Lecture 4
4 marca 2011
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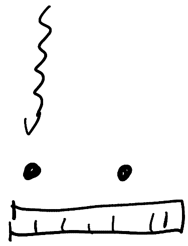
IV Extracting Physics

• the task.

$$\int Dg\, e^{-S[g]}$$



• difficult

because of GR.

AdS/CFT

• quantum GR more difficult.

$$\langle 0|\Phi(x)\Phi(y)|0\rangle = W(x,y)$$

$$\int Dg\, g_{\mu\nu}(x)\, g_{\rho\sigma}(y)\, e^{iS[g]} = ?$$

$$\langle 0|(\eta_{\mu\nu}+h_{\mu\nu}(x))(\eta_{\rho\sigma}+h_{\rho\sigma}(y))|0\rangle$$

$$\langle 0|g_{\mu\nu}(x)|0\rangle = \eta_{\mu\nu}$$

. STRATEGY for a SOLUTION
→ christ [illegible] Relat. obs
→ boundary formalism

state on b.

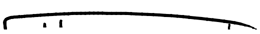
① • states "semiclassical" b.s.

② • define observables with respect to b.s.

③ • THERE IS NO PHYSICS WITHOUT APPROXIMATIONS

→ 1) 2-point function C. PERINI
→ 2) cosmology_DeSitter E. BIANCHI

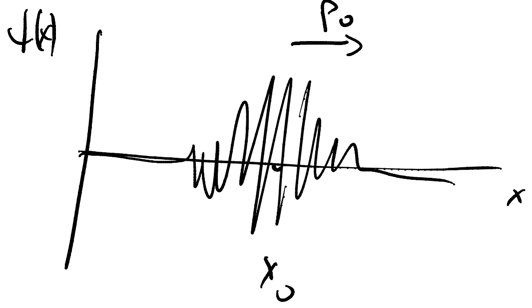
① Semiclassical states_



$\boxed{\text{Thiemann}} \longrightarrow \boxed{\text{Coherent states}}$

$\boxed{\text{Speziale - Livine - Freidel}} \nearrow$

Bianchi Perini Magliaro

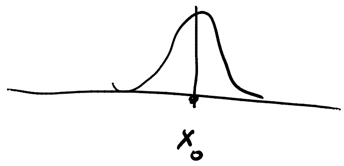


$$\psi_{x_0p_0}(x) = c\, e^{-\frac{(x-x_0)^2}{2\sigma} + ip_0x}$$

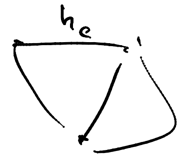
$$\psi_{x_0p_0}(x) = c\, e^{\frac{\left(x-\overbrace{(x_0+ip_0\sigma)}^{H}\right)^2}{2\sigma}} = \psi_H(x) \qquad \psi(H) = \langle\psi_H|\psi\rangle$$

$\delta(x)$ $\qquad \partial_t\psi_t(x) = -\partial_x^2\psi_t(x)$

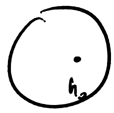
$-L^iL^i$



$\psi(h) \qquad h\in SU(2)$



$$\psi_{h_0}(h) = \delta(hh_0^{-1}) = \sum_j d_j\, Tr\left[D^j(hh_0^{-1})\right]$$



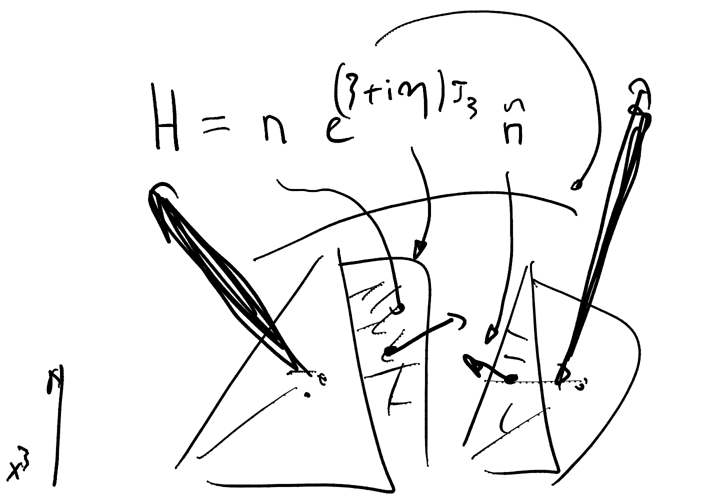
$$\delta(\alpha) = \sum_n e^{in\alpha}$$

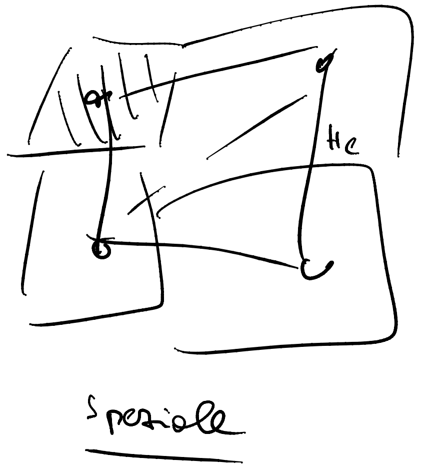
$$\psi(h) = \sum_j d_j\, e^{-tj(j+1)}\, Tr\left[D^j(hh_0^{-1})\right]$$

$$h = e^{\alpha^iJ_i} \rightsquigarrow g = e^{\alpha^iJ_i + i\beta^iJ_i} = H \in SL2C$$

$$\Gamma \qquad \Psi_{H_\ell}(h_\ell) = \int dg_n \prod \sum_j d_j\, e^{-tj(j+1)}\, Tr\left[D^j(g\, h_\ell\, H_\ell^{-1})\right]$$

$$\mathcal{H}_\Gamma \ni \boxed{\psi_{H_e}(h_e) = \int_{SU(2)} dg_n \prod_e \sum_{j} d_j \, e^{-t\, j(j+1)} \, \mathrm{Tr}\left[D^j(g_s h_e g_t^{-1} H_e^{-1})\right]}$$





spaziale

$$\psi(H_e) = \langle \psi_H | \psi \rangle$$

SL_2C

$$\boxed{A_v(H_e) = A(\xi, \eta, \vec{n}, \hat{n}) = \int_{SL_2C} dg_n \bigotimes_e \langle \vec{n} | Y^\dagger g g'^{-1} Y | \hat{n} \rangle}$$

FARRARA asympt.

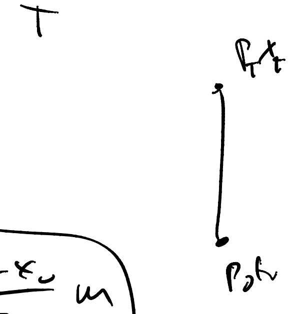
② boundary formalism.

$x(t)$ $\quad \ddot{x}(t) = 0$

$x(t)$ $\; p(t)$

$(x_0 p_0) \rightsquigarrow (x_T, p_T)$

$(x_0\, p_0\, x_T\, p_T)$ $\qquad \boxed{p_T = p_0 = \frac{x_T - x_0}{T} m}$



$$S(x_0\, x_T) = \int^T L\, dt = \frac{m(x_T - x_0)^2}{2T} \qquad \frac{\partial S}{\partial x_0} = p_0 \quad \frac{\partial S}{\partial x_T} = p$$

$$S(x_0, x_T) = \int_0^T L\,dt = \frac{m(x_T - x_0)^2}{2T} \qquad \frac{\partial S}{\partial x_0} = p_0 \quad \frac{\partial S}{\partial x_1} = p_t$$

$$W(x_0, x_T) \sim e^{\frac{i}{\hbar} S(x_0, x_T)} = e^{iT\hat{H}}$$

$$\langle \psi_T \, e^{iTH} \phi_1 \rangle =$$

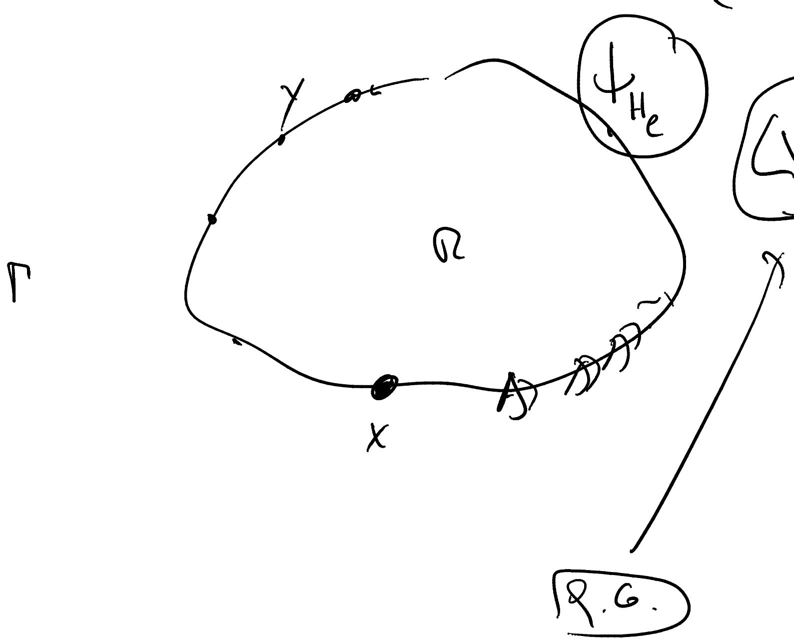
$$\int dx_0 \int dx_T \; \overline{\psi_T(x_T)} \; W(x_T, x_0) \; \phi(x_0)$$

$\psi_{x_T p_T}$

$\psi_{x_0 p_0}$

$\langle \psi_{x_0 p_0} \; W \; \psi_{x_T p_T} \rangle$ ~ peaked on solutions.

$(x_0 p_0 x_T p_T)$



$$\boxed{\langle W | \psi_{H_e} \rangle \sim 1}$$

FLAT SPACE

EUCLIDEAN

$\mathbb{R}^4$

$$\langle 0 | 0 \rangle \sim \langle \phi\, g(x)\, g(y)\, | 0 \rangle$$

$$\boxed{\langle W \,|\, \underbrace{LL}_{g}\; \underbrace{LL}_{g} \,|\, \psi_{H_c} \rangle}$$

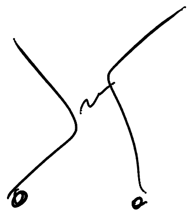
③ EXPANSIONS

i) graph $\qquad \mathcal{H} = \lim_{n \to \infty} \mathcal{H}^{\sigma}_{n/n} \qquad$ exp # of nodes

ii) vertex $\quad W = \lim_{\ell \to \infty} Z_\ell \quad$ exp # of vertices

iii) large j

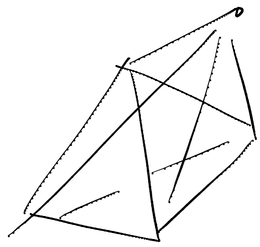
Ampl j

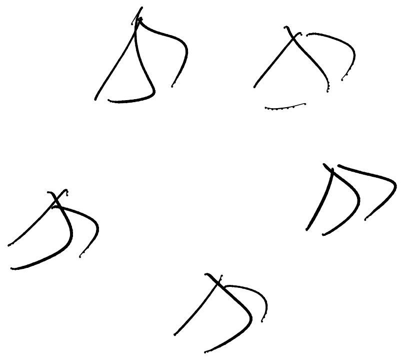


(1) 2 point function

Euclidean $\quad M_4$

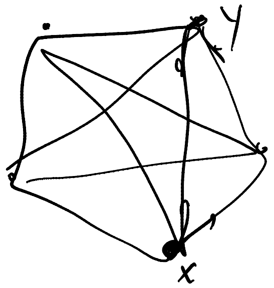
Γ





$\mathcal{H}_{\Gamma_5}$

regular 4s.



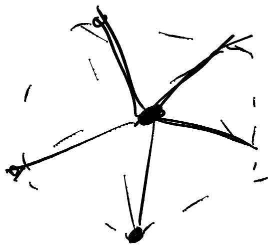
$\mathcal{H}_\ell$

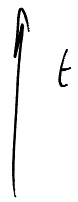
$\Gamma_5 \qquad \Psi_{\mathcal{H}_\ell}$

$$\langle W \,|\, \underline{E \cdot E}\ \ \underline{E \cdot E} \,|\, \Psi_{\mathcal{H}_\ell} \rangle \simeq \langle 0 \,|\, g^{(x)}_{\mu\nu}\, g^{(y)}_{\rho\sigma} \,|\, 0 \rangle = f(x-y)$$

$$\frac{1}{p^2}\left(\delta_{\mu\rho}\delta_{\nu\sigma} + \delta\delta\right)$$

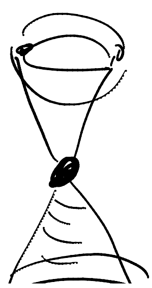
ii) vertex expansion $\quad$ 1 vertex



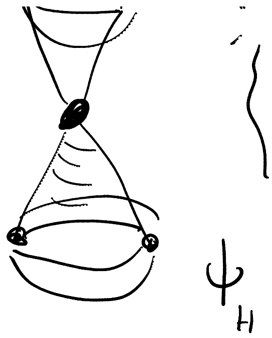


iii) large j $\quad$ calc. can be done.

(2) $\langle W \,|\, \Psi_{\mathcal{H}} \rangle \quad$ <u>cosmology</u>



$\Psi_{\mathcal{H}}$



$a, \dot a \quad H = \dot a\, t + a$

$\uparrow \;\; \uparrow$

$a_0, \dot a_0 \to a_f\, \dot a_f$

$a \sim \dot a \qquad a(t) \sim e^{\sqrt{\frac{\Lambda}{3}}\, t}$

De Sitter

(+ cosm. constant) $\quad \dot a = 0$