Quantum Gravity & Black Holes

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Projects

1.- Timelike Liouville Theory

2.- Quantum Black Holes

Timelike Liouville theory

- **Timelike Liouville Theory:** model for **2d Quantum Gravity**
  - Liouville: CFT for $\phi(\sigma)$, $\quad g_{ab} = e^{2\phi(\sigma)} h_{ab}$
  - Timelike: $-\partial_a \phi \partial_b \phi$

- QG in **Cosmology**: quantum corrections to classical dynamics of the **conformal factor**

- Problems of **4d QG**:
  - unbounded Euclidean action $\longrightarrow$ negative-norm states
  - non-renormalizable $\longrightarrow$ instead TL is **renormalizable**

Timelike Liouville Theory

- Progress: **BRST quantization**
  - **BRST operator** Q
  - Closed states: $Q|\phi\rangle_{phys} = 0$. But not exact: $|\phi\rangle_{phys} \neq Q|\psi\rangle$
  - Example of photon ($k^2 = 0$)

    Closed: $k \cdot \epsilon = 0$. But not exact: $\epsilon^\nu \neq \lambda k^\nu$

- ToDo: understanding correlation functions, finding semiclassical solutions.

Quantum Black Holes

- Entropy $\sim$ Area of the BH
  - limit of large area: Bekenstein-Hawking formula

$$\boxed{S_{BH} = \frac{A}{4}}$$

  - finite area:

$$S_Q = a_0 A + a_1 \log A + ... + \frac{a_2}{A^2} + ...$$

- Geometrical Entropy is **Thermodynamical**: BH is an **ensemble** of states

$$\boxed{S_{micro} = \log[d(states)] = S_Q}$$

Quantum Black Holes

- To compute $d(states)$ use **AdS/CFT** correspondence:

extremal BH:		dual CFT:
AdS geometry	$\leftrightarrow$	use modular forms
near horizon		$d(states) \in \mathbb{Z}$

- So far, $e^{S_Q} \approx \mathbb{Z}$.

  For exact agreement: need **non-perturbative contributions**.