Title: Hagedorn divergences and Tachyon potential

Date: Jan 30, 2007 02:00 PM

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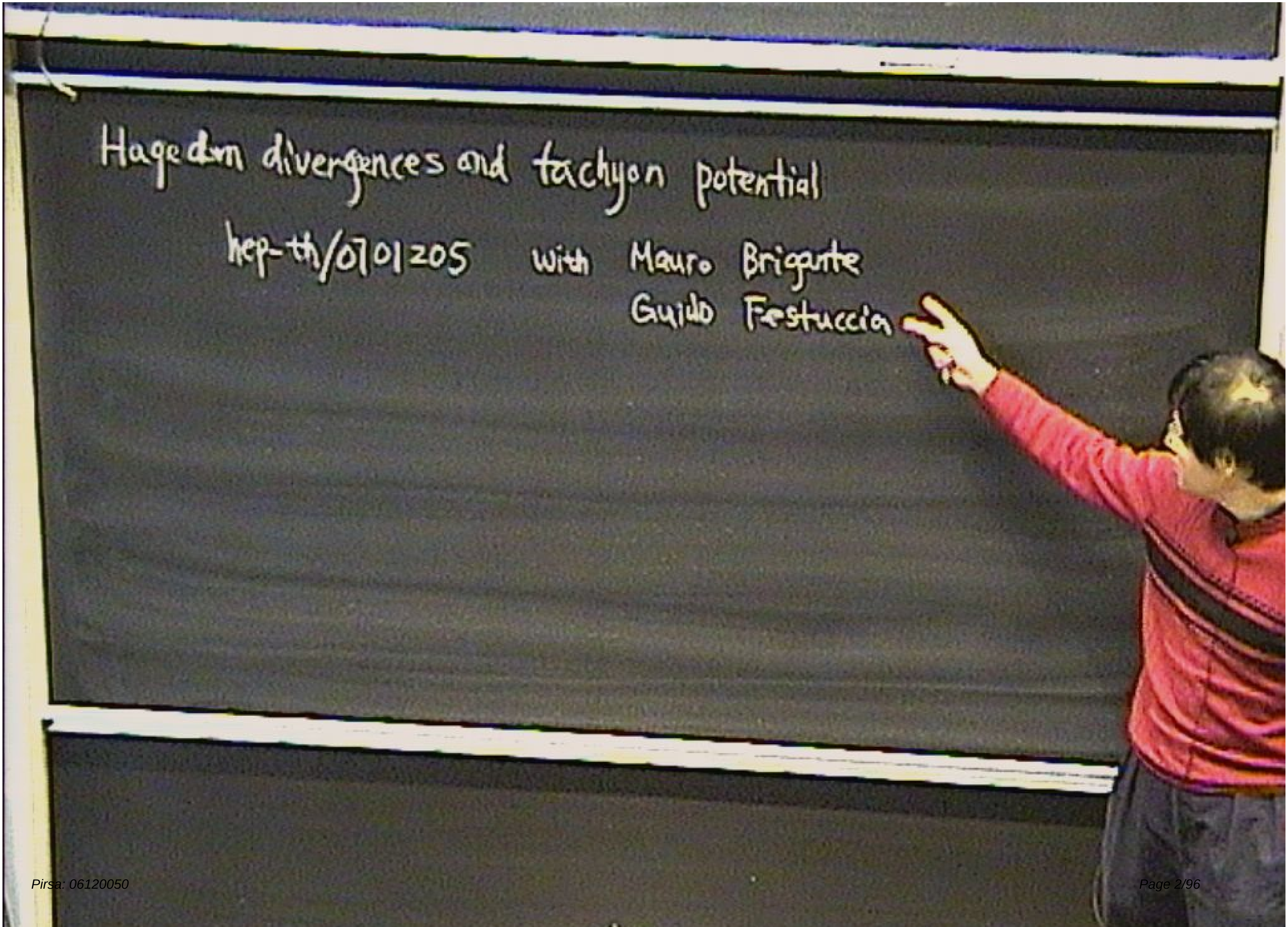
Abstract: TBA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hep-th/0701205 with Mauro Brigante
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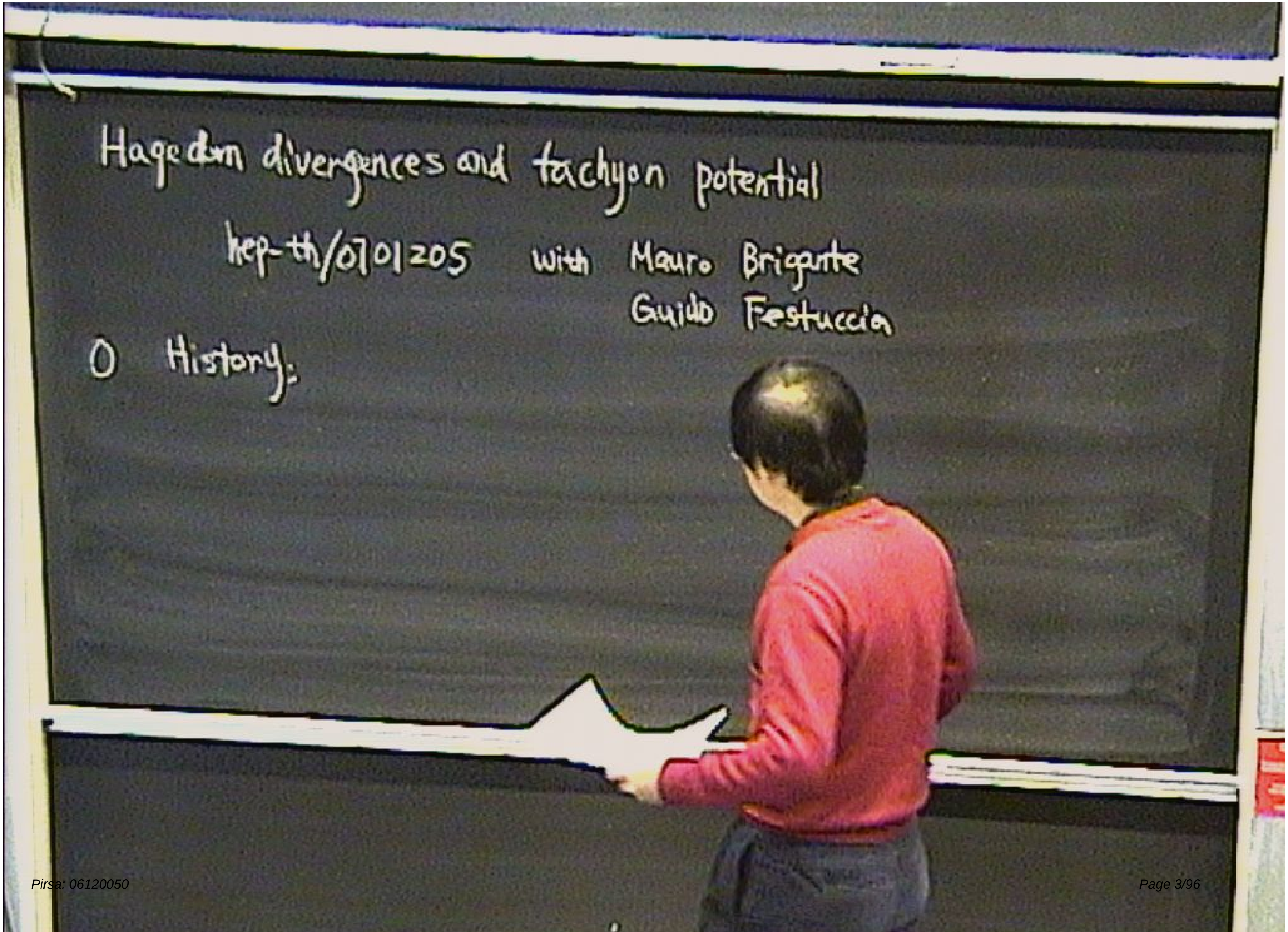
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$$Z = \mathrm{Tr}\, e^{-\beta H} = \int d\varepsilon\, \rho(\varepsilon)\, e^{-\beta \varepsilon}$$

divergent when $\beta < \beta_H$

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$n = \pm 1$, $\quad \beta \leq \underline{\beta_H = 4\pi\sqrt{\alpha'}}$, $\quad m^2 \leq 0$

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Equivalence between ① and ②: modular invariance.

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$$\underline{m^2 = -\frac{4}{\alpha'} + \left(\frac{n\beta}{2\pi\alpha'}\right)^2}, \quad n: \text{winding \#} \quad (n=\pm 1: \text{thermal scalar})$$

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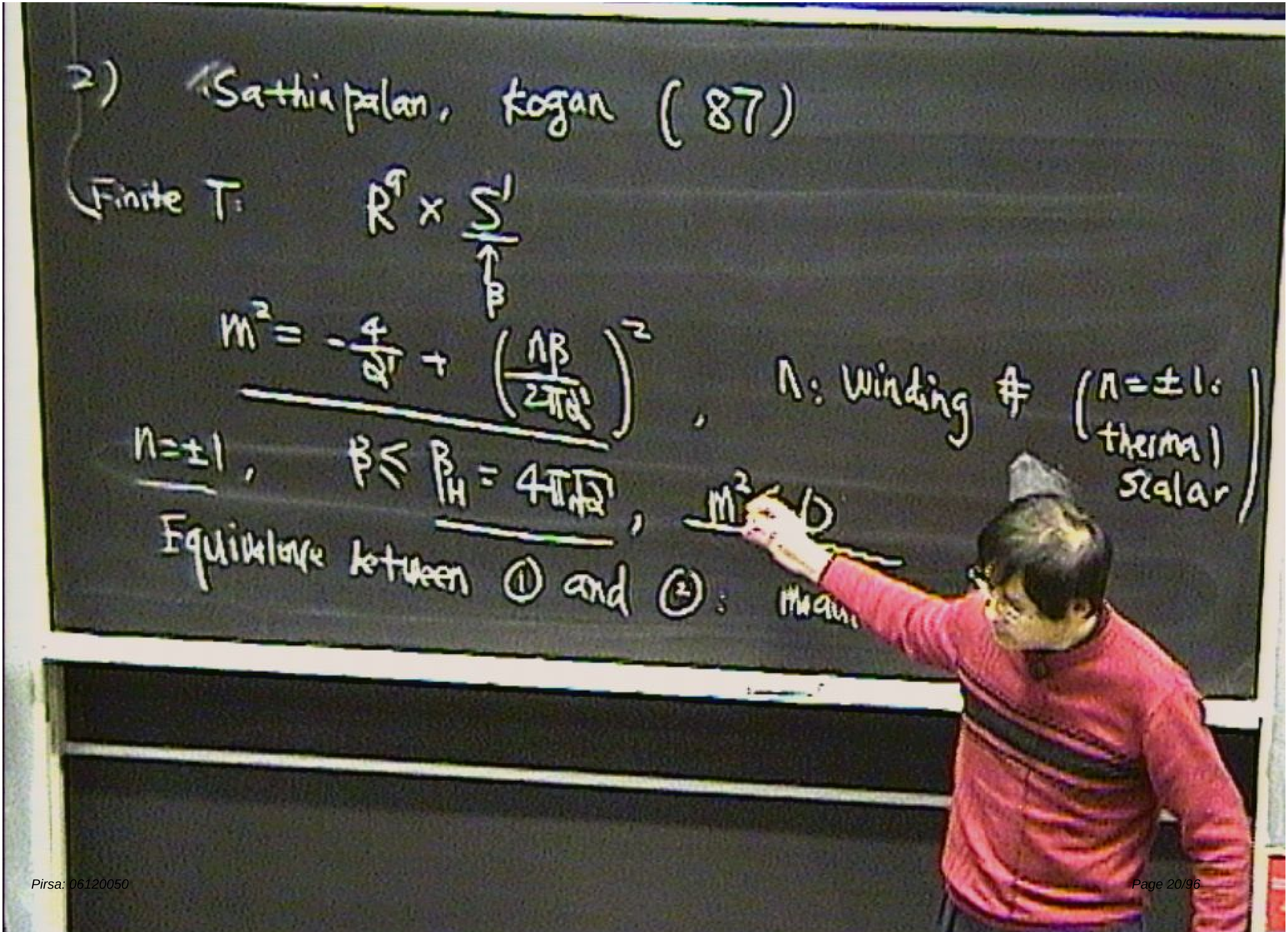
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λ_4

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$\lambda_4 > 0$, $\beta = \beta_H$, 2nd ord phase transition

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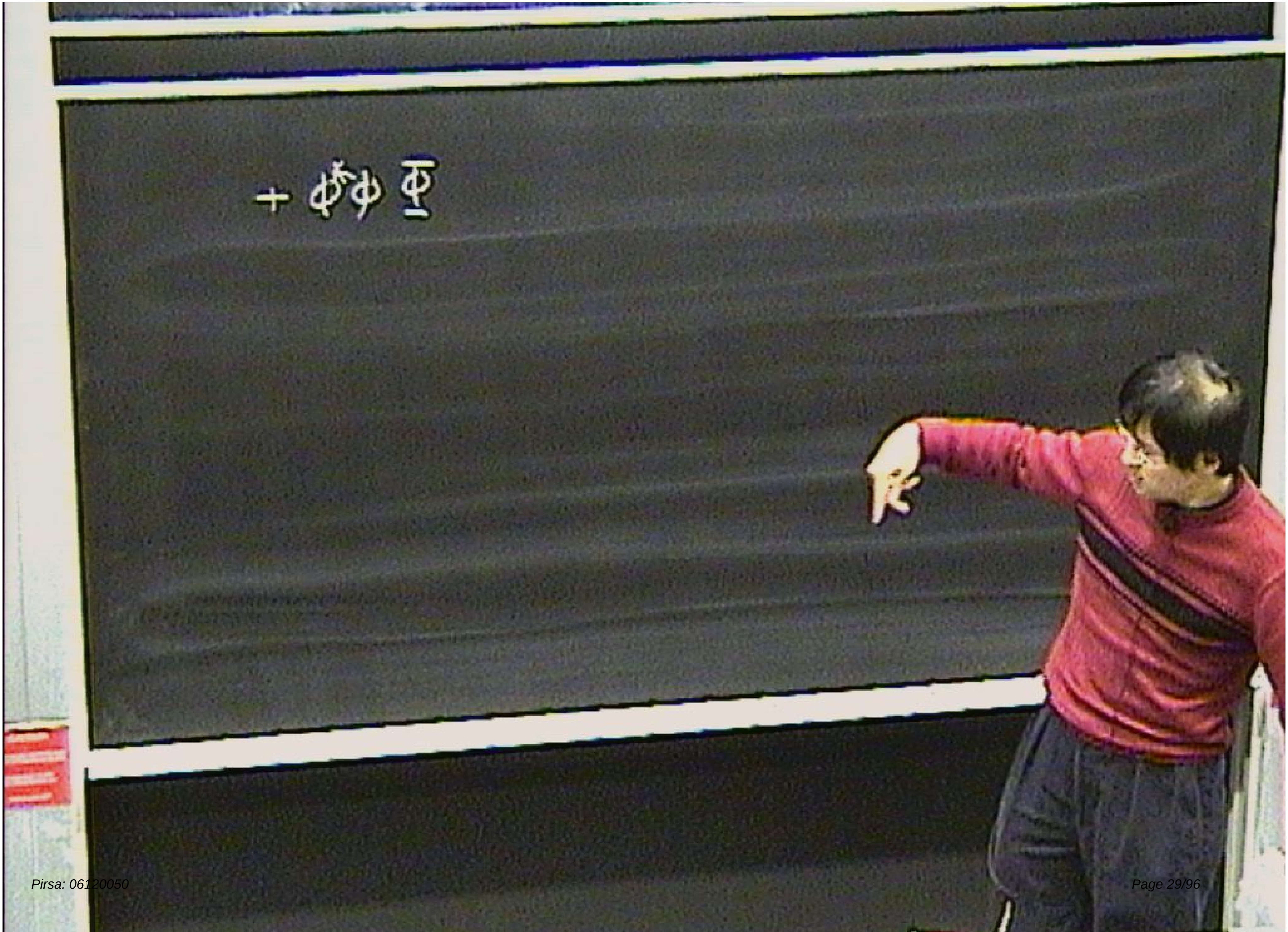

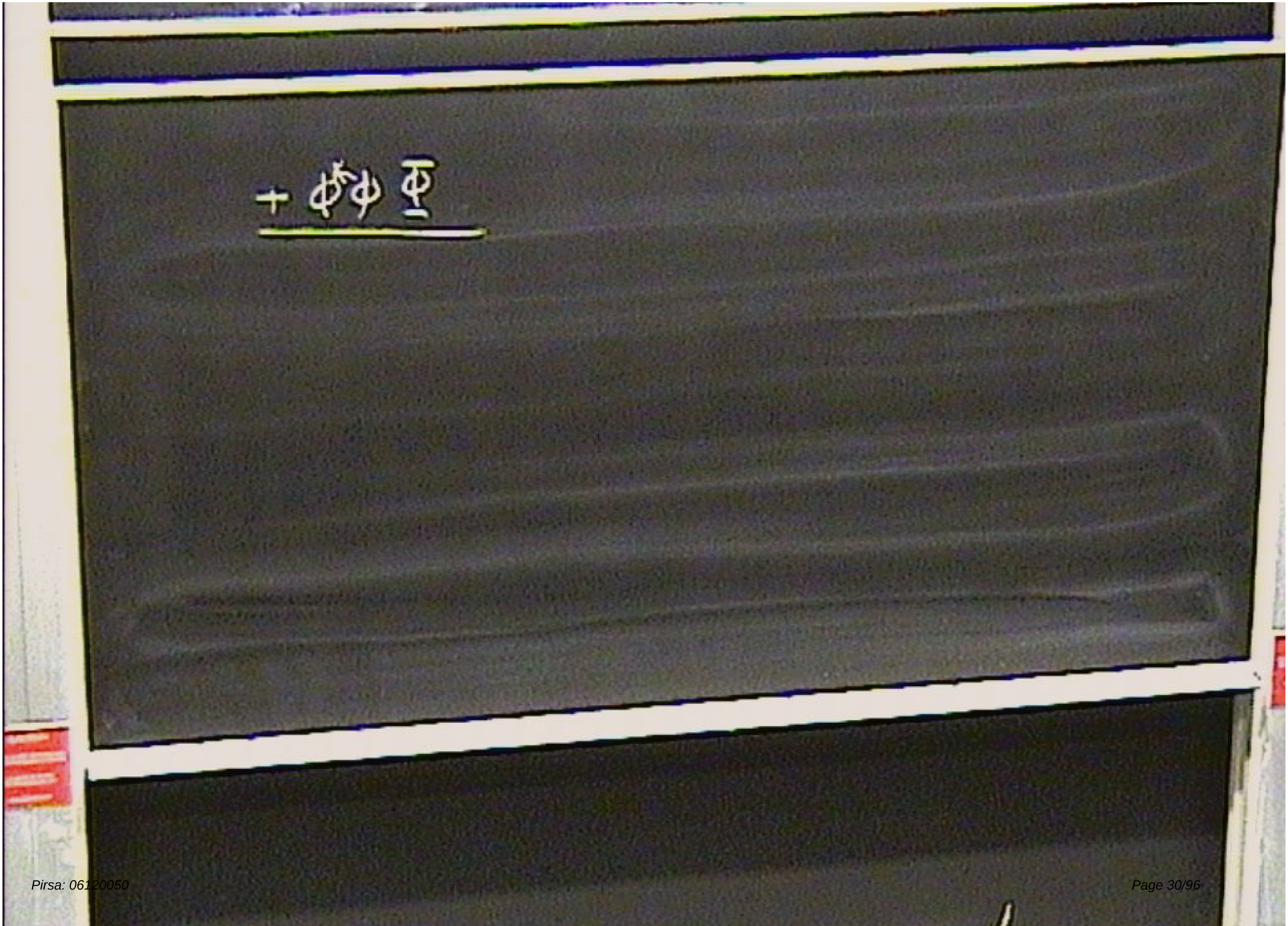
+ $\phi^* \phi\, \Phi$

$+\tilde{\phi}\phi\,\bar{\Phi}$

Q: 1) all discussion about 1-loop. What happens to higher genus amplitudes ?

2) What can one make of them ?

3)

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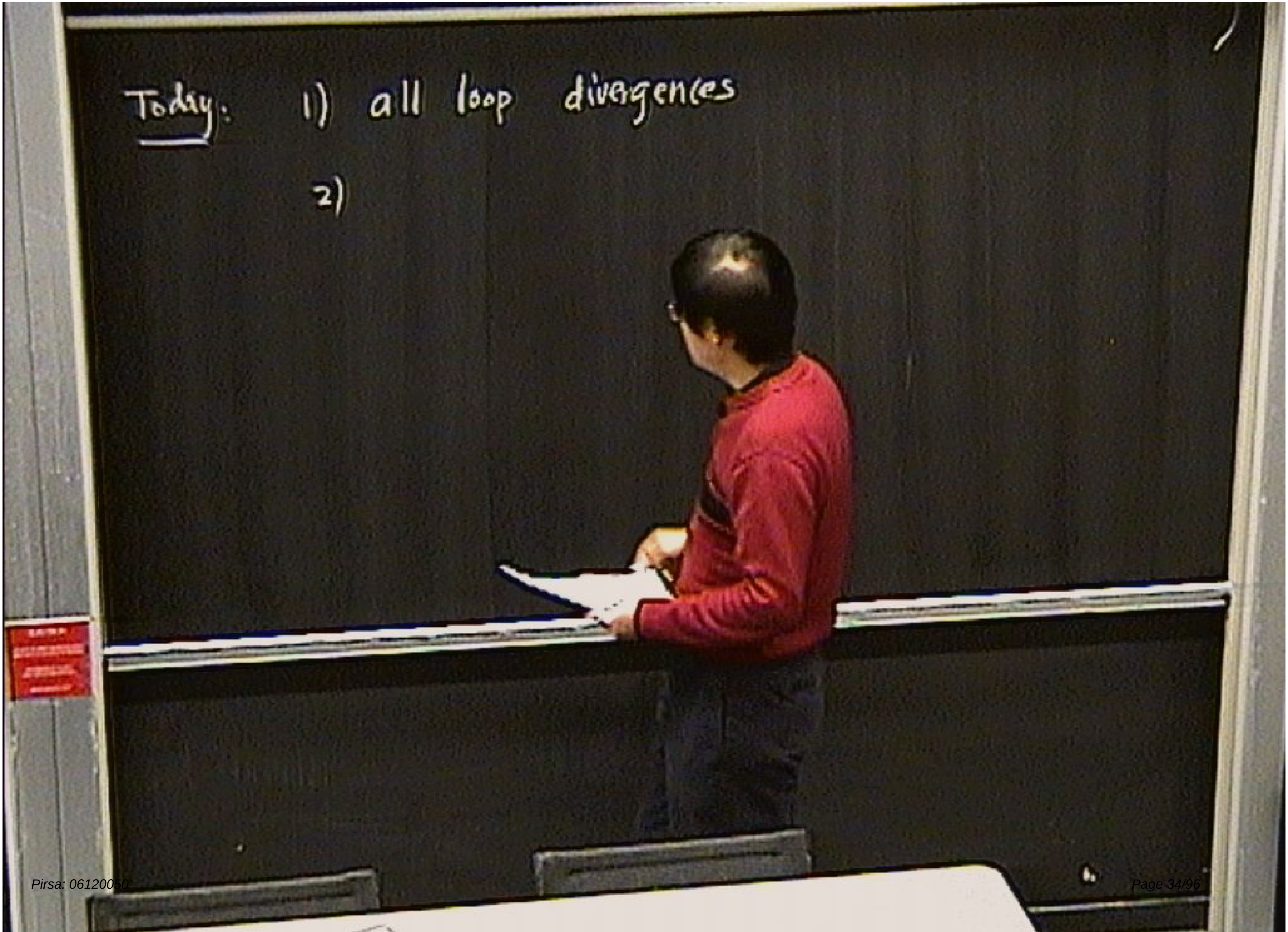
3) how to find potential for thermal scalar?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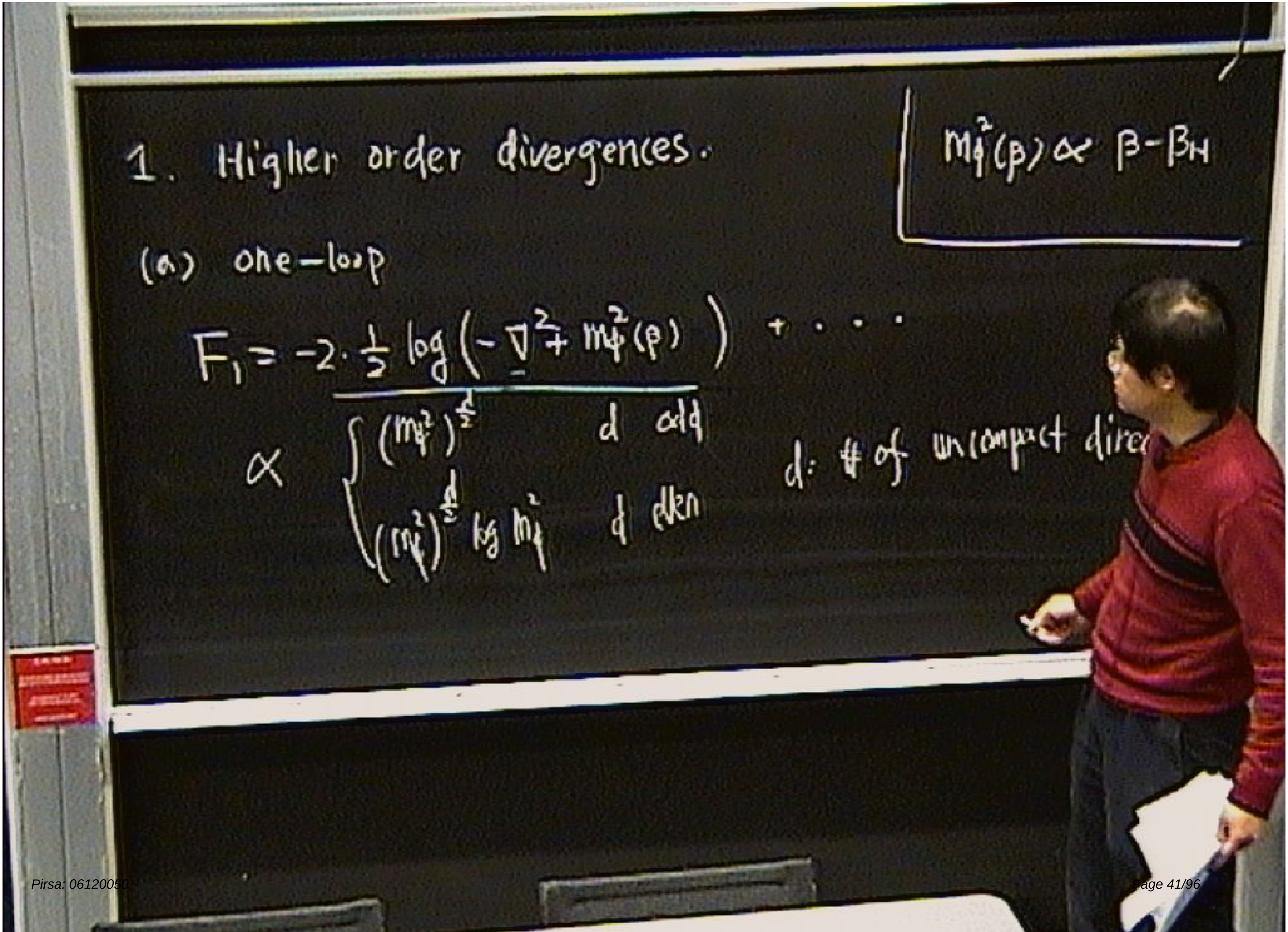
$$F_1 = -2 \cdot \frac{1}{2} \log\left(-\nabla^2 + m_\phi^2(\beta)\right) + \cdots$$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$\propto \begin{cases} (m_\phi^2)^{\frac{d}{2}} & d \text{ odd} \\ (m_\phi^2)^{\frac{d}{2}} \log m_\phi^2 & d \text{ even} \end{cases}$
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d: # of uncompact directions.

In particular $\underline{d=0}$, $F_1 = -\log(\beta-\beta_H)$ divergent at $\beta = \beta_H$

modular invariance.

(b) Higher order div.

- For consistency, restrict $d=0$.

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Uncompact, flat space. Jean's instability.

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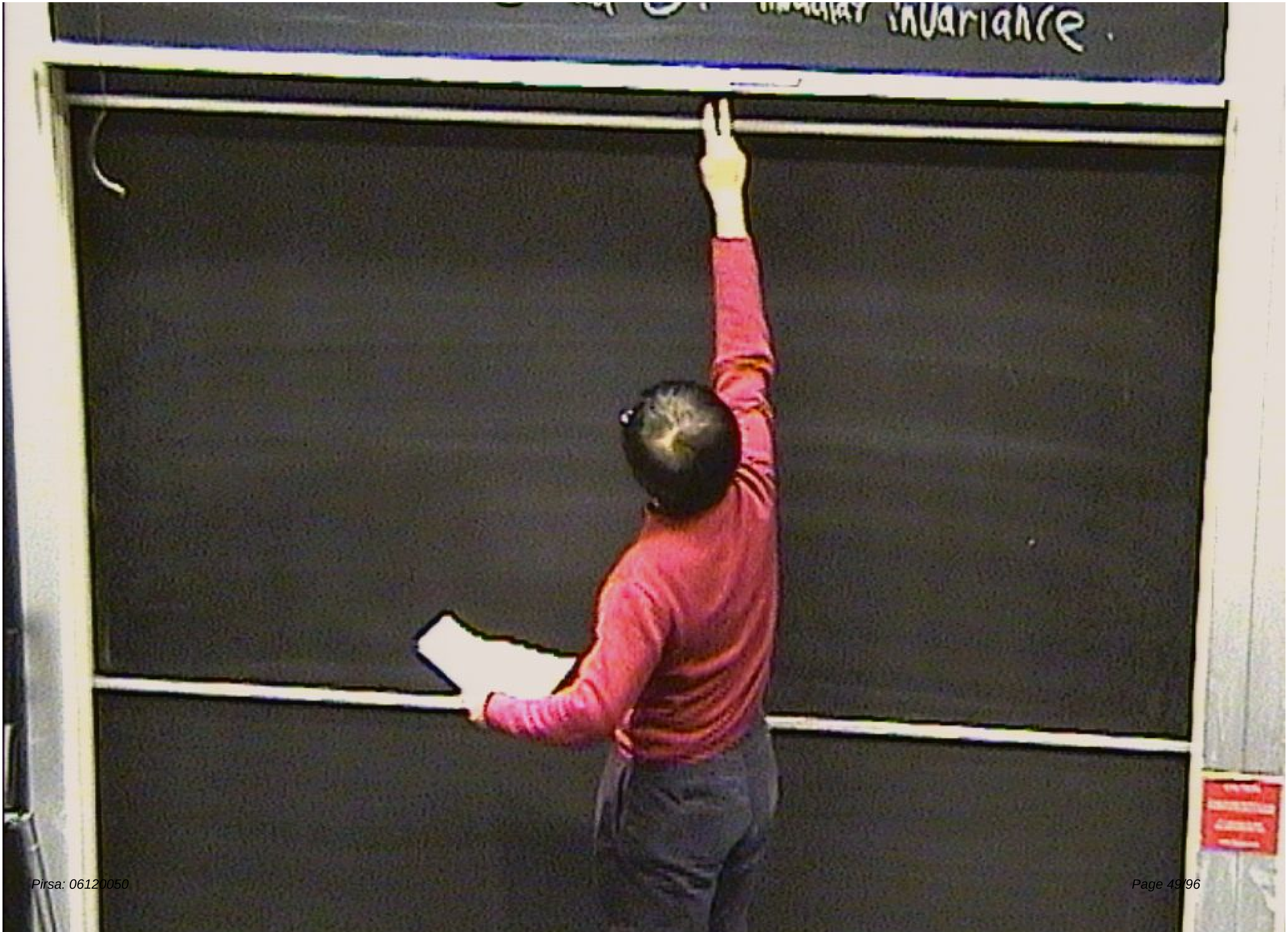
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$\Rightarrow$ mass gap., $d=0$

AdS has a mass gap.

Kogan (87)

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n: winding # ($n=\pm 1$:)


Fn =

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measure
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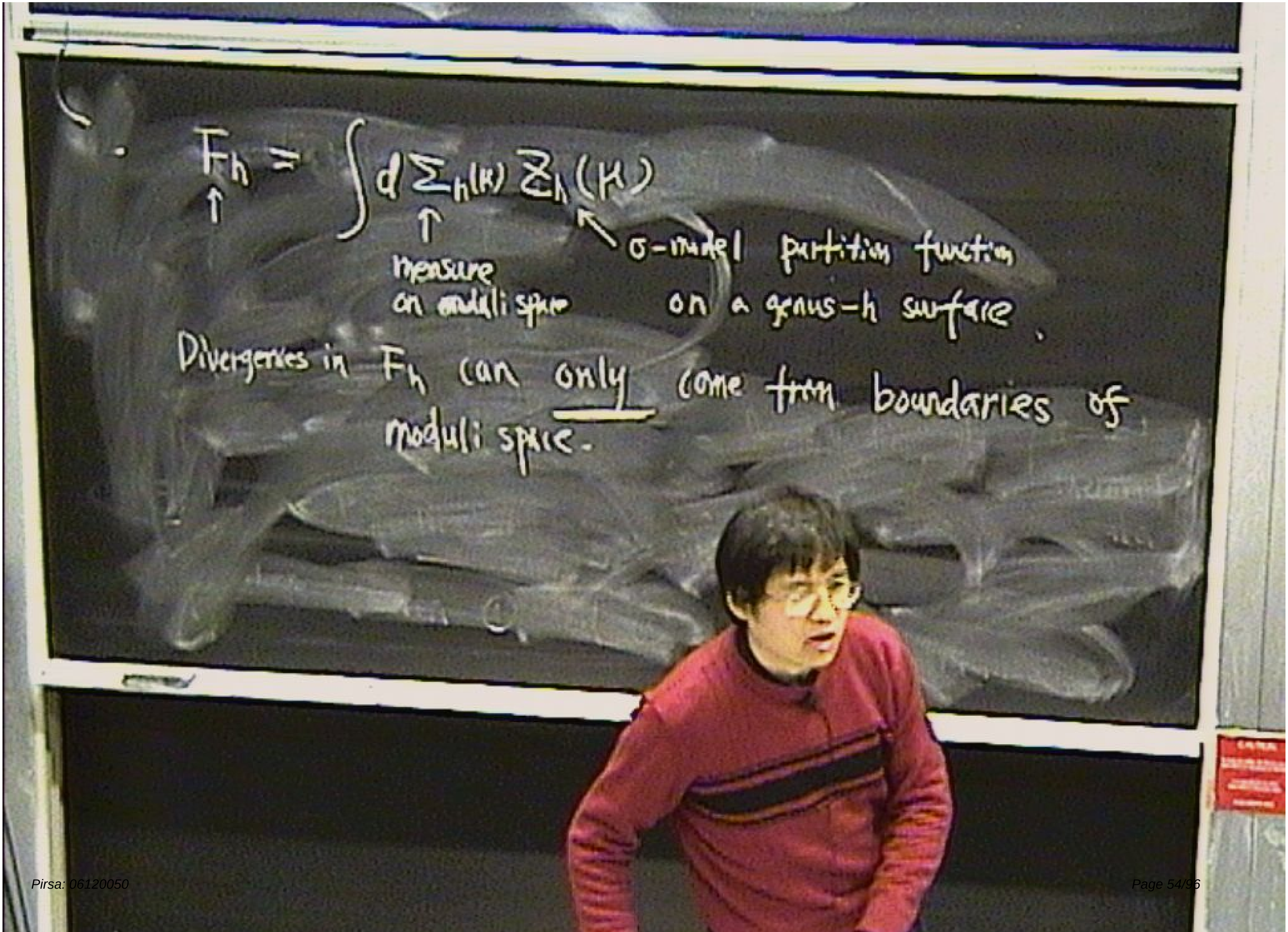
σ-model partition function on a genus-h surface.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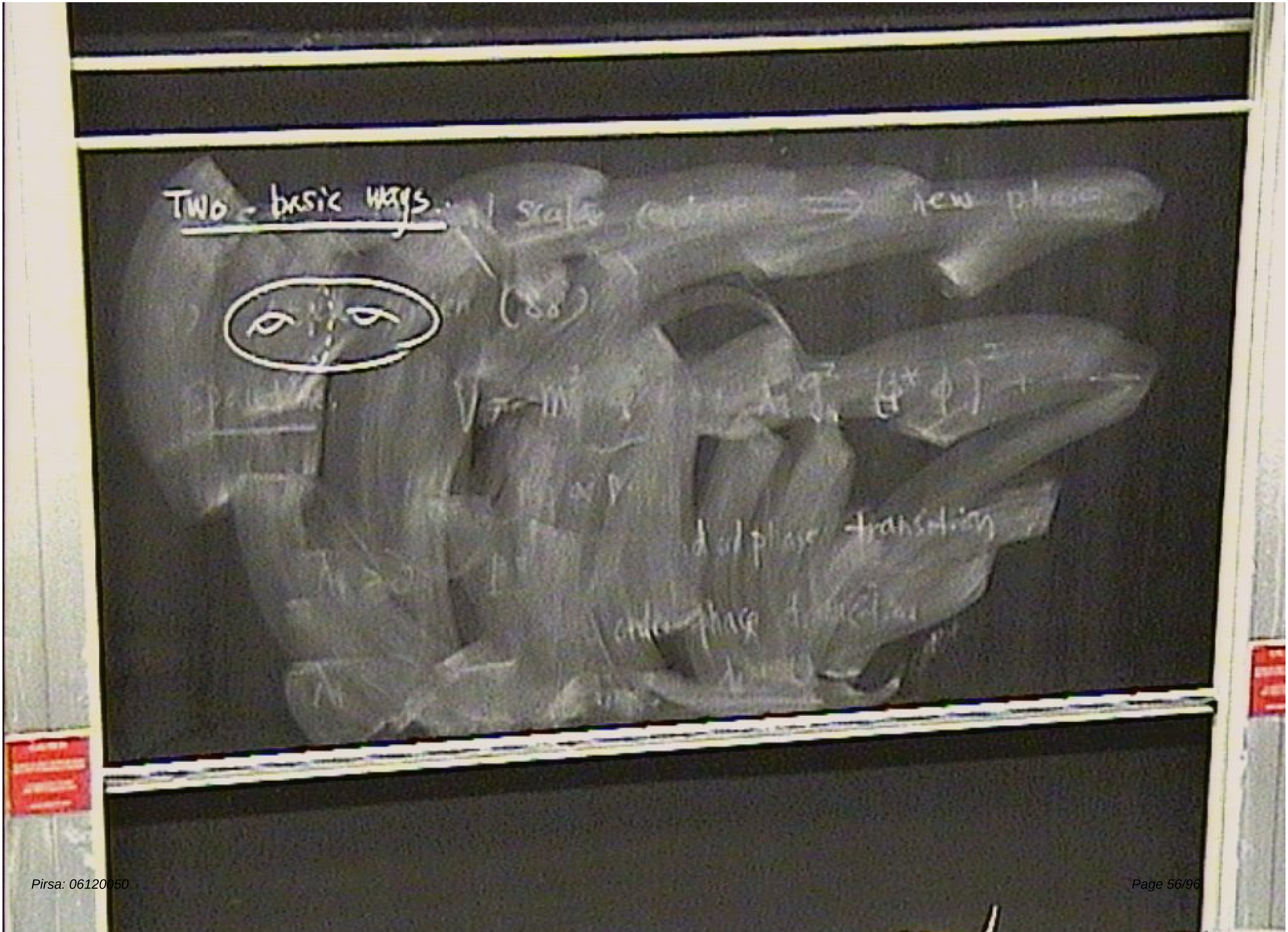
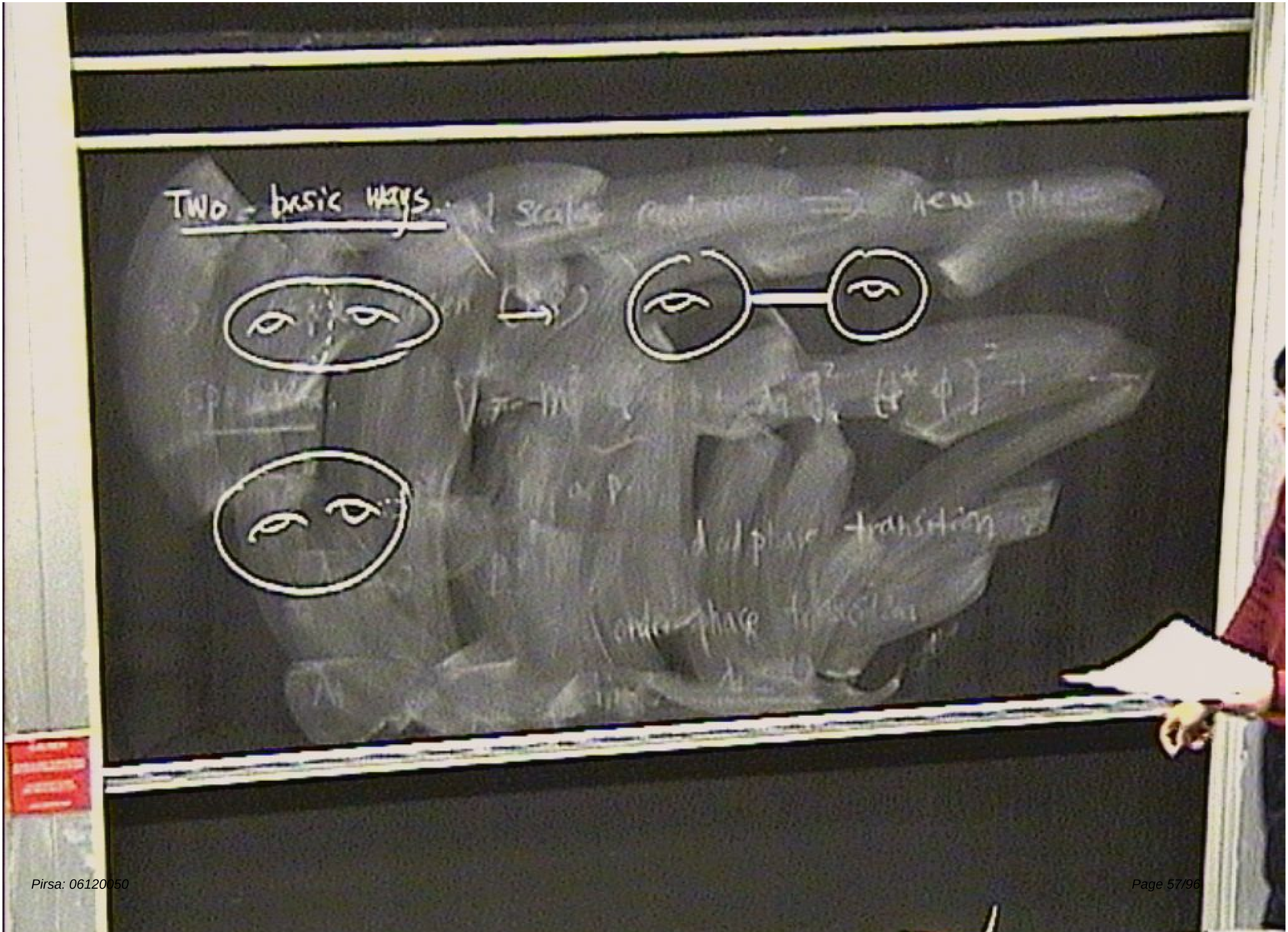
Divergences in F_h can <u>only</u> come from boundaries of moduli space.

- Boundaries of moduli space $\longleftrightarrow$ Riemann surface degenerates $\longleftrightarrow$ certain cycles pinched


Two basic ways.
phase transition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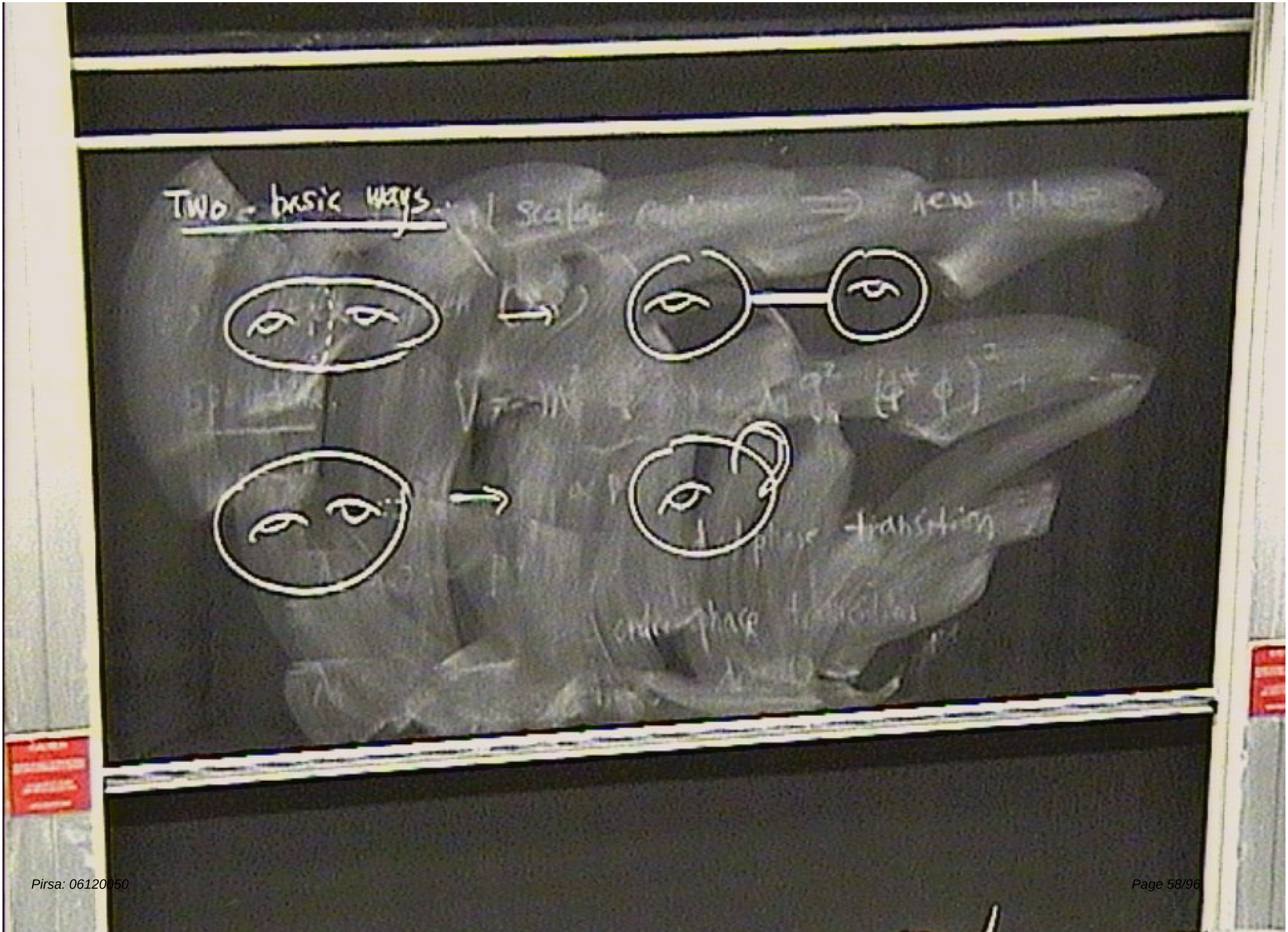
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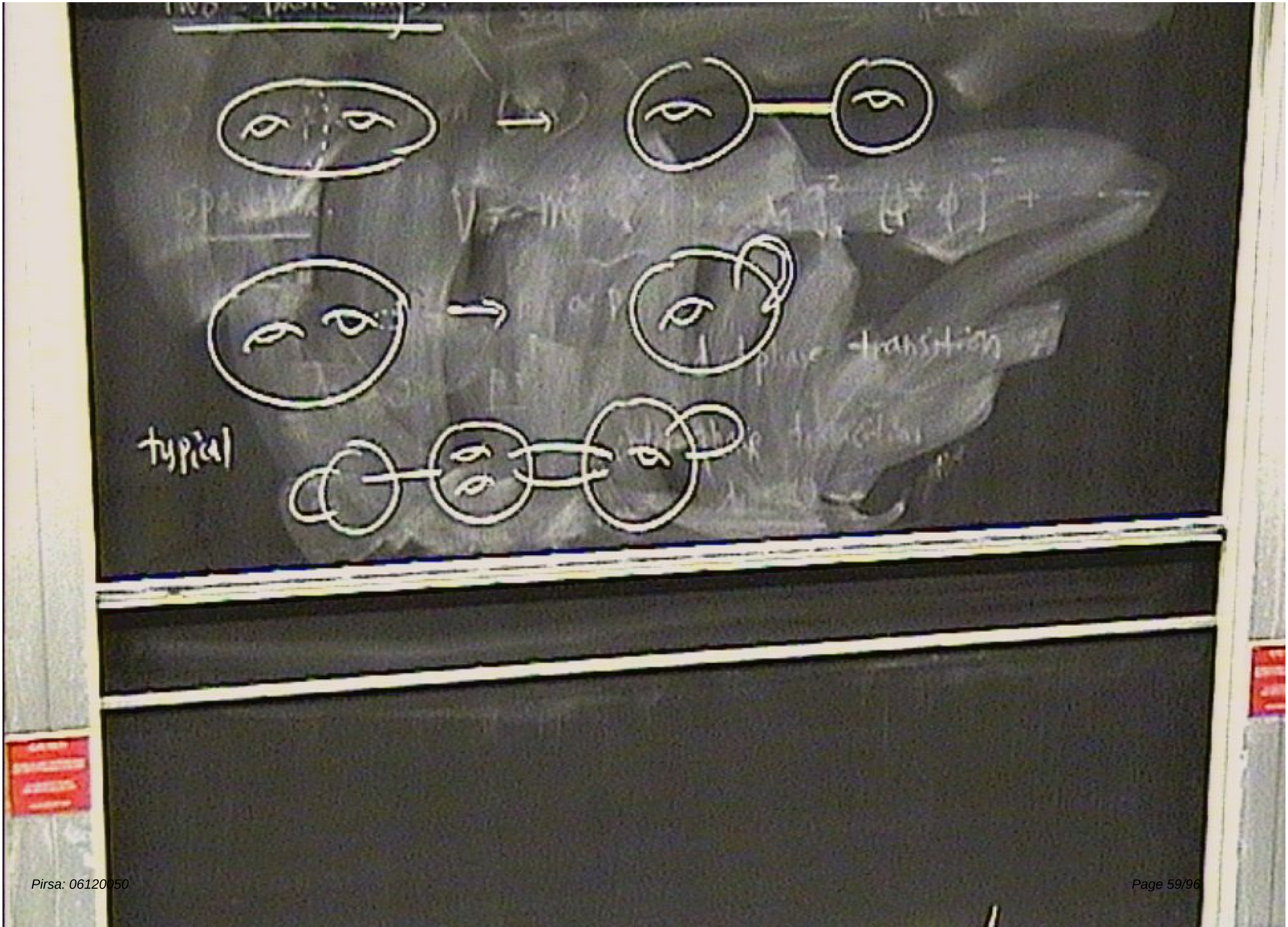
typical
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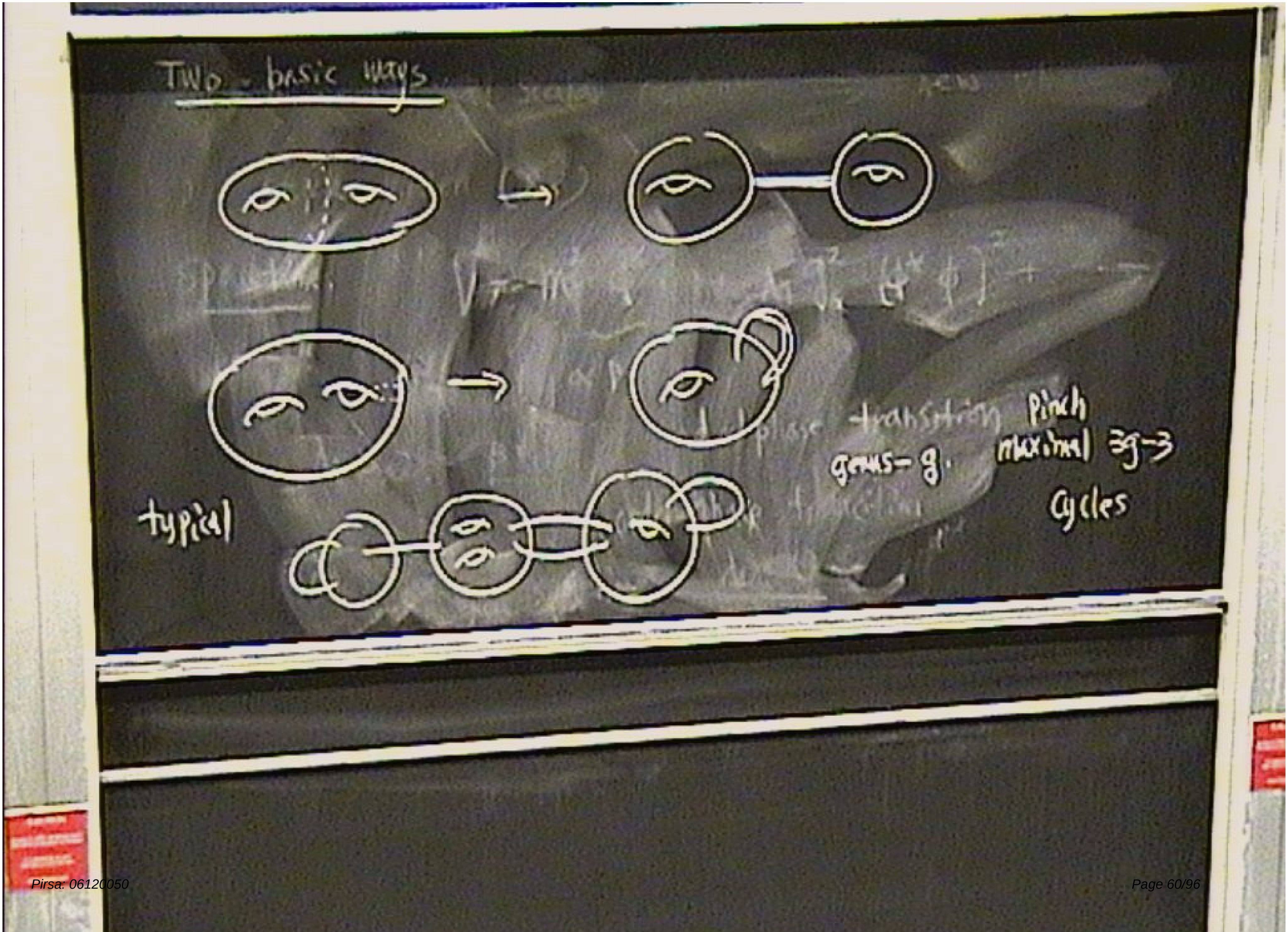

Two basic ways
typical
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Pinch
genus-g.
maximal 3g-3
cycles

- For each degenerate cycle

- For each degenerate cycle, associate a propagator.

$$G = \sum_i \frac{8\pi}{a'(-\nabla^2 + m_i^2)}$$

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$\underline{m_\phi^2 \to 0} \Rightarrow G \simeq \frac{8\pi}{\alpha'}\frac{1}{m_\phi^2}$ for $\beta \to \beta_H$

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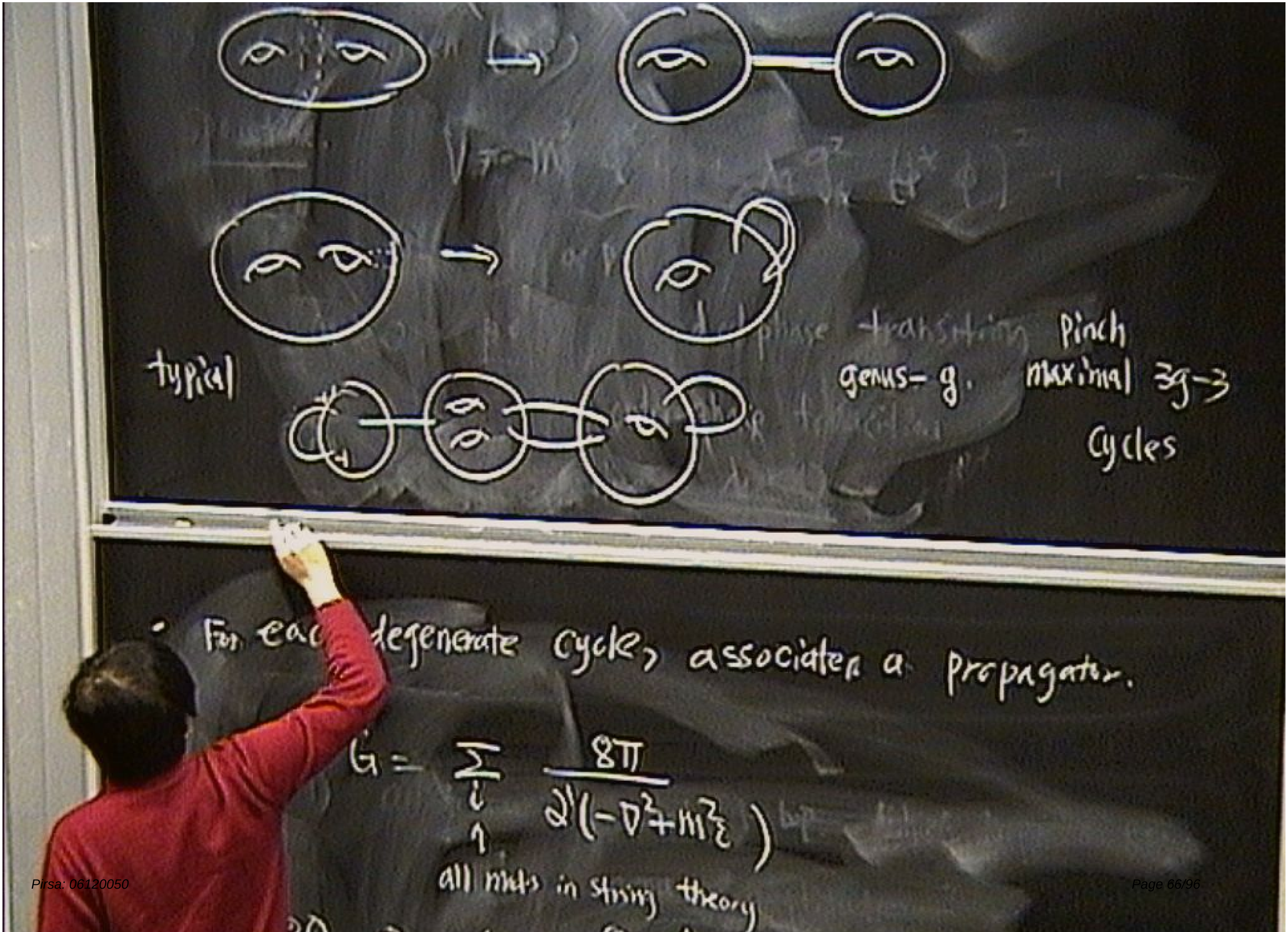
$$\underline{m_\phi^2 \to 0} \quad \Rightarrow \quad G \approx \frac{8\pi}{\alpha'}\frac{1}{m_\phi^2} \quad \text{for} \quad \beta \to \beta_H$$

source of divergences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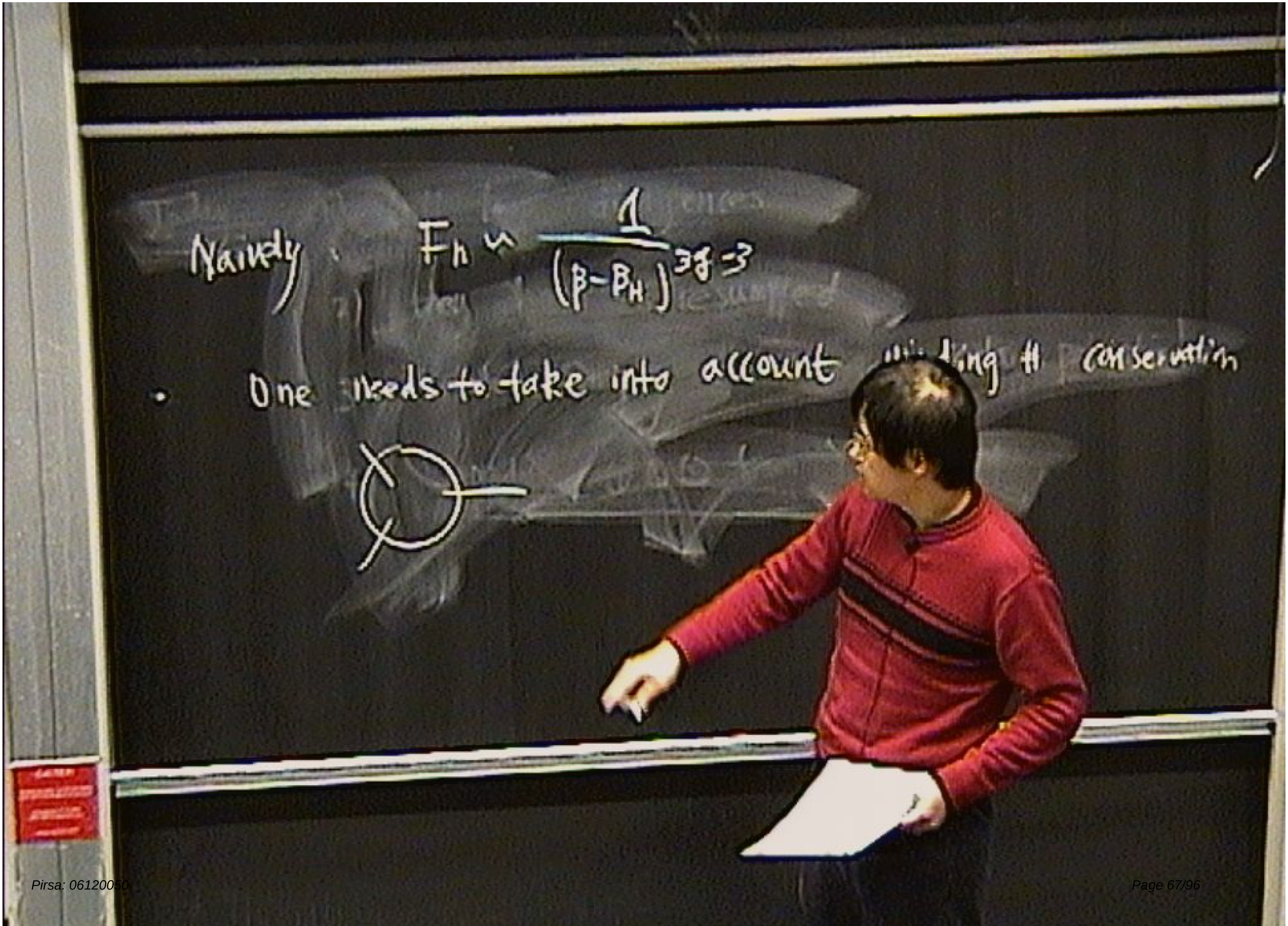
G = Σ 8π / α'(-∇²+m²)
all mds in string theory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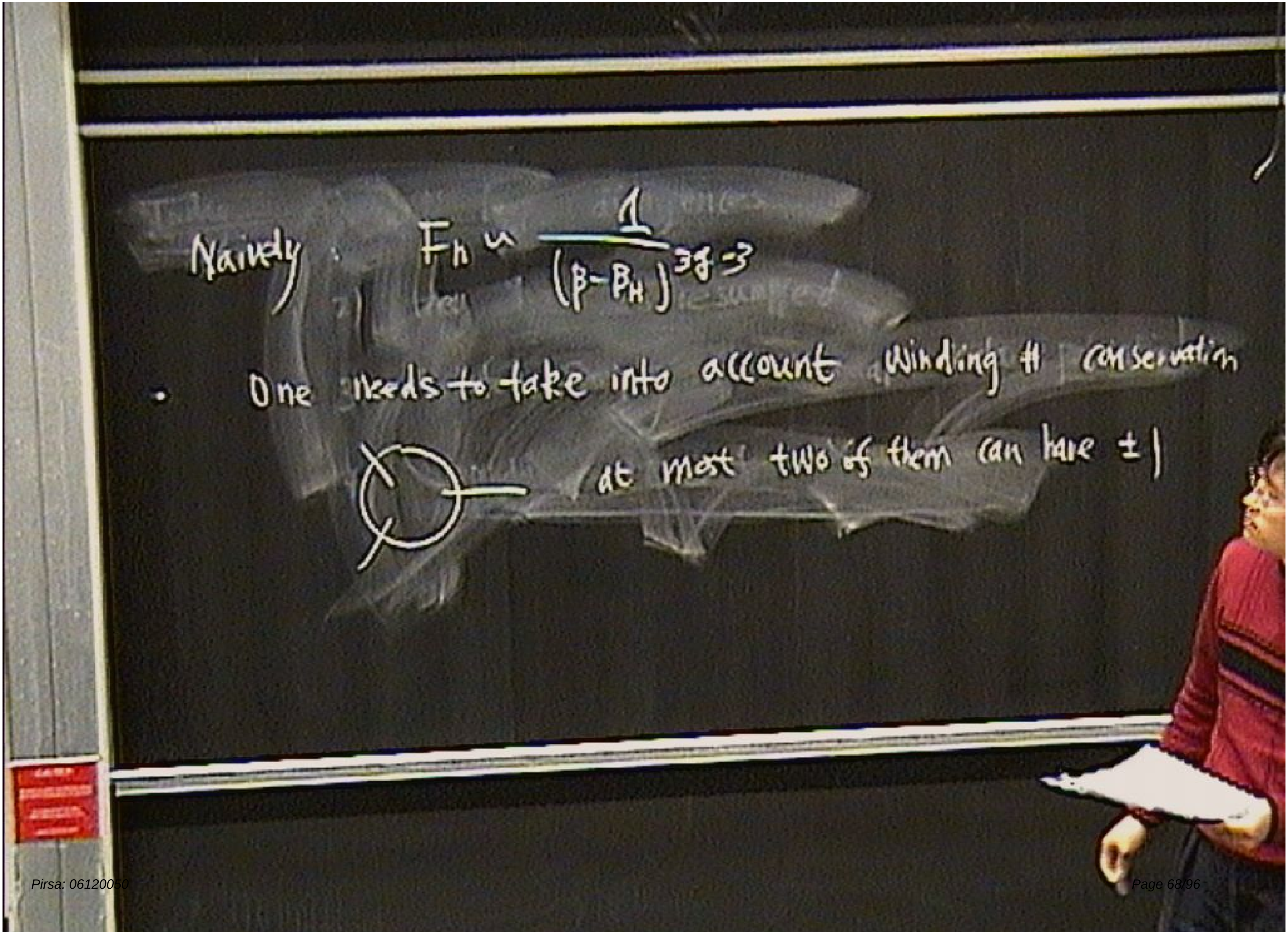
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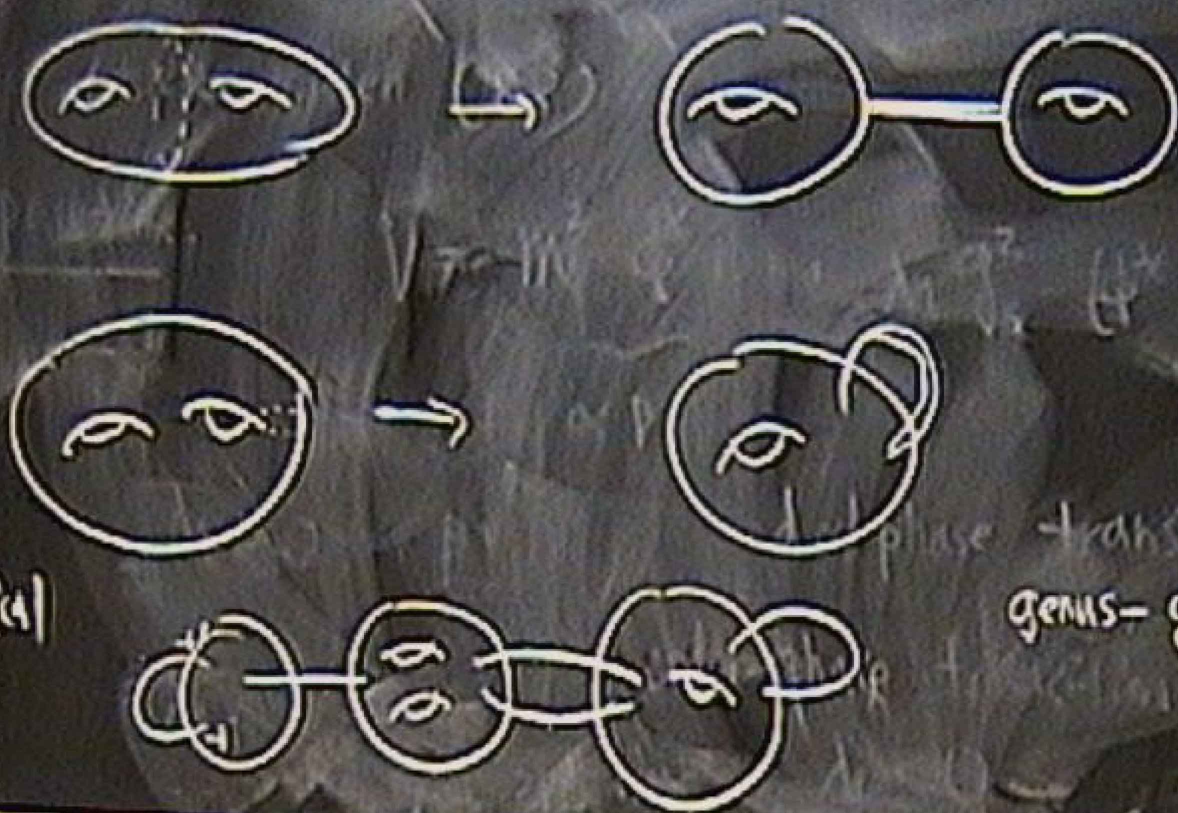
$$\Rightarrow \quad \boxed{F_g \sim \frac{1}{(\beta-\beta_H)^{2g-2}}}$$



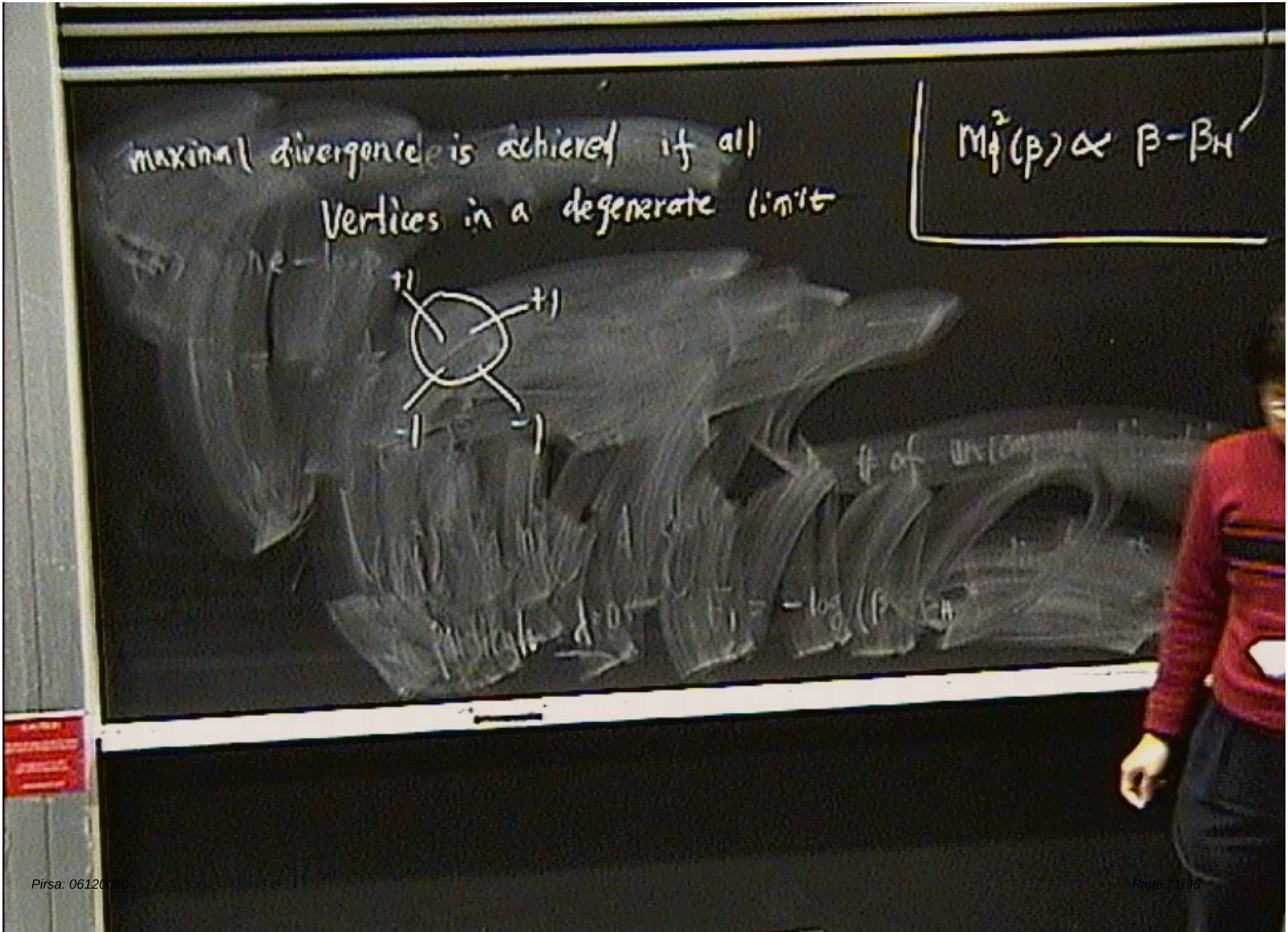
typical

Pinch

genus- g. maximal $3g-3$ cycles

• For each degenerate cycle, associate a propagator.

$$G = \sum_i$$


maximal divergence is achieved if all
vertices in a degenerate limit
$M_\phi^2(\beta) \propto \beta-\beta_H$
+1
+1
-1
-1

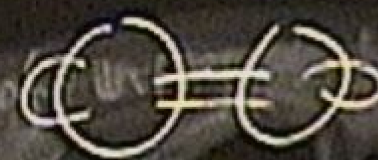
maximal divergence is achieved if all vertices in a degenerate limit

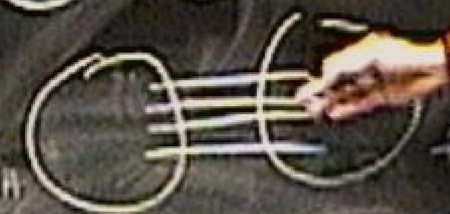
$$\boxed{M_\phi^2(\beta) \propto \beta - \beta_H}$$

$= g_s^2 \lambda_\phi$

$g=2$

$g=3$





- Most divergent terms to all orders.

$$F_{sing} = -\log(\beta-\beta_H) + \frac{a_2 \lambda_4 g_s^2}{(\beta-\beta_H)^2} + \cdots + a_g \frac{\lambda_4^{g-1}}{}$$

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$+ \ldots$

(*)

One normally argues $g_s \to 0$ ignore higher order terms

$\beta \to \beta_H$

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One normally argues, $\underline{g_s \to 0}$ ignore higher order terms

$\beta \to \beta_H$ if $\underline{\beta - \beta_H \propto g_s}$

σ-model partition function

• then all higher order terms equally important.

... divergent terms to all orders.

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- I want to argue.

$$F_{sing} = \log \int d\phi\, d\phi^* \, e^{-m_\phi^2 \phi^* \phi - g_s^2 \lambda_4 (\phi^* \phi)^2}$$

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- I want to argue.

$$F_{sing} = \log \int d\phi\, d\phi^* \, e^{-m_\phi^2 \phi^* \phi - g_s^2 \lambda_4 (\phi^* \phi)^2} \quad (**)$$

$$= \log \int d\phi\, d\phi^* \, e^{-m_\phi^2 \phi^* \phi} \sum_{n=0}^{\infty} \frac{g_s^{2n} \lambda_4^n}{n!} (\phi^* \phi)^{2n}$$

$F_{sing} = \ldots \delta(\beta-\beta_H) + \frac{\ldots}{(\beta-\beta_H)^2} + \ldots + a_g \left(\frac{\lambda_4 \quad g_s}{(\beta-\beta_H)^{2g-2}}\right)$

$+ \ldots \qquad (*)$

One normally argues, $\underline{g_s \to 0}$ ignore higher order terms

$\beta \to \beta_H$ if $\underline{\beta - \beta_H \propto g_s^2}$

- then all higher order terms equally important.
- I want to argue.

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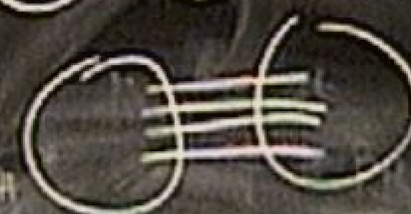
maximal divergence is achieved if all Vertices in a degenerate limit

$= g_s^2 \lambda_4$

$M_\phi^2(\beta) \propto \beta - \beta_H$

$g=2$:

$g=3$



$+ \cdots$

$$F_{sing} = -\log(\beta-\beta_H) + \frac{a_2 \lambda_4 g_s^2}{(\beta-\beta_H)^2} + \cdots + a_g \frac{\lambda_4^{g-1} \; g_s^{2g-2}}{(\beta-\beta_H)^{2g-2}}$$

$$+ \cdots \qquad (*)$$

One normally argues, $\underline{g_s \to 0}$ ignore higher order terms

$\beta \to \beta_H$ if $\underline{\beta-\beta_H \propto g_s}$

then all higher order terms equally important.

- I want to argue.

$$F_{sing} = \log \int d\phi\, d\phi^* \; e^{\underline{-m_\phi^2 \phi^* \phi - g_s^2 \lambda_4 (\phi^* \phi)^2}} \quad (**)$$

$$= \log \int d\phi\, d\phi^* \; e^{-m_\phi^2 \phi^* \phi} \sum \frac{g_s^{2n} \lambda_4^n}{\cdots} (\phi^* \phi)^{2n}$$

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$$F_{sing} = \log \int d\phi \, d\phi^* \; e^{-m_\phi^2 \phi^*\phi - g_s^2 \lambda_2 (\phi^*\phi)^2} \qquad (**)$$

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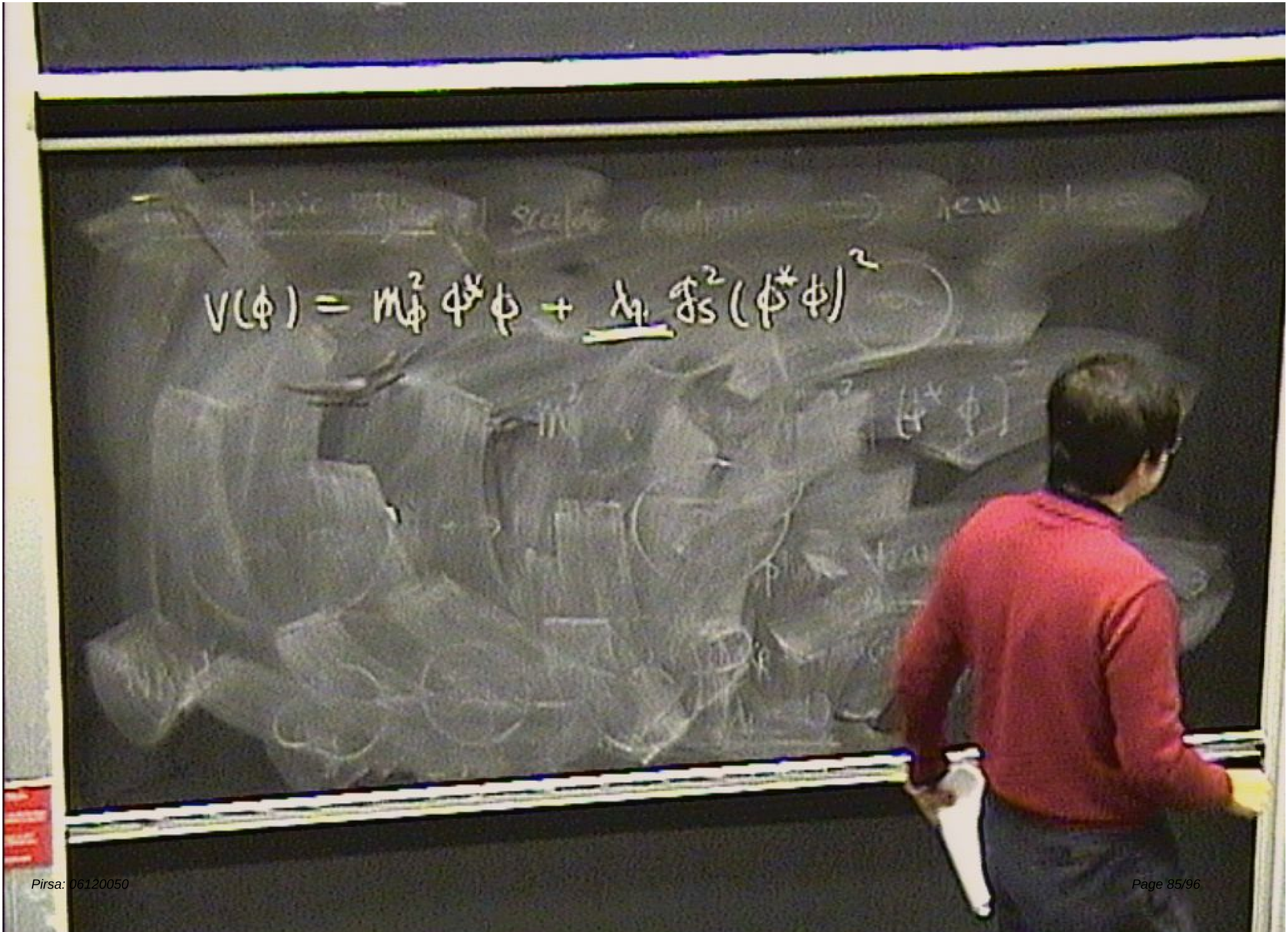
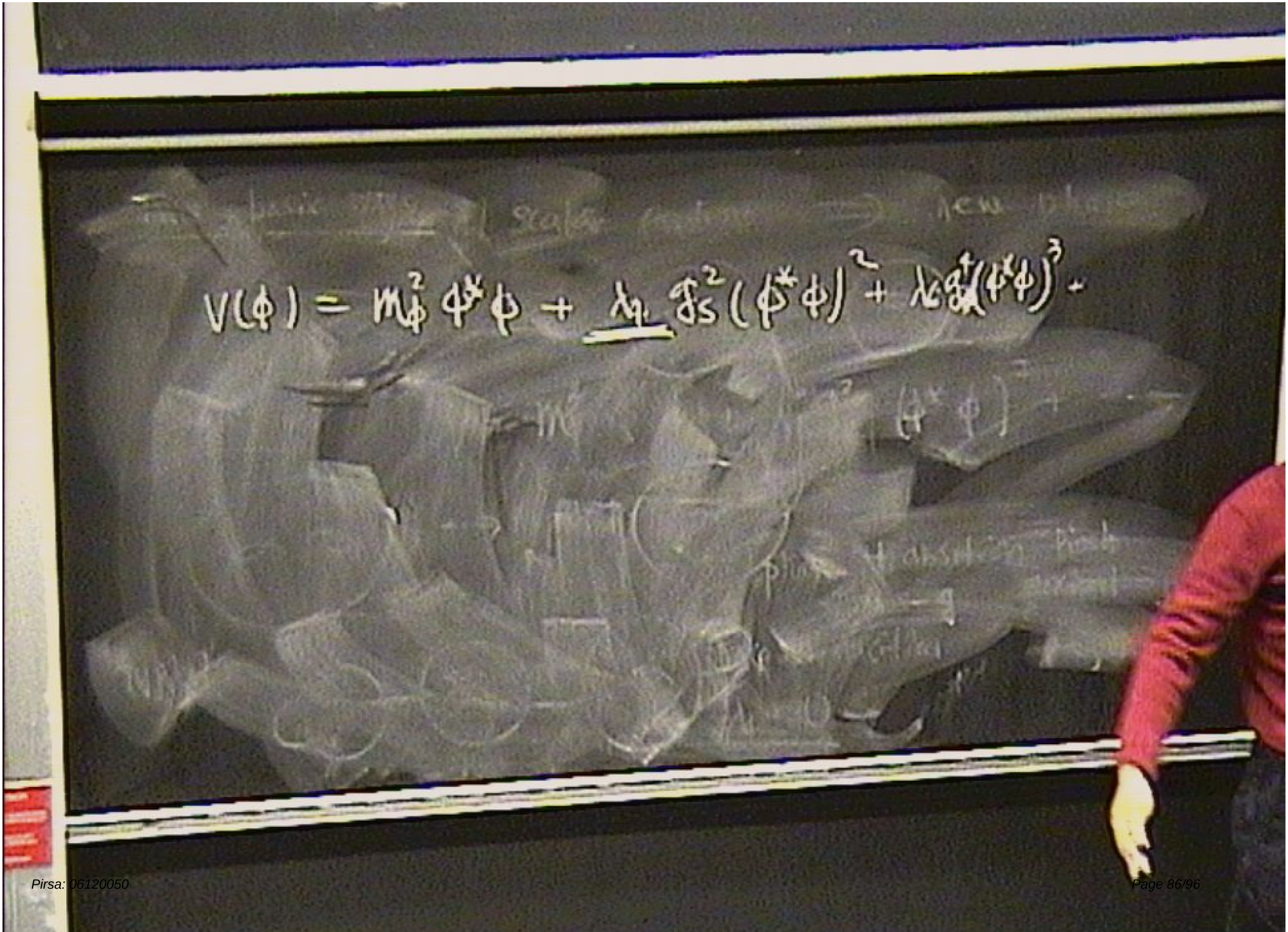

$V(\phi) = m_\phi^2 \phi^* \phi + \lambda_q g_s^2 (\phi^* \phi)^2$


$V(\phi) = m_\phi^2 \phi^*\phi + \lambda_4 g_s^2 (\phi^*\phi)^2 + \lambda_6 g_s^4 (\phi^*\phi)^3 +$

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In Ads: HP transition $T_{HP} \sim O\left(\frac{1}{R}\right)$

$T_H \sim O\left(\frac{1}{l_s}\right)$

$T_{||} \gg T_{HP}$

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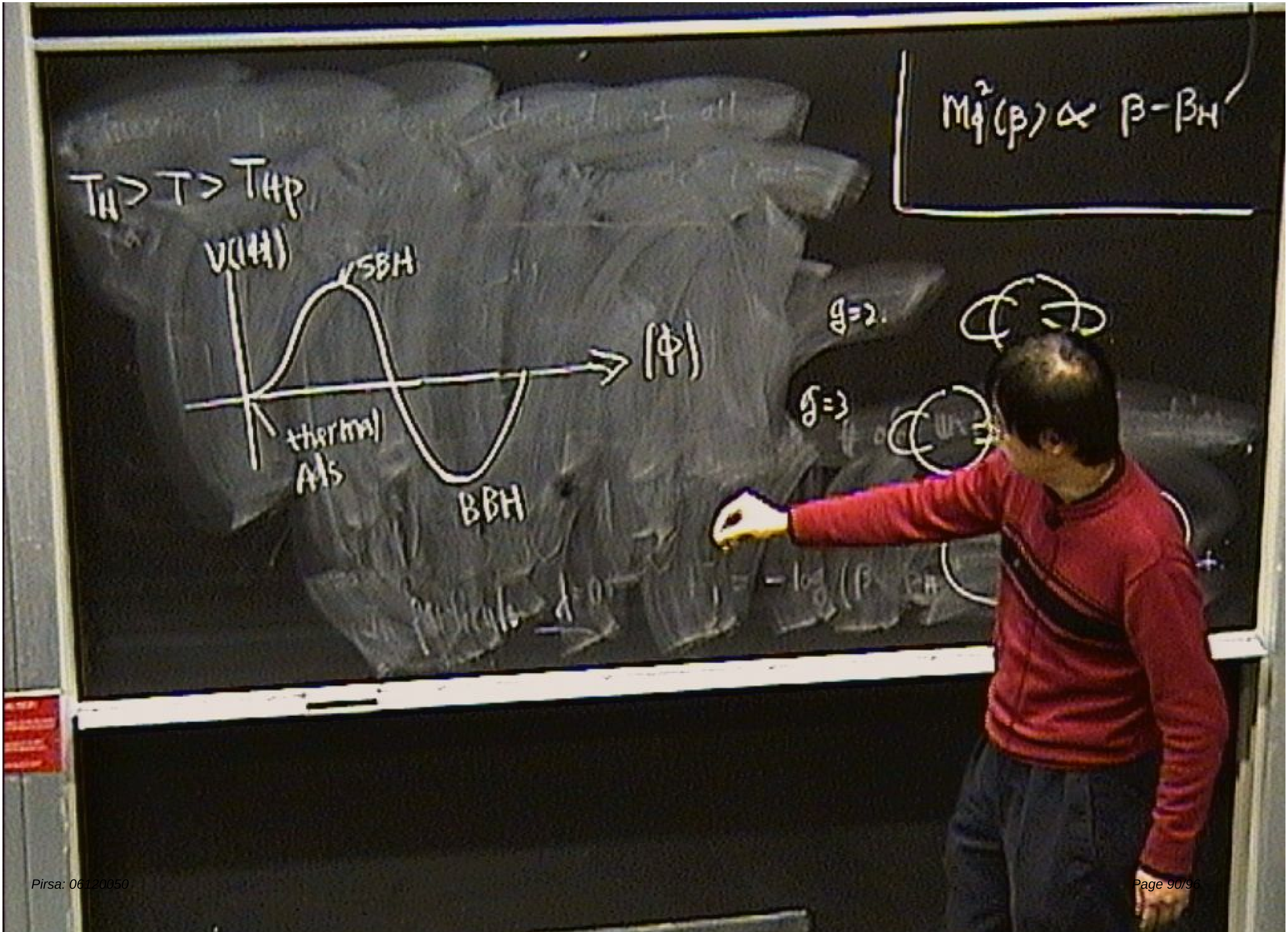
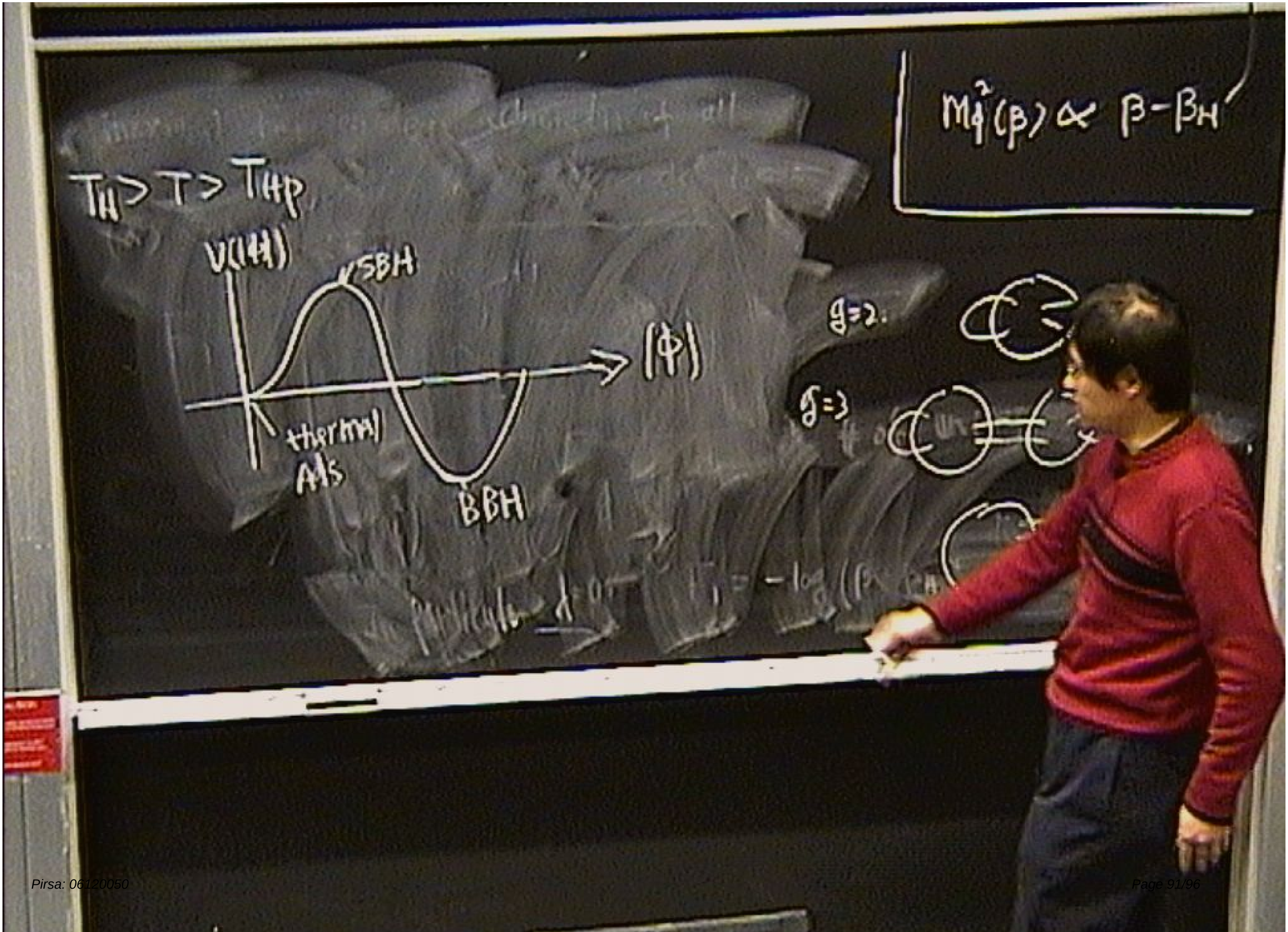

$M_\phi^2(\beta) \propto \beta - \beta_H$
$T_H > T > T_{Hp}$
V(|φ|)
SBH
|φ|
thermal
AdS
BBH
g=2.
g=3



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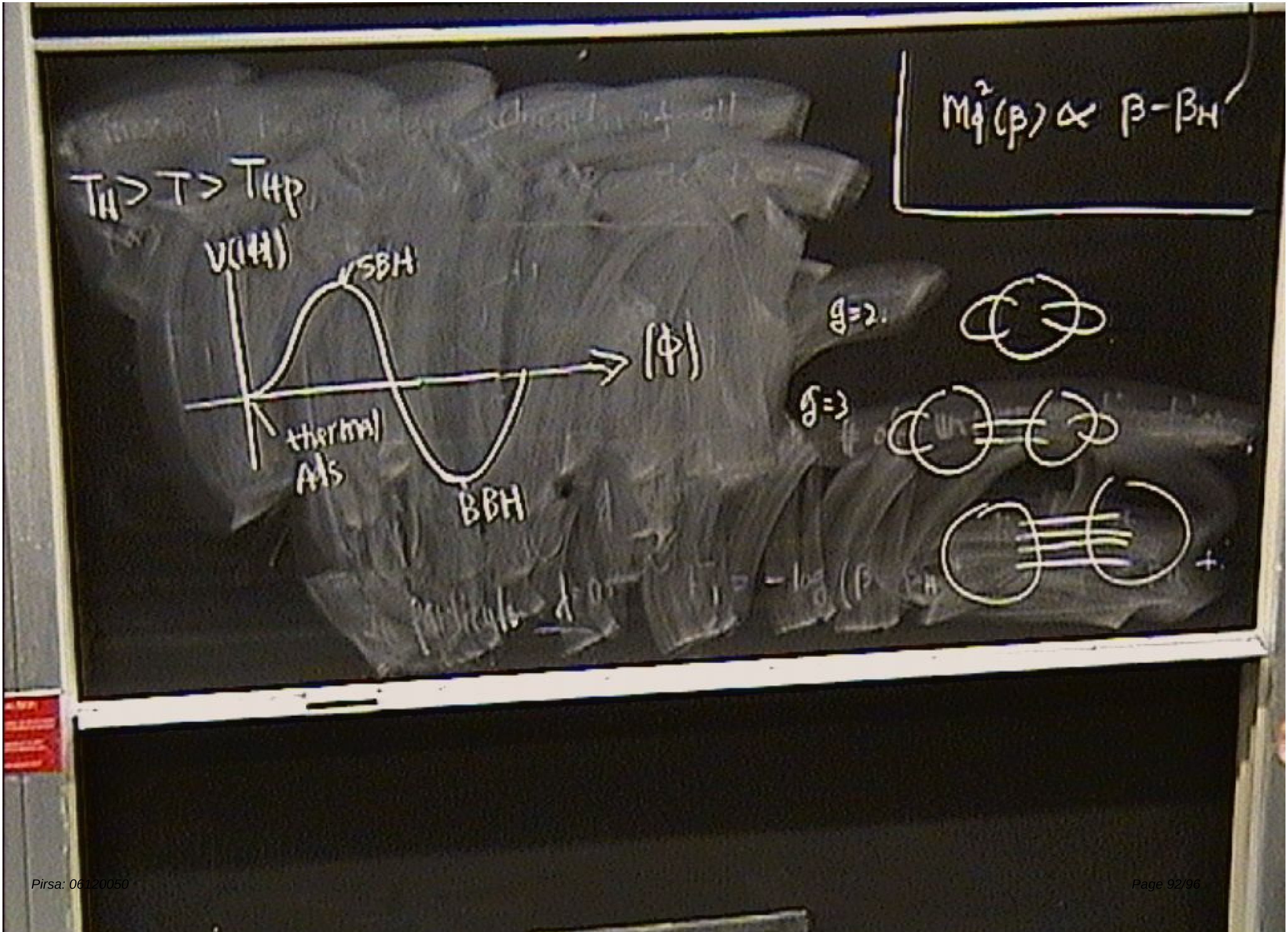
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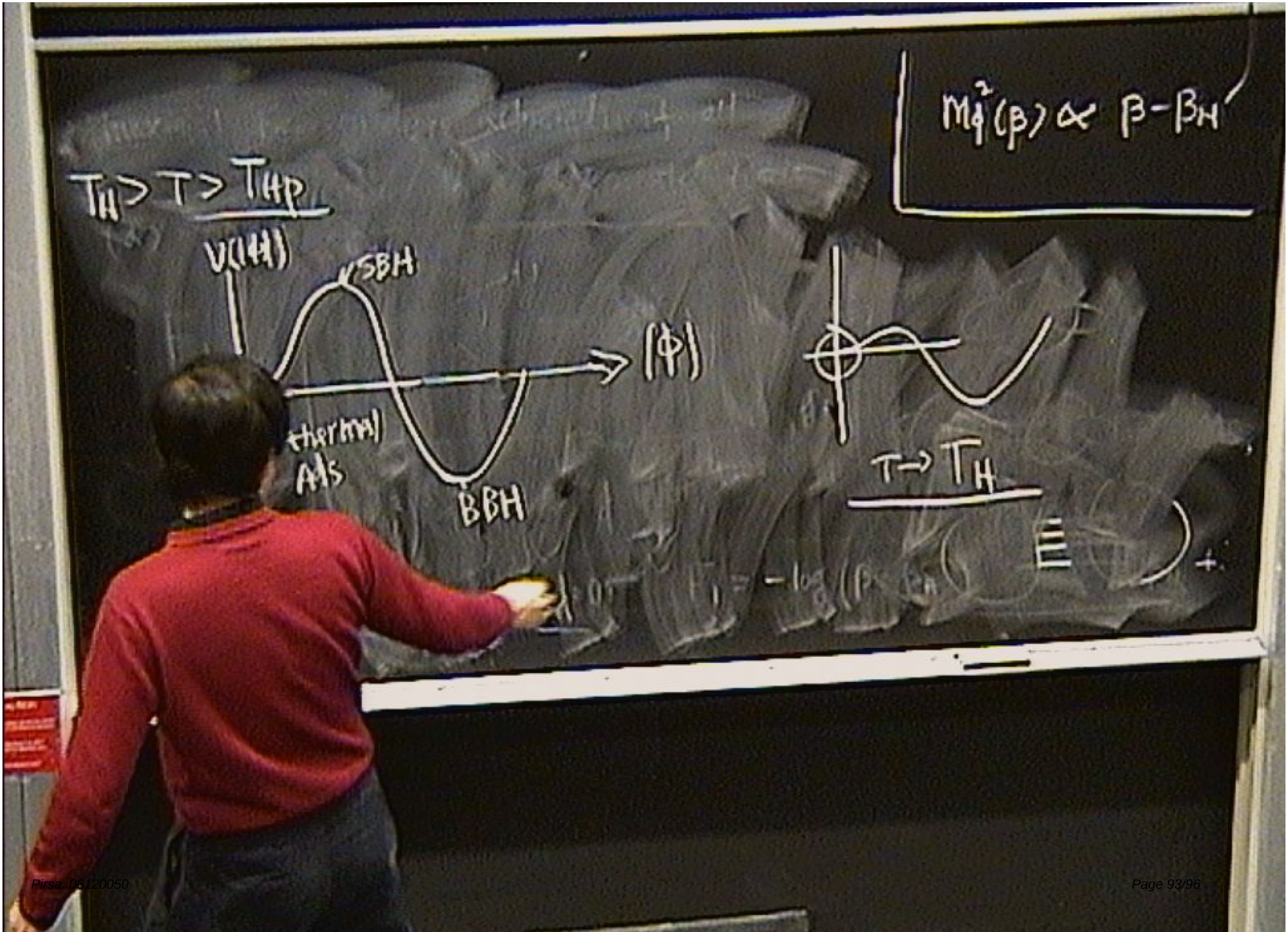
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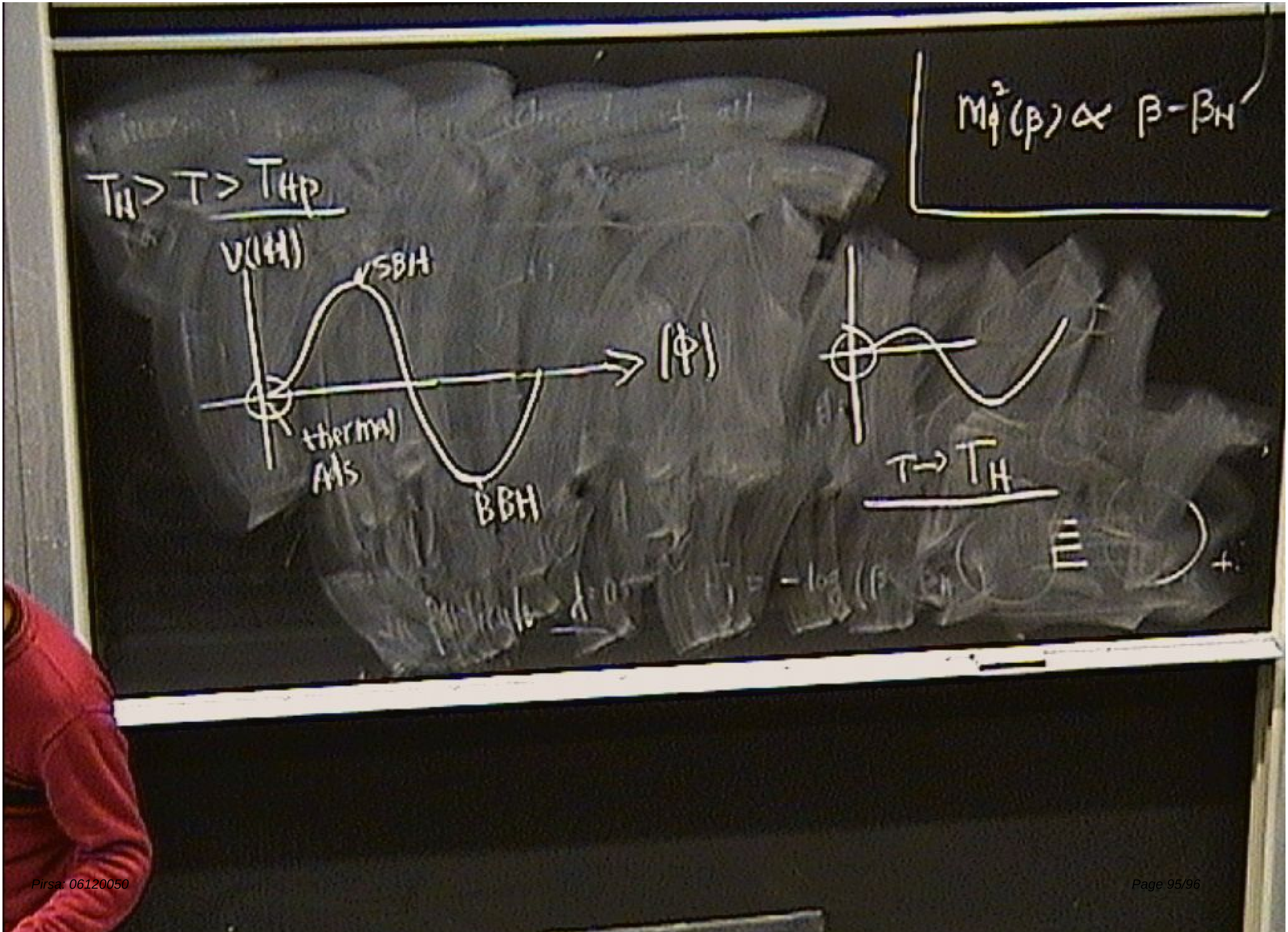
$$V(\phi) = m_\phi^2 \phi^* \phi + \underline{\lambda_4}\, g_s^2 (\phi^*\phi)^2 + \lambda_6 g_s^4 (\phi^*\phi)^3 + \dots$$

In AdS:

HP transition $T_{HP} \sim O(\frac{1}{R})$

$T_H \sim O(\frac{1}{\sqrt{\alpha'}})$

$T_H \gg T_{HP}$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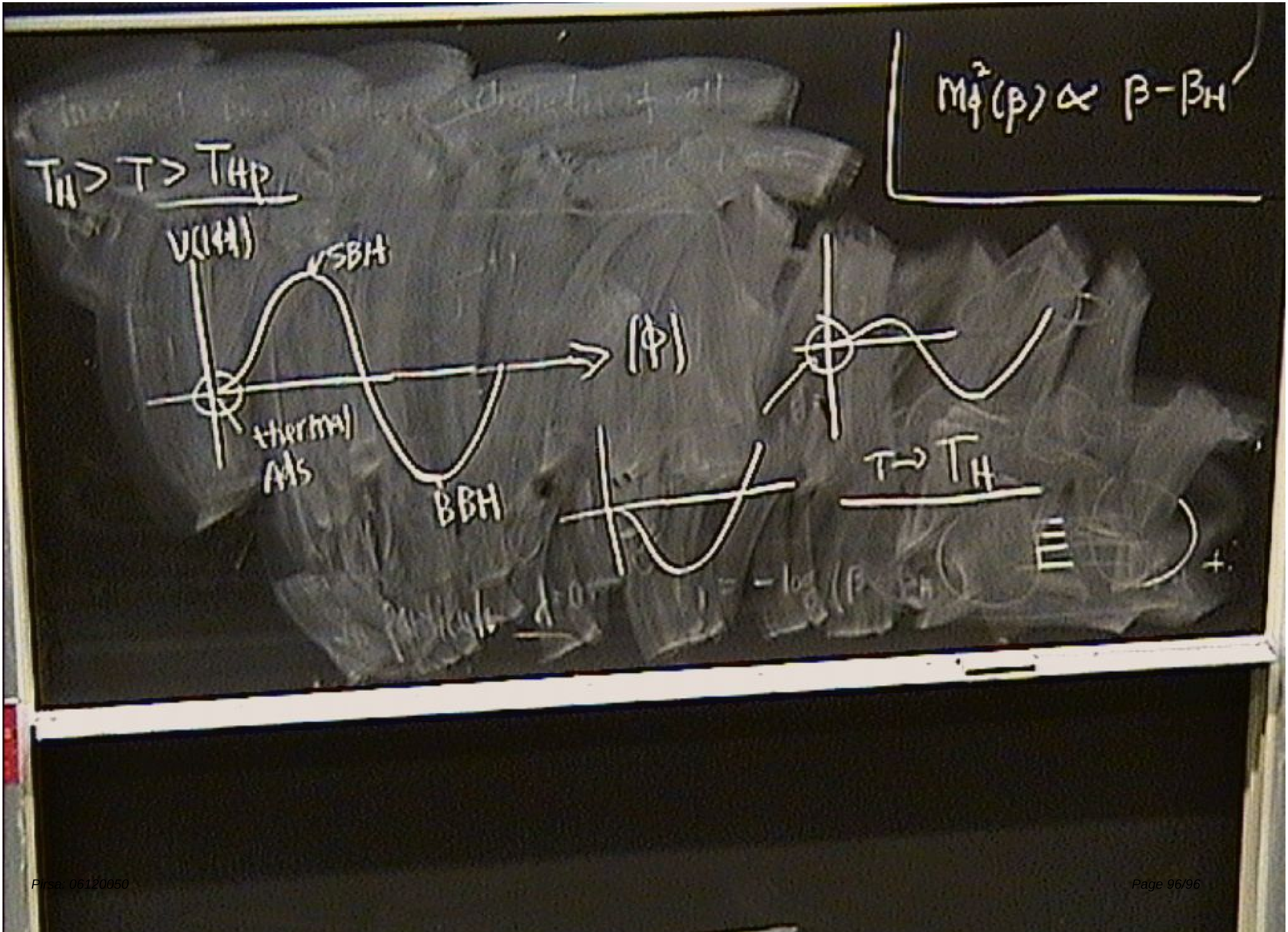
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