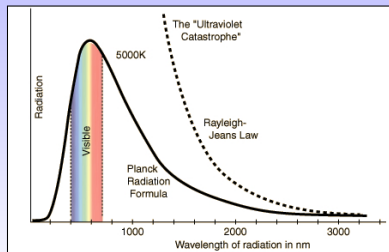


# Why *Quantum* Gravity?

- 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)

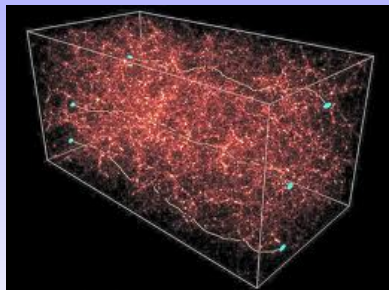
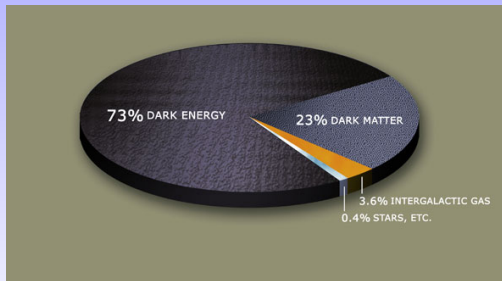


# Why *Quantum* Gravity?

## 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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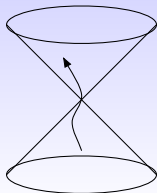
But it is not geometric



# 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.



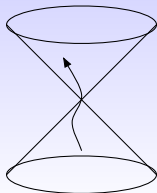
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→ Relativistic Phase Space

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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 → 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.
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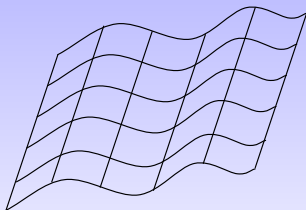
We have general relativity set in a broader framework.

# Biconformal Space

## Curved Phase Space

### *Curved Momentum space*

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





**Thank You**

