Title: Focus Lecture

Date: Jul 19, 2016 05:00 PM

URL: http://pirsa.org/16070015

Abstract:

$\hbar = c = 1$

Motivation: - NH region BH

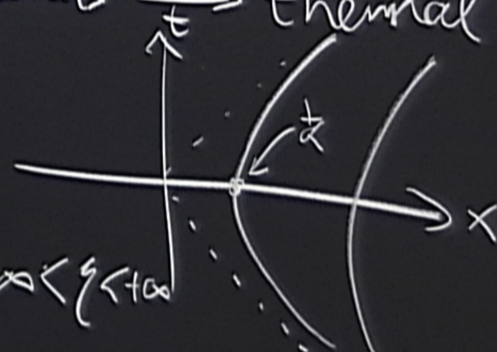
- physics of Hawking rad: Unruh effect
- lesson: inert $|0\rangle$ flat coords $\Longrightarrow$ thermal acc. obs.

$ds^2 = -dt^2 + dx^2$

$t(\tau) = \frac{1}{\alpha} sh(\alpha\tau)$, $x(\tau) = \frac{1}{\alpha} ch(\alpha\tau)$

$t = R\, sh\, \xi$, $x = R\, ch\, \xi$ $\quad 0 < R < \infty$, $-\infty < \xi < +\infty$

$ds^2 = -R^2 d\xi^2 + dR^2$



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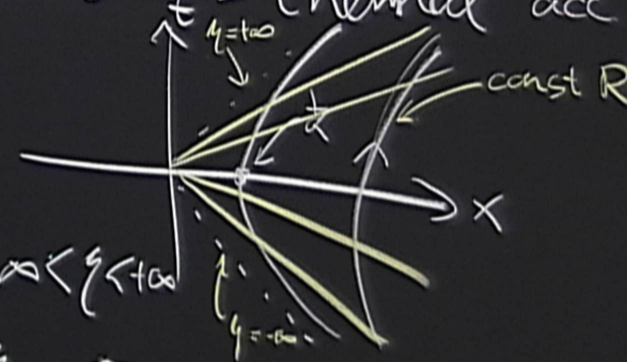
$ds^2 = -dt^2 + dx^2$

$\rightarrow t(\tau) = \frac{1}{\alpha}\,\mathrm{sh}(\alpha\tau)\,,\quad x(\tau) = \frac{1}{\alpha}\,\mathrm{ch}(\alpha\tau)$

$t = R\,\mathrm{sh}\,\xi\,,\quad x = R\,\mathrm{ch}\,\xi \qquad 0 < R < \infty\,,\ -\infty < \xi < +\infty$



$$\boxed{ds^2 = -R^2 d\xi^2 + dR^2}$$

Acc obs: $R = \frac{1}{\alpha}\,,\quad \xi = \alpha\tau$

Rindler wedge:

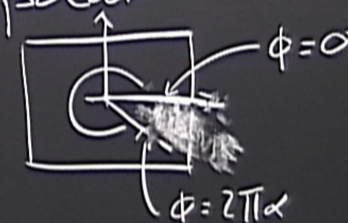
- obs see a horizon $R=0$
- ξ trans: boosts $\quad x^2(\tau) - t^2(\tau) = \frac{1}{\alpha^2} \qquad \xi \longrightarrow \xi + c$
- higher dim: $ds^2 = -dt^2 + dx^2 + dy^2 \leftarrow d-2$

$$= -R^2 d\xi^2 + dR^2 + dy^2$$

- analytic cont: $\xi \equiv i\phi$

$$ds^2 = dR^2 + R^2 d\phi^2$$

polar



$$\phi \sim \phi + 2\pi$$

$$\xi \sim \xi + 2\pi i$$

$\Rightarrow$ thermal physics

Quick: Unruh eff

$$t \sim t + i\boxed{\beta} \iff \rho = \frac{e^{-\beta H}}{Z} \qquad [H, \mathcal{O}(t,x)] = -i\partial_t \mathcal{O}$$

$$\xi \sim \xi + \boxed{2\pi}\, i \iff \rho = \frac{e^{-2\pi K}}{Z} \qquad [K, \mathcal{O}] = -i\partial_\xi \mathcal{O}$$

$$T = \frac{1}{2\pi}\alpha = \frac{\hbar \alpha}{2\pi c k_B} \qquad \langle n_\omega \rangle = \frac{1}{e^{2\pi\omega} - 1}$$

$\Rightarrow$ thermal physics

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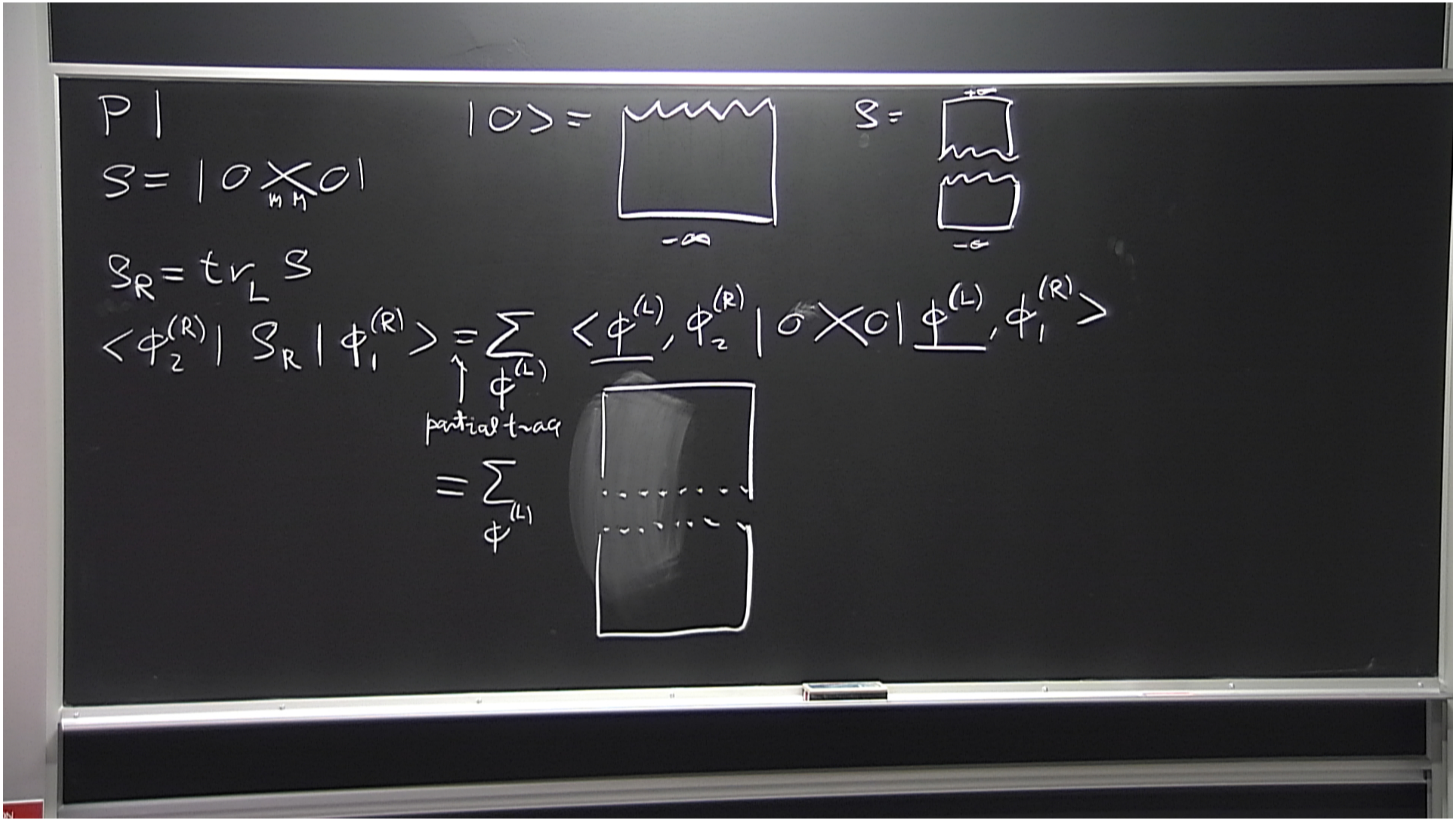
$$T = \frac{1}{2\pi}\alpha = \frac{\hbar \alpha}{2\pi c k_B} \qquad \langle n_\omega \rangle = \frac{1}{e^{2\pi\omega} - 1}$$

$$\phi \sim \int d\omega \left[a_\omega e^{+i\omega(\xi - \log R)} + a_\omega e^{-i\omega\xi} \right.$$

$$n_\omega \equiv a^\dagger_\omega a_\omega$$


PI
$\rho = |0\rangle\langle 0|$
$|0\rangle =$
$-\infty$
$\rho =$
$\rho_R = \mathrm{tr}_L\, \rho$
$\langle \phi_2^{(R)} | \rho_R | \phi_1^{(R)} \rangle = \sum_{\phi^{(L)}} \langle \phi^{(L)}, \phi_2^{(R)} | 0 \rangle\langle 0 | \phi^{(L)}, \phi_1^{(R)} \rangle$
partial trace
$= \sum_{\phi^{(L)}}$

$$= \langle \Phi_2 | e^{-2\pi K_E} | \Phi_1 \rangle \qquad [K_E, \mathcal{O}] = \partial_\phi \mathcal{O}$$

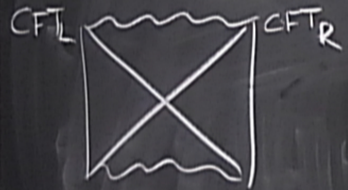
$$\wr$$

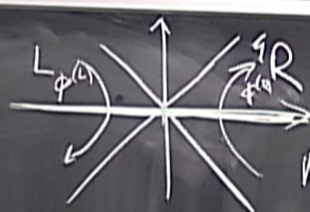
$$e^{-\beta H}$$

$$T = \frac{1}{2\pi}$$

...physics

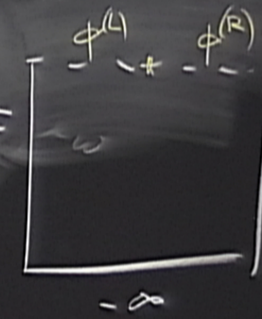
TFD interp.

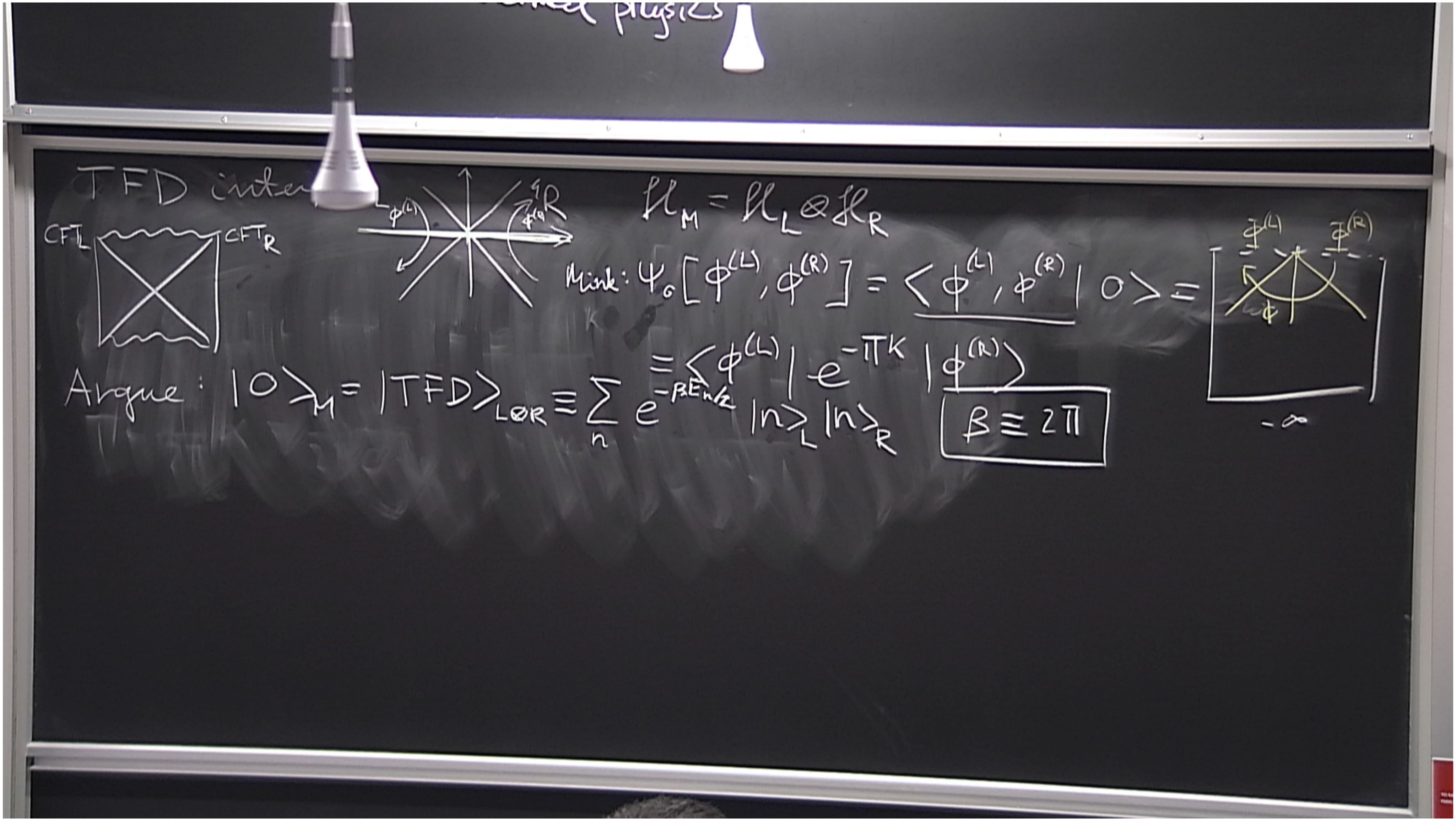




$$\mathcal{H}_M = \mathcal{H}_L \otimes \mathcal{H}_R$$

Mink: $\Psi_0[\phi^{(L)}, \phi^{(R)}] = \langle \phi^{(L)}, \phi^{(R)} | 0 \rangle =$



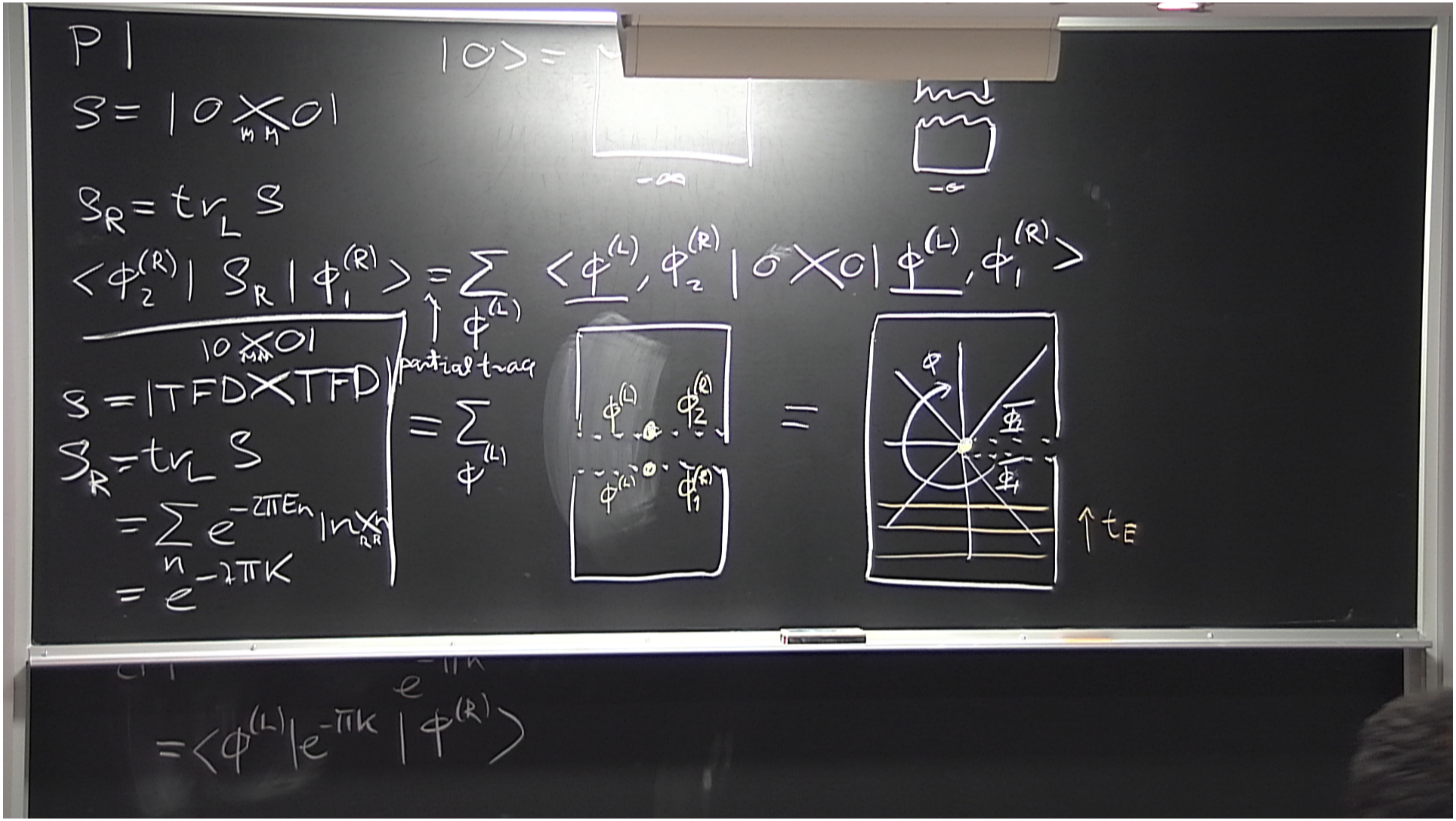

physics
TFD
CFT_L
CFT_R
$\phi^{(L)}$
$\phi^{(R)}$
$\mathcal{H}_M = \mathcal{H}_L \otimes \mathcal{H}_R$
Mink: $\Psi_0[\phi^{(L)}, \phi^{(R)}] = \langle \phi^{(L)}, \phi^{(R)} | 0 \rangle =$
$= \langle \phi^{(L)} | e^{-\pi K} | \phi^{(R)} \rangle$
Argue: $|0\rangle_M = |TFD\rangle_{L \otimes R} \equiv \sum_n e^{-\beta E_n/2} |n\rangle_L |n\rangle_R$
$\beta \equiv 2\pi$
$\Phi^{(L)}$
$\Phi^{(R)}$
ϕ
$-\infty$

$$\langle \phi^{(L)}, \phi^{(R)} | TFD \rangle = {}_L\langle \phi^{(L)} |\, {}_R\langle \phi^{(R)} | \sum_n e^{-\pi E_n} |n\rangle_L |n\rangle_R$$

$$= \sum_n \langle \phi^{(L)} | n \rangle \underbrace{e^{-\pi E_n} \langle n | \phi^{(R)} \rangle}_{e^{-\pi K}}$$

CPT

$$= \langle \phi^{(L)} | e^{-\pi K} | \phi^{(R)} \rangle$$



PI
$|0\rangle =$
$\rho = |0\rangle\langle 0|_{MM}$
$\rho_R = \mathrm{tr}_L\, \rho$
$\langle \phi_2^{(R)} | \rho_R | \phi_1^{(R)} \rangle = \sum_{\phi^{(L)}} \langle \phi^{(L)}, \phi_2^{(R)} | 0 \rangle\langle 0 | \phi^{(L)}, \phi_1^{(R)} \rangle$
$|0\rangle\langle 0|_{MM}$
partial trace
$\rho = |TFD\rangle\langle TFD|$
$\rho_R = \mathrm{tr}_L\, \rho$
$= \sum_n e^{-2\pi E_n} |n\rangle\langle n|_{RR}$
$= e^{-2\pi K}$
$= \sum_{\phi^{(L)}}$
$\phi^{(L)}$ $\phi_2^{(R)}$ $\phi^{(L)}$ $\phi_1^{(R)}$
$=$
ϕ Φ_2 Φ_1
$\uparrow t_E$
$e^{-\pi K}$
$= \langle \phi^{(L)} | e^{-\pi K} | \phi^{(R)} \rangle$