Title: Degravitation

Date: Sep 11, 2007 09:30 AM

URL: http://pirsa.org/07090031

Abstract:

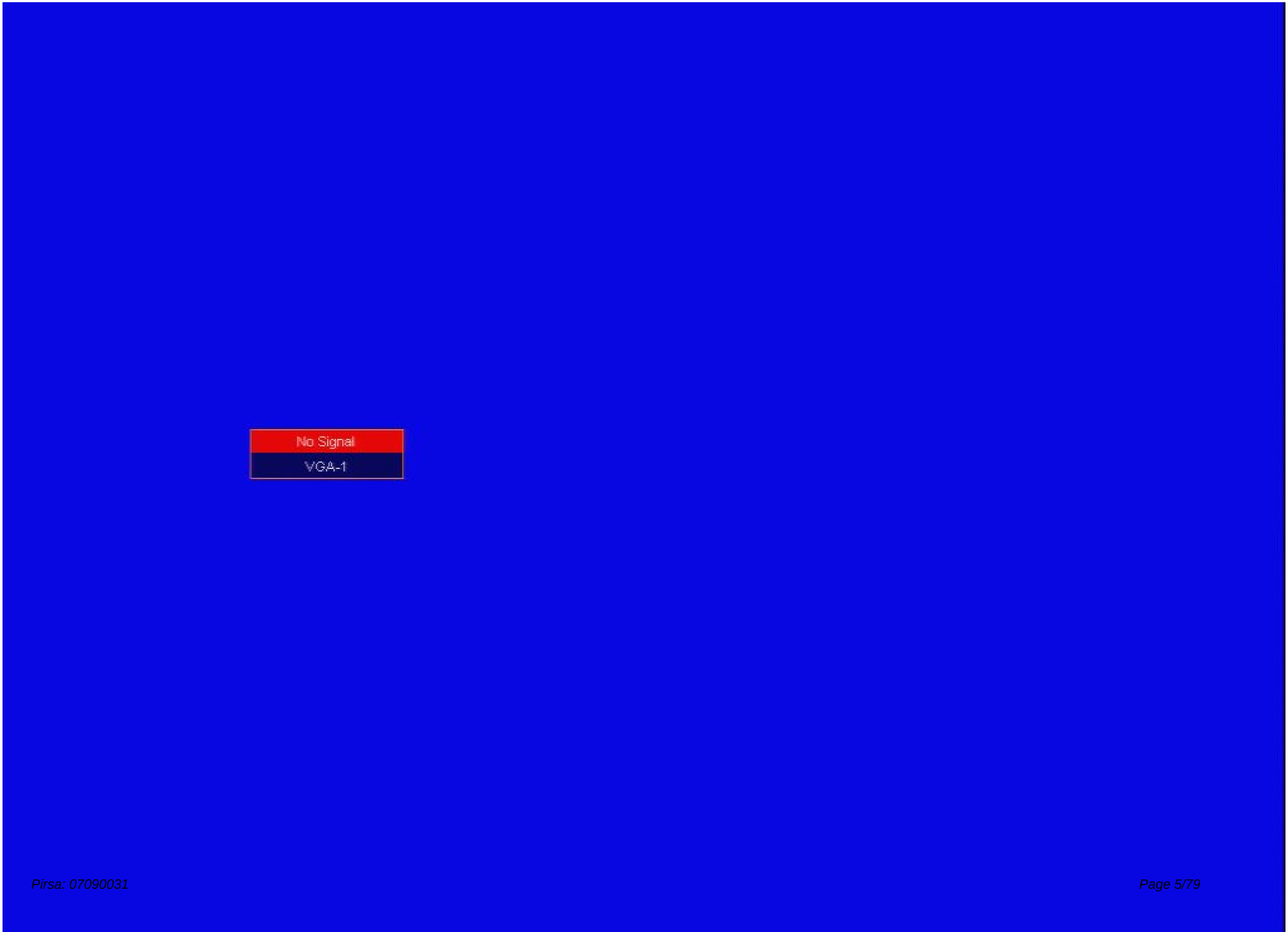
No Signal

VGA-1

No Signal
VGA-1

No Signal

VGA-1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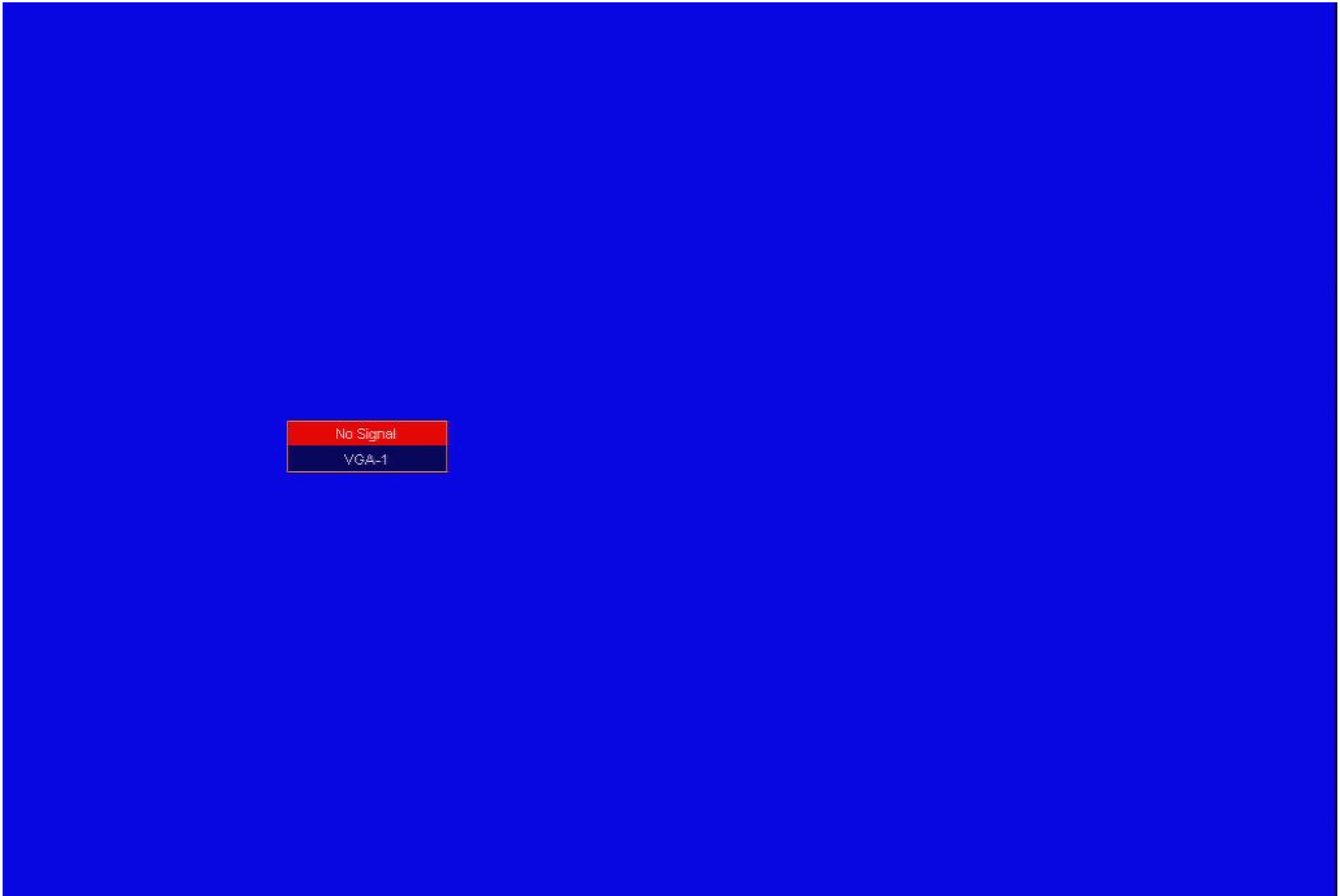
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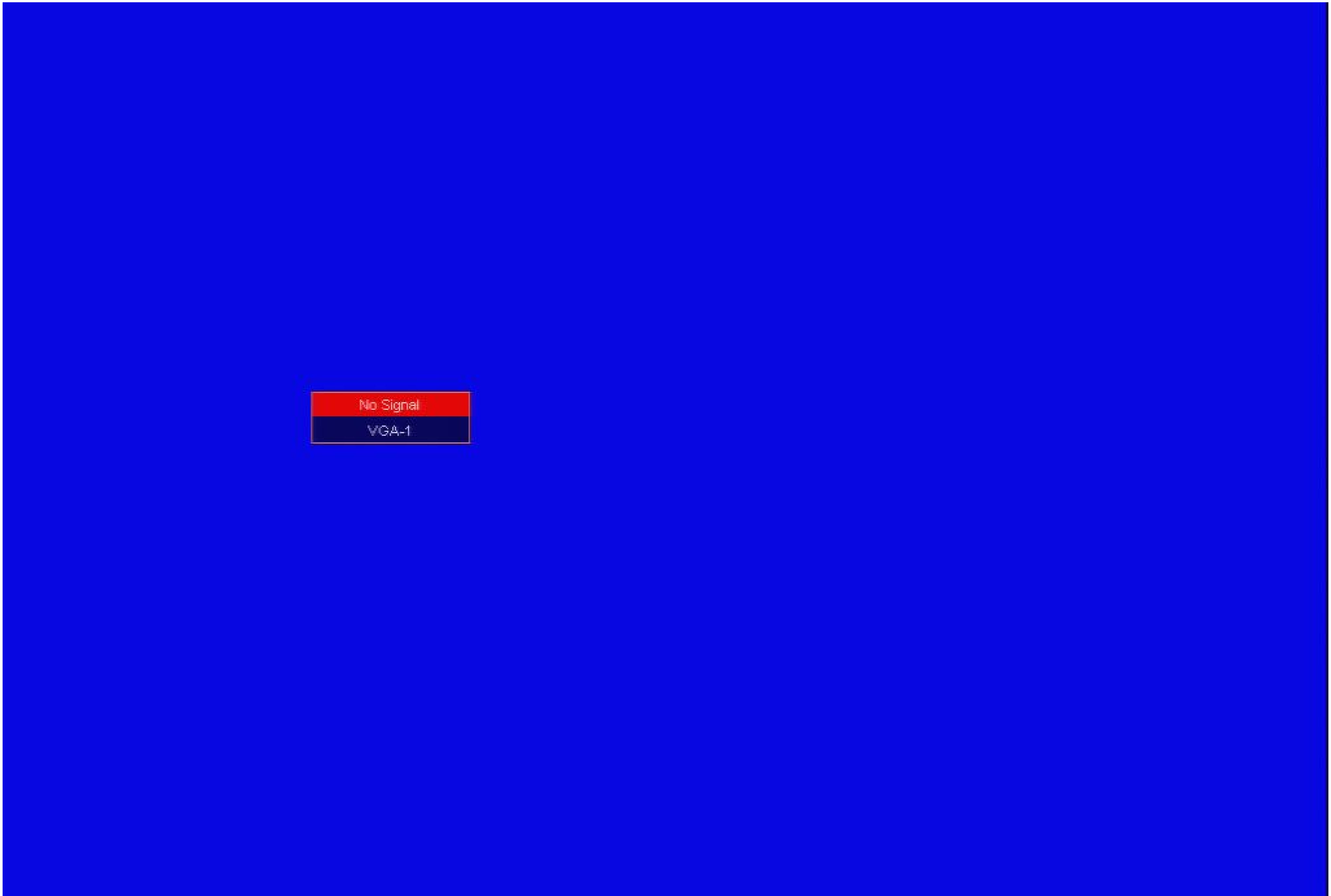
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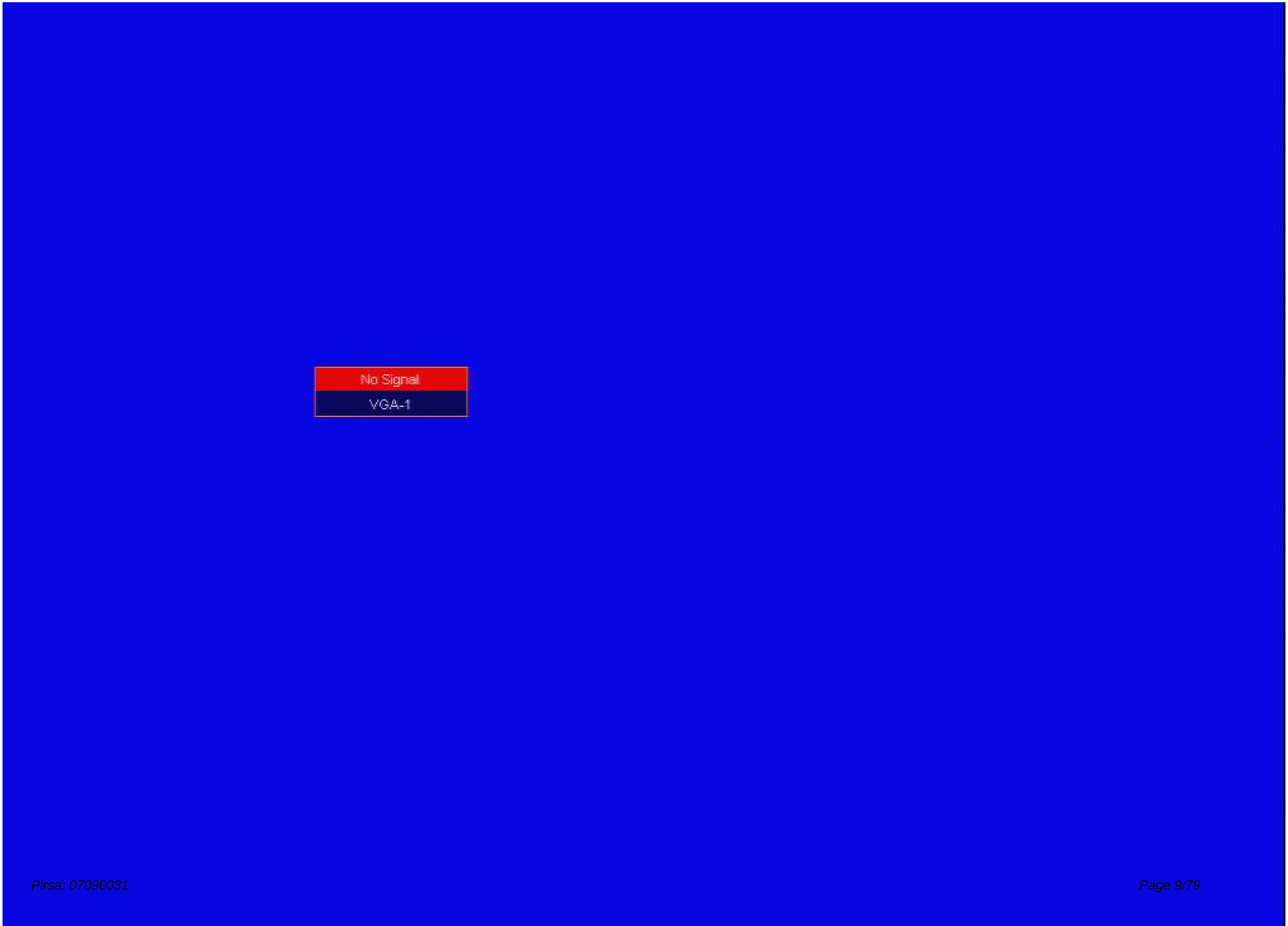
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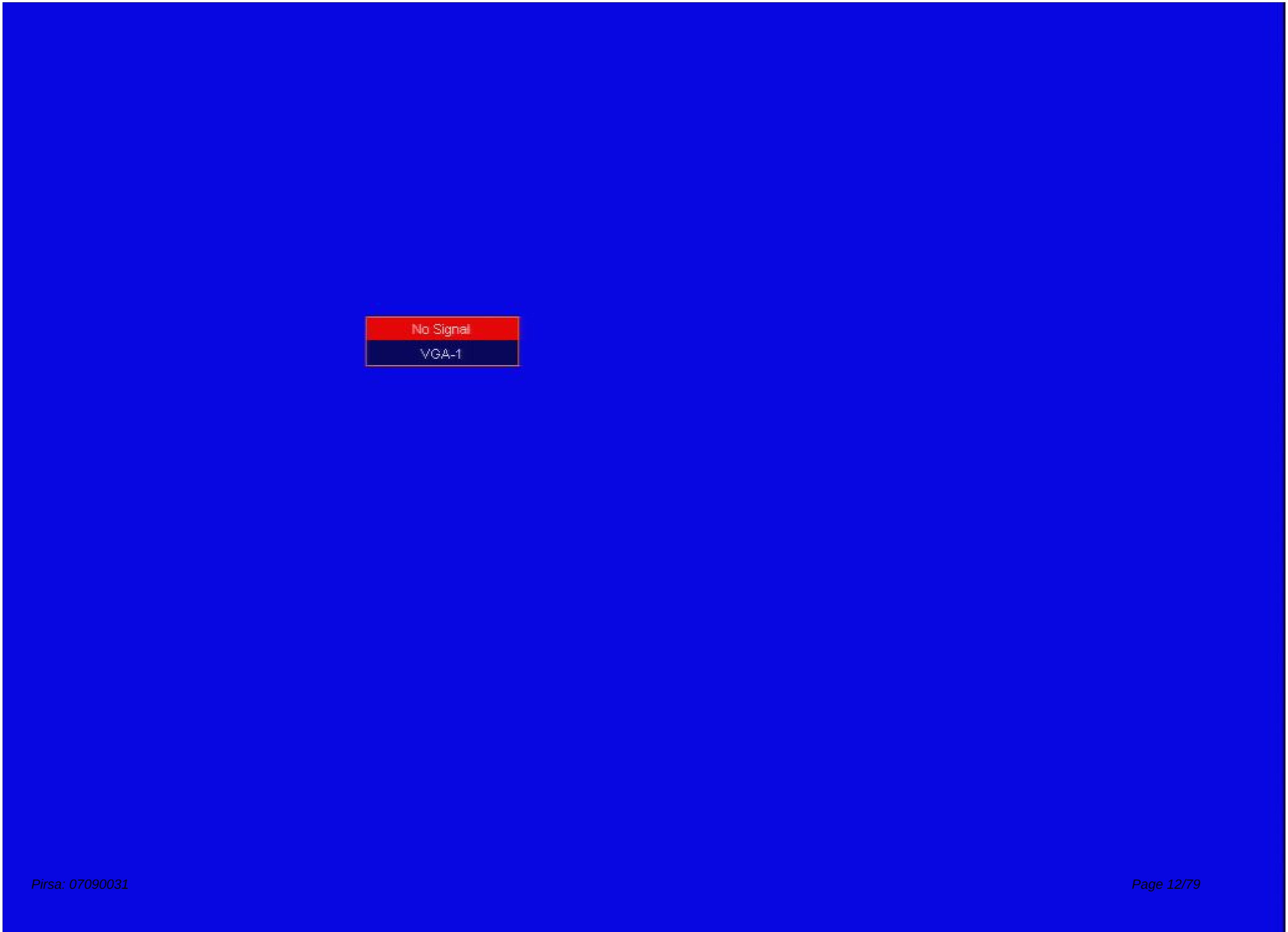
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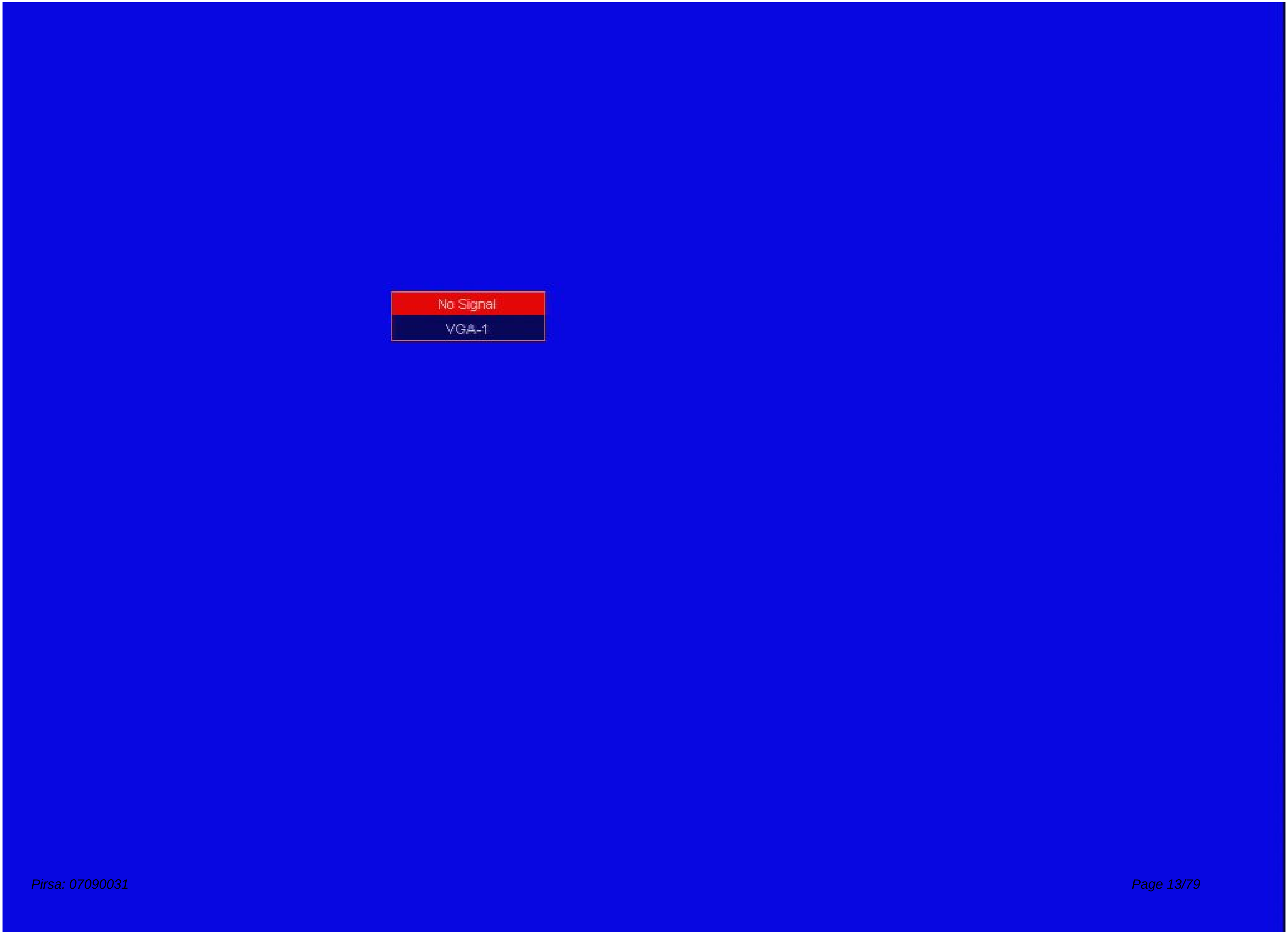
VGA-1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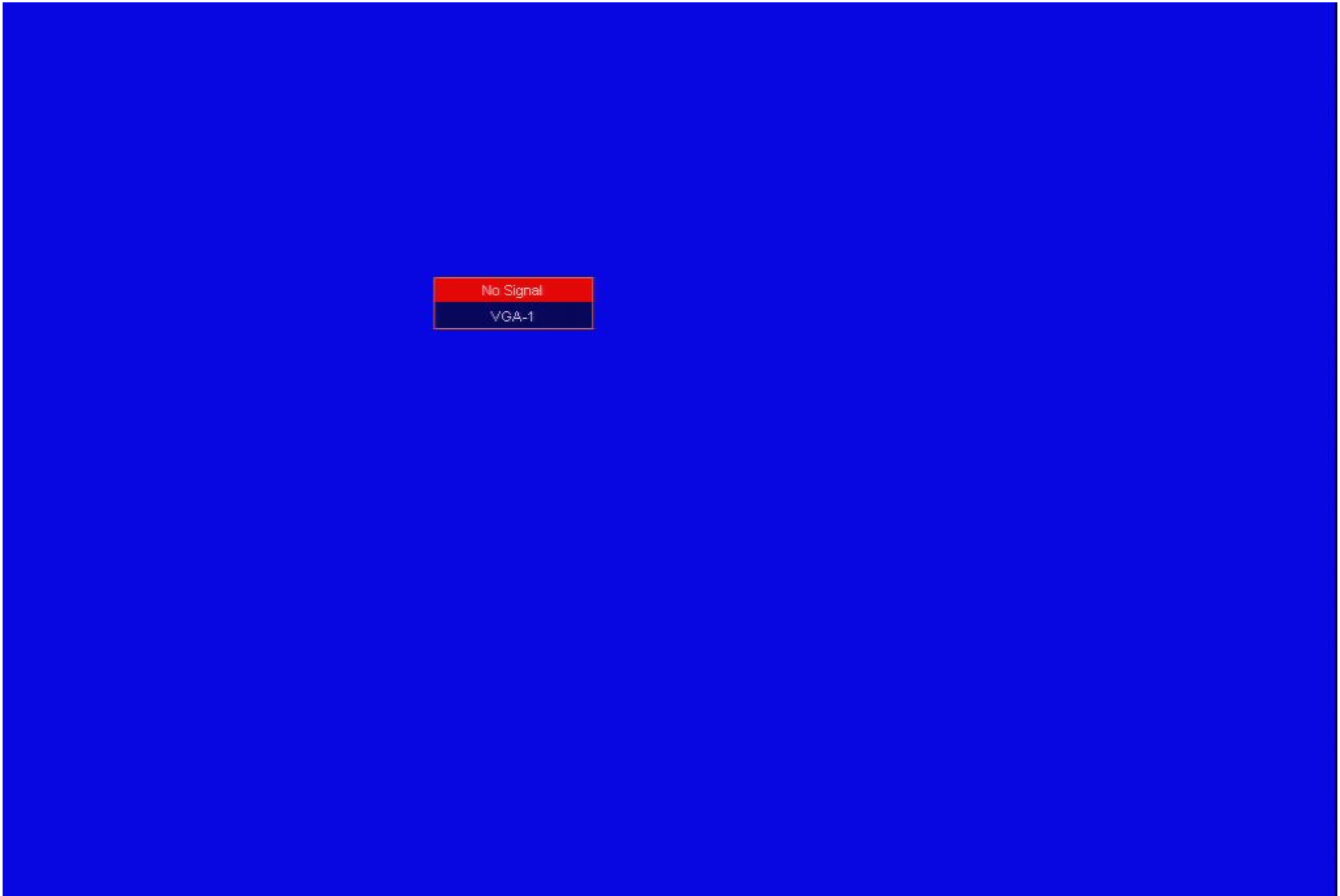
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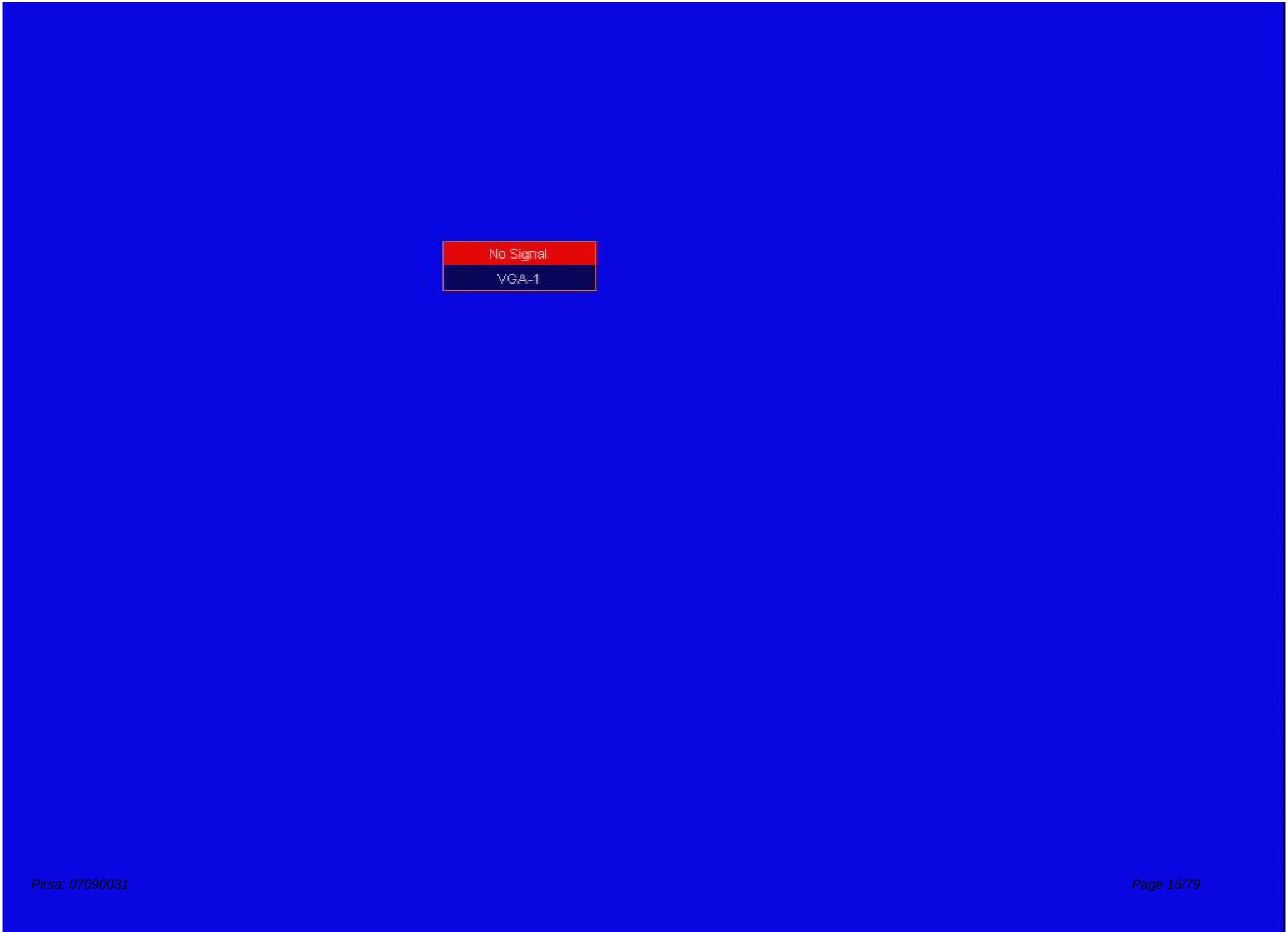
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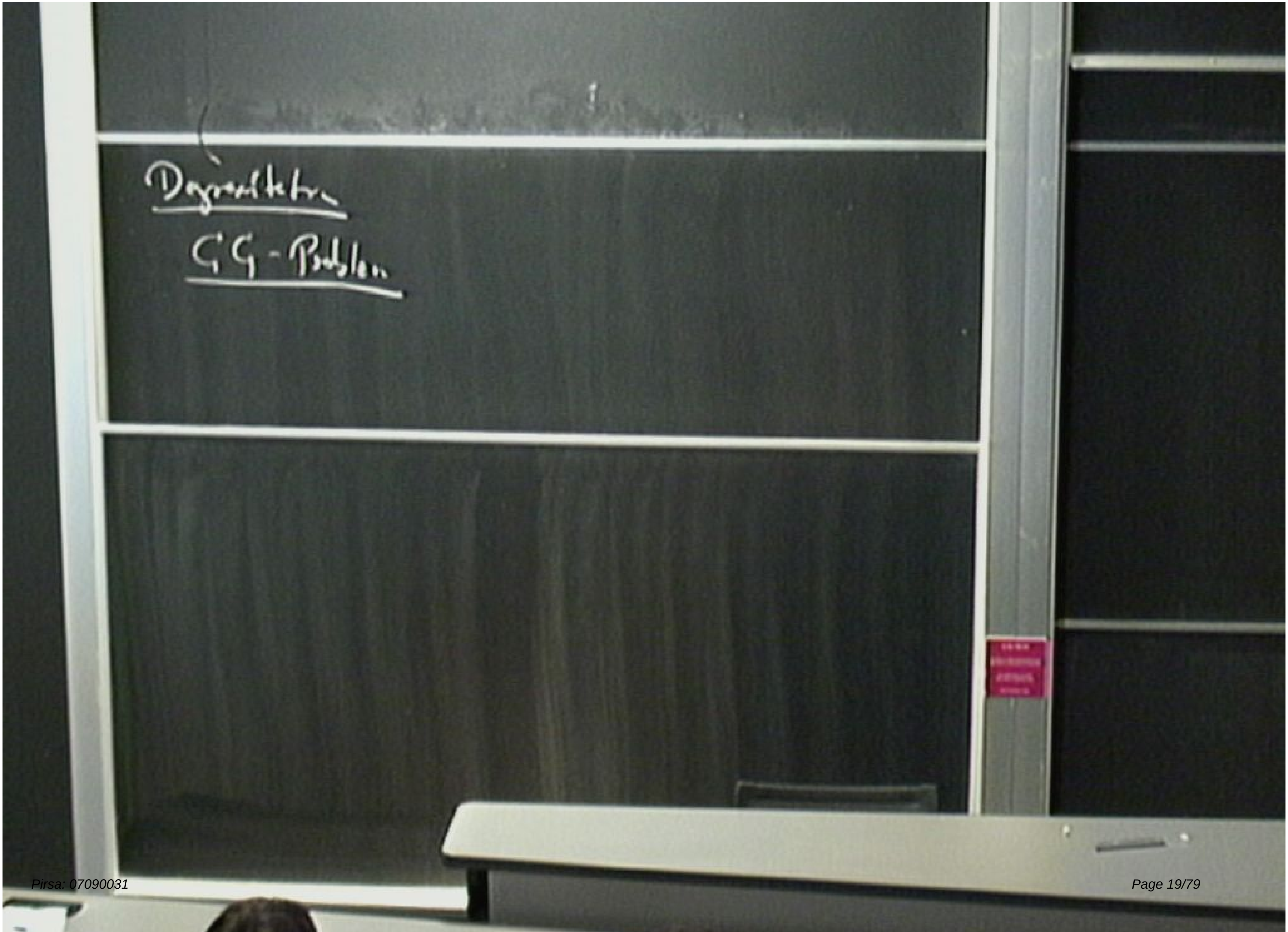

Degeneration
GG - Problem

Degravitation

CC - Problem

$\epsilon^{obs}_{vac} \sim 10^{-12}\ \mathrm{eV}^4$

Degravitation

CC - Problem

$$\epsilon_{vac}^{obs} \sim 10^{-12}\, eV^4$$

$$\epsilon_{vac}^{SM} = c_0 \overbrace{\Lambda^4}^{\text{UV-cutoff}} + c_2 \Lambda^2 m^2 + c_4 m^4 \ln\frac{\Lambda}{m} + \dots$$

UV-sensitive

$$\mathcal{E}^{SM}_{\text{vac}} = c_0 \Lambda^4 + c_2 \Lambda^2 m^2 + c_4 m^4 \ln \frac{\Lambda}{m} + \ldots$$

eV^4

Consistent UV-completion?

EFT:

$$\epsilon^{e^-}_{lab} \approx 10^{35}\,\epsilon^{obs}_{lab}$$

$$\epsilon^{SM}_{\text{vac}} = c_0 \Lambda^4 + c_2 \Lambda^2 m^2 + \ldots$$

c_0, c_2: Why is $\epsilon^{\text{obs}}_{\text{vac}}$ small?

$\mathcal{E}^{SM}$

Q1: Why is $\mathcal{E}^{obs}_{vac}$ small?

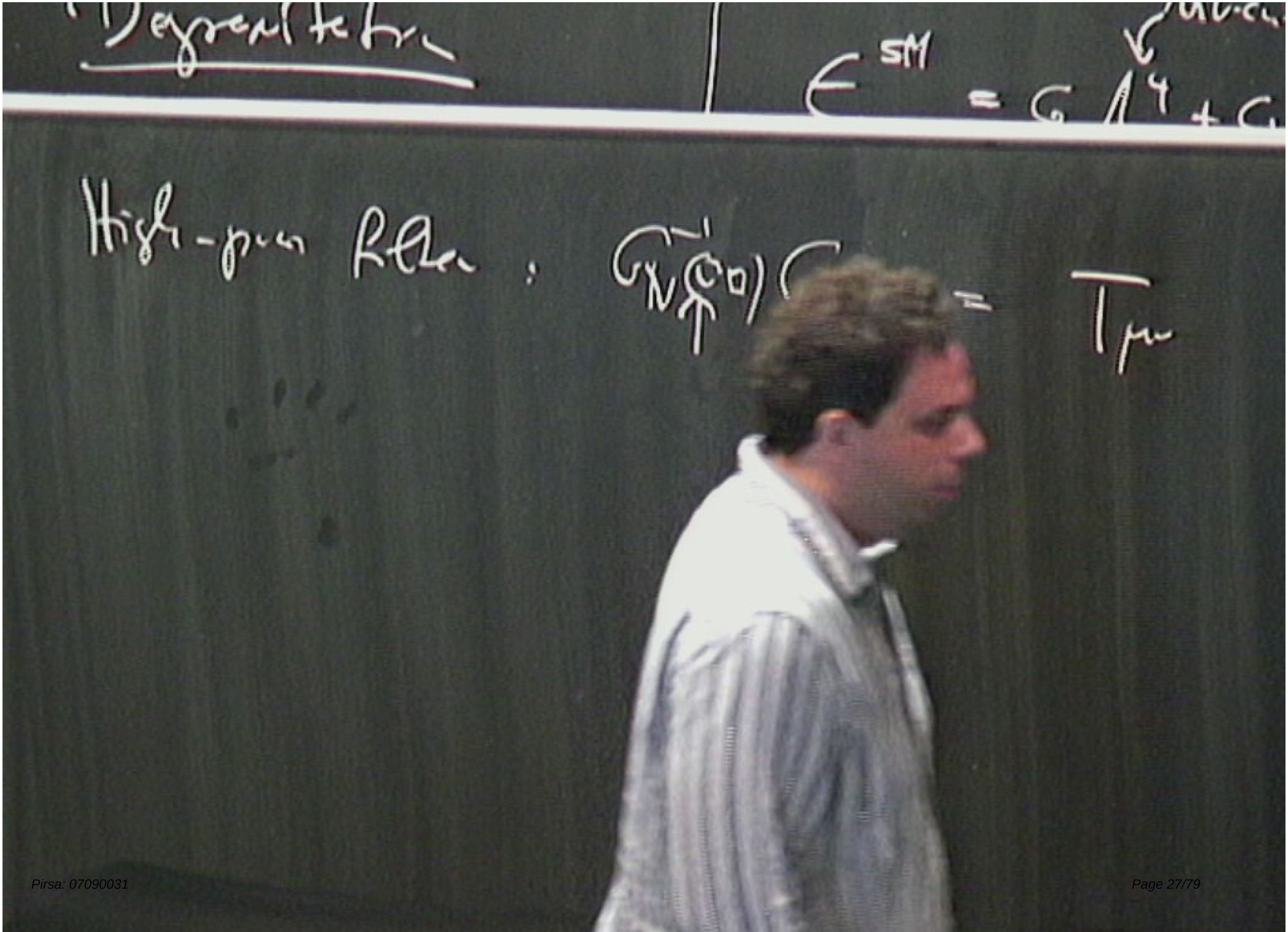
Q2: Why does $\mathcal{E}_{vac}$ gravitate so weakly?

Resonance

Scales: $k \gg \frac{1}{L}$ Emoluen

Field size

$k \lesssim \frac{1}{L}$ filter-out


Degravitation
High-pass filter :

Degravitation

$\epsilon^{SM} = c_1 \Lambda^4 + c \ldots$

High-pass filter: $G_N^{-1}(L^2\Box)\, G_{\mu\nu} = T_{\mu\nu}$

High-spin Rtlen : $G_N^{-1}(L^2\Box)\,(\mathcal{E}h)_{\mu\nu} = T_{\mu\nu}$

IR- Cuhmira : $1 - m^2(\Box)$

High-spin fields: $G_N^{-1}(L^2\Box)\,(\mathcal{E}h)_{\mu\nu} = T_{\mu\nu}$

IR-Modification: $1 - \dfrac{m^2(\Box)}{\Box}$

High-pass filter: $G_N^{-1}(L^2\Box)\,(\mathcal{E}\tilde{h})_{\mu\nu} = -T_{\mu\nu}$

IR-behaviour: $\left\{1 - \frac{m^2(\Box)}{\Box}\right\}(\mathcal{E}\tilde{h})_{\mu\nu} = -T_{\mu\nu}$

High-spin Relation: $G_N^{-1}(L^2\Box)\,(\mathcal{E}\tilde{h})_{\mu\nu} = -T_{\mu\nu}$

IR-Completion: $\left\{1 - \frac{m^2(\Box L^2)}{\Box}\right\}(\mathcal{E}\tilde{h})_{\mu\nu} = -T_{\mu\nu}$

$$(\mathcal{E}\tilde{h})_{\mu\nu} = \Box \tilde{h}_{\mu\nu} - \eta_{\mu\nu}\Box \tilde{h} - \partial^{\alpha}\partial_{(\mu}\tilde{h}_{\nu)\alpha} + \eta_{\mu\nu}\partial^{\alpha}\partial^{\beta}\tilde{h}_{\alpha\beta} + \partial_{\mu}\partial_{\nu}\tilde{h}$$

$$m^2(D) \overset{\mathrm{IR}}{=} \frac{1}{L^2}\left(L^2\Box\right)^{\alpha}$$

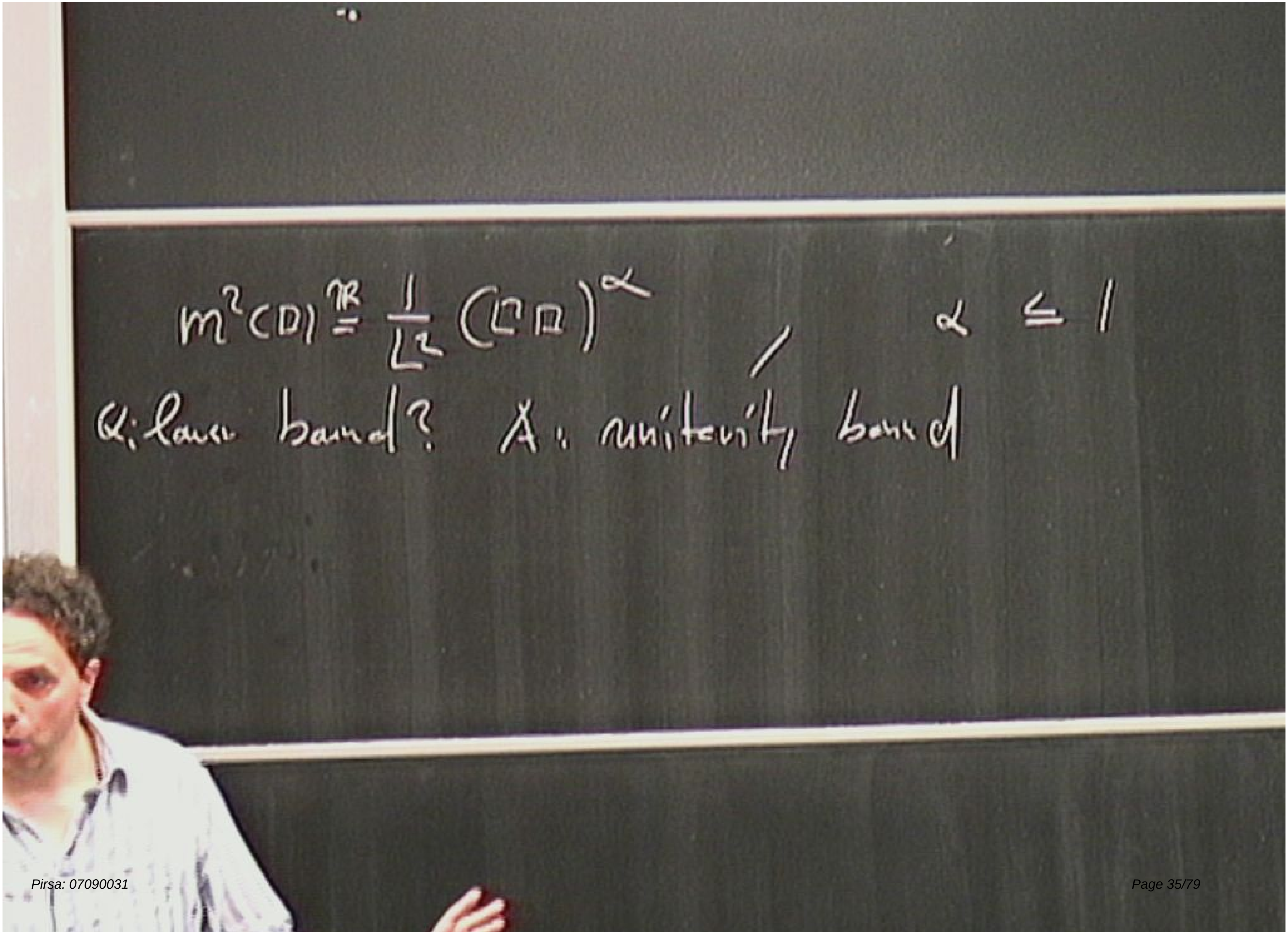
High-pass filter: $G_\lambda(L^2\Box)\,(\mathcal{E}\tilde{h})_{\mu\nu} = -T_{\mu\nu}$

IR-modification:

$$\left\{1 - \frac{m^2(L^2\Box)}{\Box}\right\}(\mathcal{E}\tilde{h})_{\mu\nu} = -T_{\mu\nu}$$

$\Box\{\tilde{h}_{\mu\nu} - \tfrac{1}{2}\eta_{\mu\nu}\tilde{h}\}$

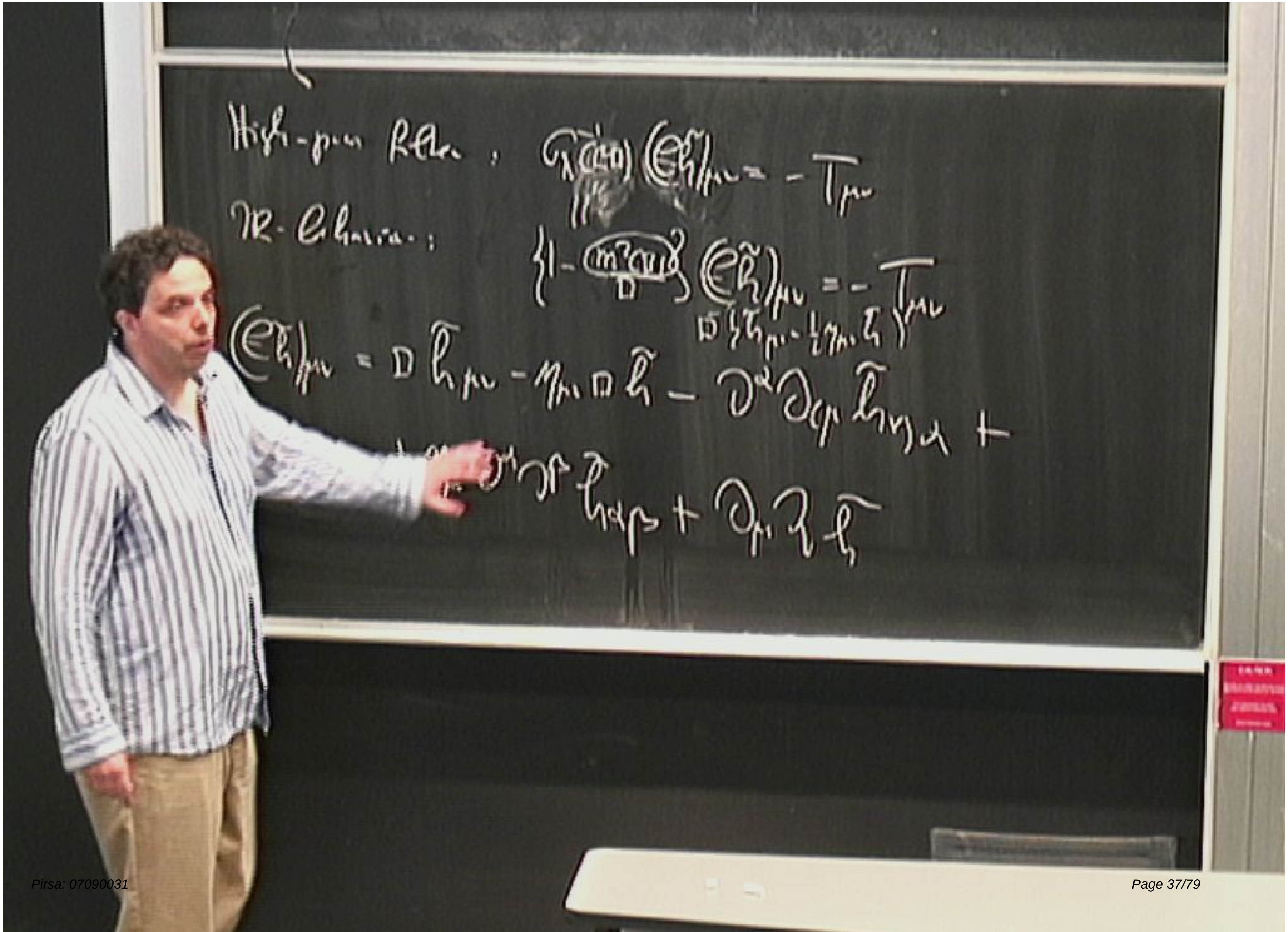
$$(\mathcal{E}\tilde{h})_{\mu\nu} = \Box\tilde{h}_{\mu\nu} - \eta_{\mu\nu}\Box\tilde{h} - \partial^\alpha\partial_{(\mu}\tilde{h}_{\nu)\alpha} + \eta_{\mu\nu}\partial^\alpha\partial^\beta\tilde{h}_{\alpha\beta} + \partial_\mu\partial_\nu\tilde{h}$$


$m^2(\Box) \overset{IR}{=} \frac{1}{L^2}(L^2\Box)^{\alpha}$ / $\alpha \leq 1$
Q: lower bound? A: unitarity bound

$$m^2(\Box) \overset{IR}{=} \frac{1}{L^2}(L^2\Box)^\alpha \qquad \alpha \leq 1$$

Q: lower bound? A: unitarity bound

$$\Delta(k^2) = \frac{1}{k^2+m^2(k^2)} = \int_0^\infty ds \frac{\rho(s)}{k^2+s}$$



$$m^2(\square) \overset{\text{IR}}{=} \frac{1}{L^2}\left(L^2\square\right)^{\alpha} \qquad \alpha \leq 1$$

Q: lower bound? A: unitarity bound

$$\Delta(k^2) = \frac{1}{k^2+m^2(k^2)} = \int_0^\infty ds\, \frac{\rho(s)\geq 0}{k^2+s}$$

$$\downarrow k^2\to 0$$

$$\frac{L^2}{(k^2L^2)^\alpha}$$

$$m^2(\Box) \overset{?}{=} \frac{1}{L^2}\left(L^2\Box\right)^{\alpha} \qquad \alpha \leq 1$$

Q: lower bound? A: unitarity bound

$$\Delta(k^2) = \frac{1}{k^2+m^2(k^2)} = \int_0^\infty ds\, \frac{\rho(s) \geq 0}{k^2+s}$$

$$\Big\downarrow \; k^2 \to 0$$

$\alpha < 0$ $$\frac{L^2}{(k^2L^2)^{\alpha}}$$

$$m^2(\Box) \overset{IR}{=} \frac{1}{L^2}(L^2\Box)^\alpha \qquad \alpha \le 1$$

Q: lower bound? A: unitarity bound

$$\Delta(k^2) = \frac{1}{k^2+m^2(k^2)} = \int_0^\infty ds \frac{\rho(s) \geq 0}{k^2+s}$$

$$\downarrow k^2\to 0$$

$$\alpha<0 \qquad \frac{L^2}{(k^2L^2)^\alpha} \xrightarrow{\alpha<0} L^2(k^2L^2)^{|\alpha|}$$

$$m^2(\Box) \overset{IR}{=} \frac{1}{L^2}\left(L^2\Box\right)^{\alpha} \qquad \alpha \leq 1$$

Q: lower bound? A: unitarity bound

$$\Delta(k^2) = \frac{1}{k^2+m^2(k^2)} = \int_0^\infty ds \frac{\rho(s)}{k^2+s}, \quad \rho(s) \geq 0$$

$$\downarrow k^2\to 0$$

$$\alpha<0 \qquad \frac{L^2}{(k^2L^2)^{\alpha}} \xrightarrow{\alpha<0} L^2\left(k^2L^2\right)^{|\alpha|} = 0$$

$$m^2(\Box) \overset{IR}{=} \frac{1}{L^2}\left(L^2\Box\right)^{\alpha} \qquad \alpha \le 1$$

Q: lower bound? A: unitarity bound

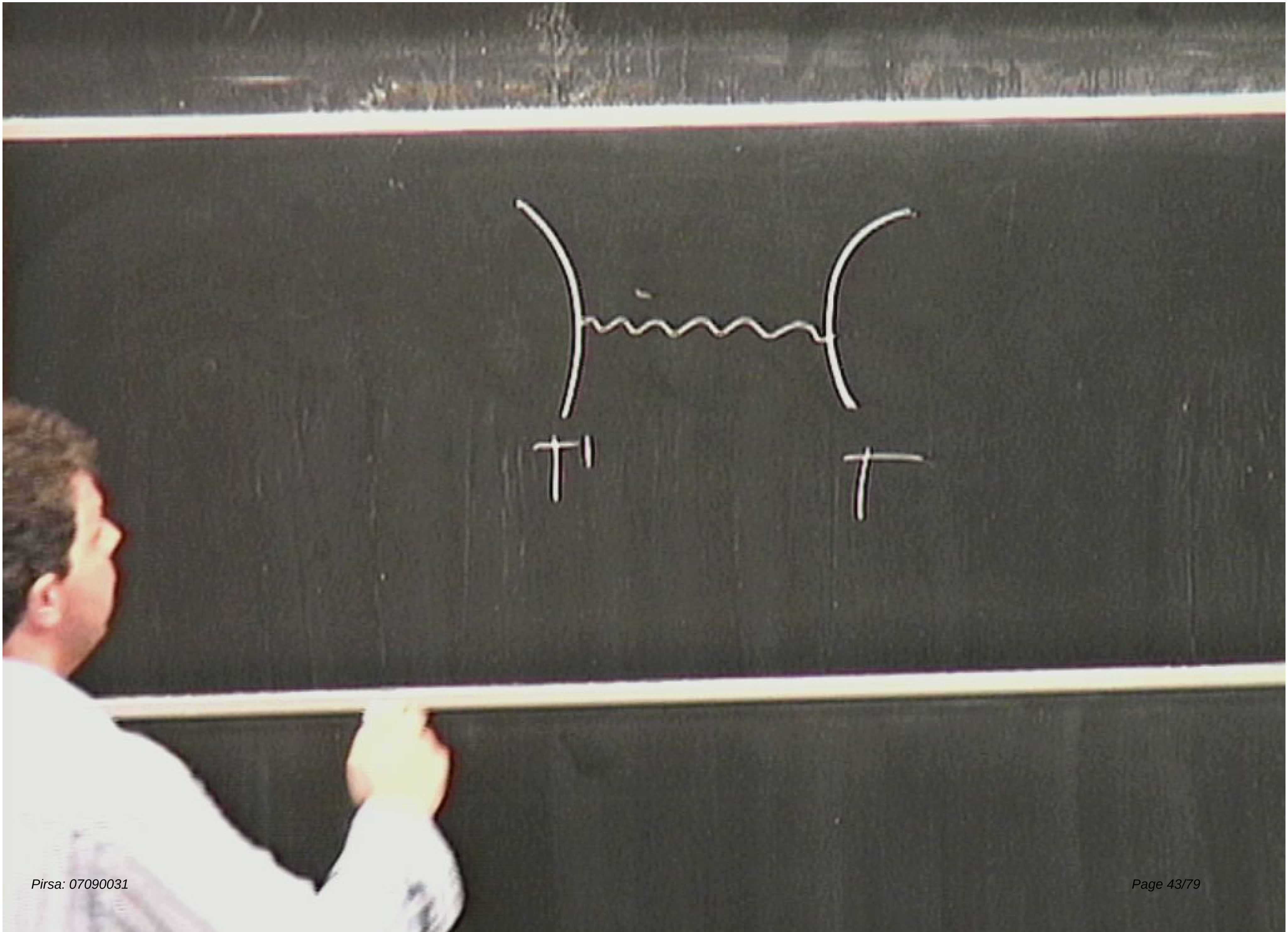
$$\Delta(k^2) = \frac{1}{k^2+m^2(k)} = \int_0^\infty ds\, \frac{\rho(s) \ge 0}{k^2+s}$$

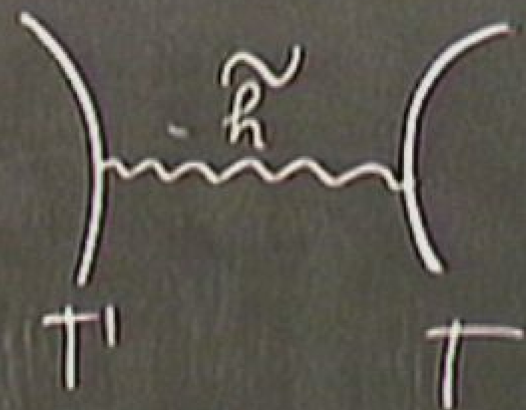
$$\Big\downarrow \; k^2 \to 0$$

$$\alpha < 0 \qquad \frac{L^2}{(k^2L^2)^{\alpha}} \xrightarrow{\alpha<0} L^2\left(k^2L^2\right)^{|\alpha|} = 0$$

$$\rho(s) \ge 0, \quad \rho(s) \not\equiv 0$$

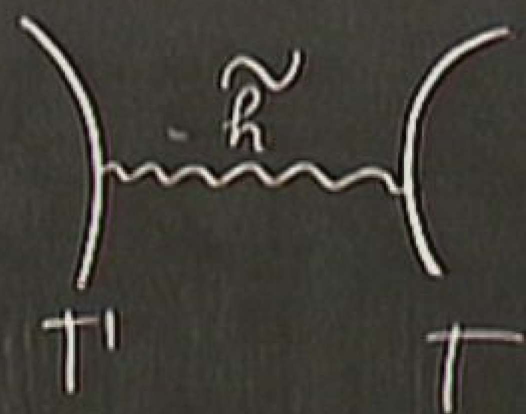
$$\rightsquigarrow \qquad 0 \le \alpha \le 1$$


T'
T



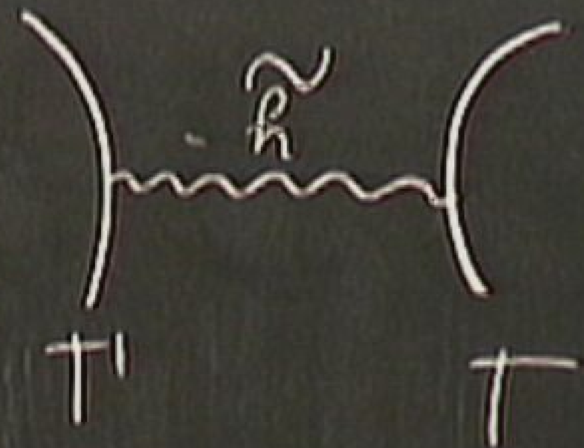
$\sim$

$$\sim \quad T'^{\lambda\beta} \quad \frac{1}{2}\eta_{\lambda\mu}\eta_{\nu\beta} - \qquad T^{\mu\nu}$$



$\sim$

$$\sim \; T'^{\alpha\beta} \; \frac{\frac{1}{2}\eta_{\alpha\mu}\eta_{\nu\beta} - \frac{1}{2}\eta_{\mu\nu}\eta_{\alpha\beta}}{\Box - m^2(\Box)} \; T^{\mu\nu}$$



$$\sim$$

$$\sim \; T'^{\lambda\beta} \; \frac{\frac{1}{2}\eta_{\lambda\mu}\eta_{\nu\beta} - \frac{1}{3}\eta_{\mu\nu}\eta_{\lambda\beta}}{\Box - m^2(\Box)} \; T^{\mu\nu}$$

$\xrightarrow{m \to 0}$ Einstein

unique general ghost-free linearized theory massive gravity (incl. all polarizations)

unique general ghost-free linearized theory massive gravity (incl. all polarizations)

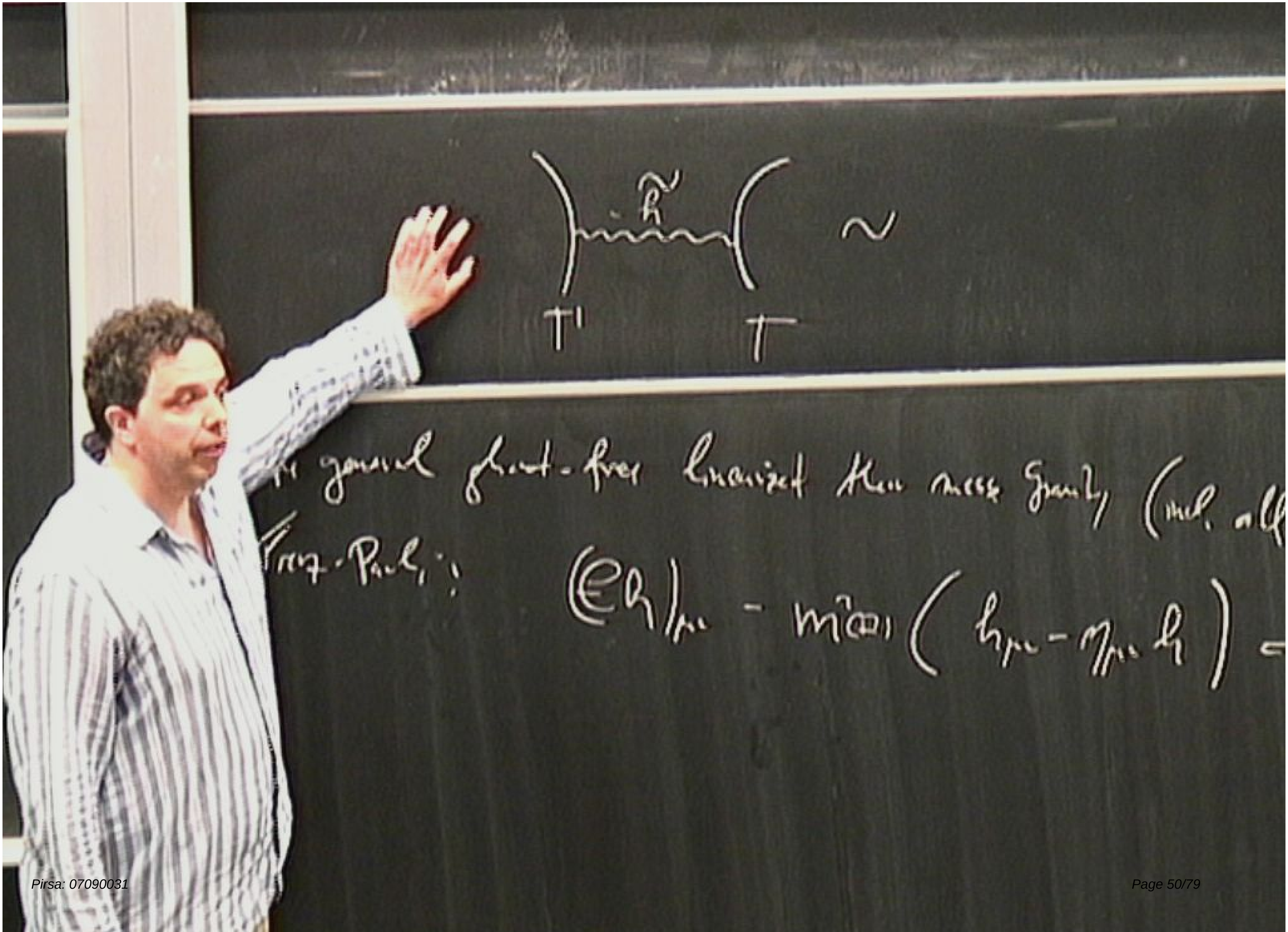
Fierz-Pauli:

$$(\mathcal{E}h)_{\mu\nu} - m^2 \left(h_{\mu\nu} - \eta_{\mu\nu} h \right) = -T_{\mu\nu}$$

unique general ghost-free linearized theory massive gravity (incl. all polarizations)

Fierz-Pauli:

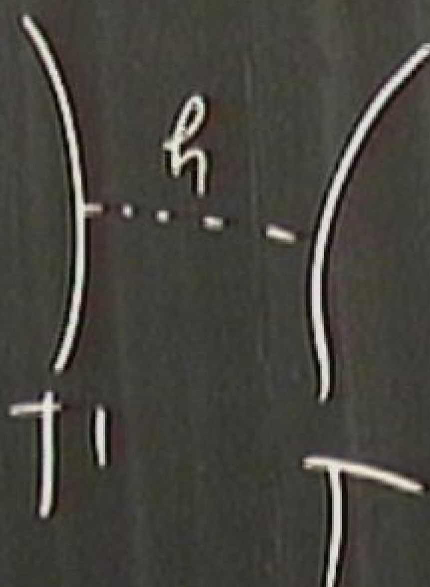
$$(\mathcal{E}h)_{\mu\nu} - m^2(\Box)\left(h_{\mu\nu} - \eta_{\mu\nu} h\right) = -T_{\mu\nu}$$


T'
T

unique general ghost-free linearized then mass

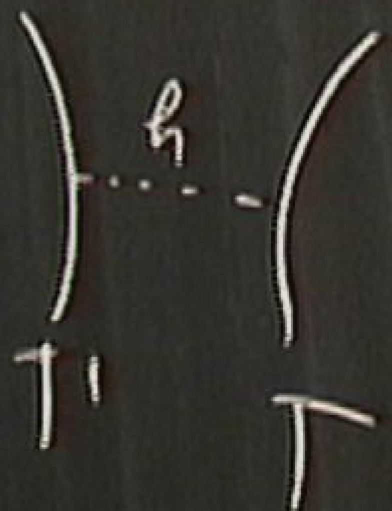
Fierz-Pauli:

$$(\mathcal{E}h)_{\mu\nu} - m^2(x)\,(h$$



Fierz-Pauli:

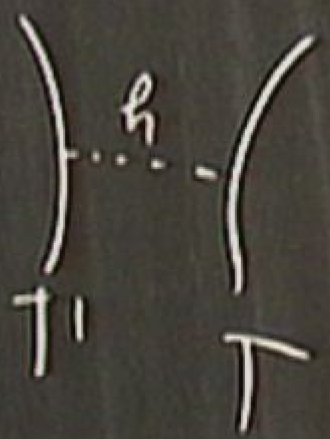
$$(\mathcal{E}h)_{\mu\nu} - m^2(\Box)\left(h_{\mu\nu} - \eta_{\mu\nu} h\right) = \ldots$$



$$\sim T'^{\alpha\beta}\,\frac{\frac{1}{2}\eta_{\alpha\mu}\eta_{\beta\nu} - \frac{1}{3}\eta_{\alpha\beta}\eta_{\mu\nu}}{\Box - m^2(\Box)}\,T^{\mu\nu}$$

... massive gravity (incl. all polarizations)

Fierz-Pauli:
$$(\mathcal{E}h)_{\mu\nu} - m^2(\alpha)\left(h_{\mu\nu} - \eta_{\mu\nu} h \right) = - T_{\mu\nu}$$



$$\sim T'^{\alpha\beta}\, \frac{\frac{1}{2}\eta_{\alpha\mu}\eta_{\beta\nu} - \frac{1}{3}\eta_{\alpha\beta}\eta_{\mu\nu}}{p^2 - m^2(\alpha)}\, T^{\mu\nu}$$

$\cancel{\xrightarrow{m\to 0}}$ Einstein ✓ vDVZ - disc.

$\alpha < 0 \qquad \frac{L^2}{(k^2L^2)^\alpha} \xrightarrow{\alpha<0} L^2 (k^2 L^2)^{|\alpha|} = 0 \qquad \Sigma(s) \neq 0$

massive general ghost-free linearized theory massive gravity (incl. all polarizations)

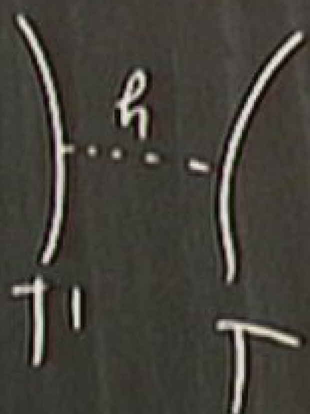
Fierz-Pauli:
$$(\mathcal{E}h)_{\mu\nu} - m^2(\Lambda)\left(h_{\mu\nu} - \eta_{\mu\nu} h\right) = -T_{\mu\nu}$$

$$T' \overset{h}{\cdots\cdots} T \sim T'^{\alpha\beta}\, \frac{\frac{1}{2}\eta_{\alpha\mu}\eta_{\beta\nu} - \frac{1}{3}\eta_{\alpha\beta}\eta_{\mu\nu}}{p^2 - m^2(\Lambda)}\, T^{\mu\nu}$$

$\xrightarrow{m\to 0}\!\!\!\!\!\!/\;\;$ Einstein $\quad$ ✓ vDVZ-disc.

more general ghost-free linearized theories massive gravity (incl. all polarizations)

Fierz-Pauli: $$(\mathcal{E}h)_{\mu\nu} - m^2(\Delta)\left(h^{(0,1,1,2)}_{\mu\nu} - \eta_{\mu\nu} h \right) = -T_{\mu\nu}$$



$$\sim \; T'^{\alpha\beta} \; \frac{\frac{1}{2}\eta_{\alpha\mu}\eta_{\beta\nu} - \frac{1}{3}\eta_{\alpha\beta}\eta_{\mu\nu}}{\Box - m^2(\Delta)} \; T^{\mu\nu}$$

$\xrightarrow{m \to 0}$ ~~→~~ Einstein $\quad$ vDVZ-disc.

Stückelberg:

$$h_{\mu\nu} = \hat{h}^{(0,2)}_{\mu\nu} + \partial_{(\mu} A^{(0,1)}_{\nu)}$$

Stückelberg:

$$h_{\mu\nu} = \hat{h}^{(0,1)}_{\mu\nu} + \partial_{(\mu} A^{(0,1)}_{\nu)}$$

gauge - slenny

Stückelberg:

$$h_{\mu\nu} = \hat{h}^{(0,1)}_{\mu\nu} + \partial_{(\mu} A^{(0,1)}_{\nu)}$$

gauge - slemy

$$(\mathcal{E}\hat{h})_{\mu\nu} - m^2 (\square) \left\{ \hat{h}_{\mu\nu} - \eta_{\mu\nu} \hat{h} + \partial_{(\mu} A_{\nu)} - \eta_{\mu\nu} 2 \partial \cdot A \right\} = -T_{\mu\nu}$$

$$\hat{h}_{\mu\nu} \longrightarrow \hat{h}_{\mu\nu} + \partial_{(\mu} \xi_{\nu)}$$

Stückelberg:

$$h_{\mu\nu} = \hat{h}^{(0,1)}_{\mu\nu} + \partial_{(\mu} A^{(0,1)}_{\nu)}$$

gauge - slemy

$$(\mathcal{E}\hat{h})_{\mu\nu} - m^2(\square)\left\{\hat{h}_{\mu\nu} - \eta_{\mu\nu}\hat{h} + \partial_{(\mu} A_{\nu)} - \eta_{\mu\nu} 2\partial\cdot A\right\} = -T_{\mu\nu}$$

$$\hat{h}_{\mu\nu} \to \hat{h}_{\mu\nu} + \partial_{(\mu}\xi_{\nu)}$$

$$A_\mu \to A_\mu - \xi_\mu$$

High-freq field $h_{\mu\nu}$ is gauge inv $\Rightarrow$ $h_{\mu\nu}$ is an obs (in principle)

$\Rightarrow$ $h_{\mu\nu}$ must be bounded from above

$h_{\mu\nu}$ is gauge inv $\Rightarrow$ $h_{\mu\nu}$ is an obs (in principle)

$\Rightarrow$ "$h_{\mu\nu}$" must be "dangled" by a gauge

$\Rightarrow$ Itself D with

$h_{\mu\nu} = D\, h\, h$

gauge - sleepy

$$h_{\mu\nu} = \hat{h}^{(0,1)}_{\mu\nu} + \partial_{(\mu} A^{(0,1)}_{\nu)}$$

$$(\mathcal{E}\hat{h})_{\mu\nu} - m^2(\Box)\left\{ \hat{h}_{\mu\nu} - \eta_{\mu\nu}\hat{h} + \partial_{(\mu}A_{\nu)} - \eta_{\mu\nu}\, 2\,\partial\cdot A \right\} = -T_{\mu\nu}$$

$$\hat{h}_{\mu\nu} \longrightarrow \hat{h}_{\mu\nu} + \partial_{(\mu}\xi_{\nu)}$$

$$A_\mu \longrightarrow A_\mu - \xi_\mu$$

$$\partial^\mu F_{\mu\nu} = -J_\nu \,, \quad J_\nu = \partial^\mu \left(\hat{h}_{\mu\nu} - \eta_{\mu\nu} \hat{h}^\rho_\rho \right)$$

$$\partial^\mu F_{\mu\nu} = - J_\nu \, , \quad J_\nu = \partial^\mu \left(\hat{h}_{\mu\nu} - \eta_{\mu\nu} \hat{h} \right)$$

$$A_\mu = - \frac{\partial^\nu}{\Box} \left\{ \hat{h}_{\nu\mu} - \eta_{\nu\mu} \hat{h} \right\}$$

gauge - story

$$h_{\mu\nu} = \hat{h}^{(0,1)}_{\mu\nu} + \partial_{(\mu} A^{(0,1)}_{\nu)}$$

$$(\mathcal{E}\hat{h})_{\mu\nu} - m^2(\square) \left\{ \hat{h}_{\mu\nu} - \eta_{\mu\nu} \hat{h} + \partial_{(\mu} A_{\nu)} - \eta_{\mu\nu} 2 \partial \cdot A \right\} = -T_{\mu\nu}$$

$$\hat{h}_{\mu\nu} \longrightarrow \hat{h}_{\mu\nu} + \partial_{(\mu} \xi_{\nu)}$$

$$A_\mu \longrightarrow A_\mu - \xi_\mu$$

$$\partial^\mu F_{\mu\nu} = - J_\nu \, , \quad J_\nu = \partial^\mu \left(\hat{h}_{\mu\nu} - \eta_{\mu\nu} \hat{h} \right)$$

$$A_\mu = - \frac{\partial^\nu}{\Box} \left\{ \hat{h}_{\nu\mu} - \eta_{\nu\mu} \hat{h} \right\} + \partial_\mu \Theta$$

$$\partial^\mu F_{\mu\nu} = -\mathcal{J}_\nu \, , \quad \mathcal{J}_\nu = \partial^\mu \left(\hat{h}_{\mu\nu} - \eta_{\mu\nu} \hat{h} \right)$$

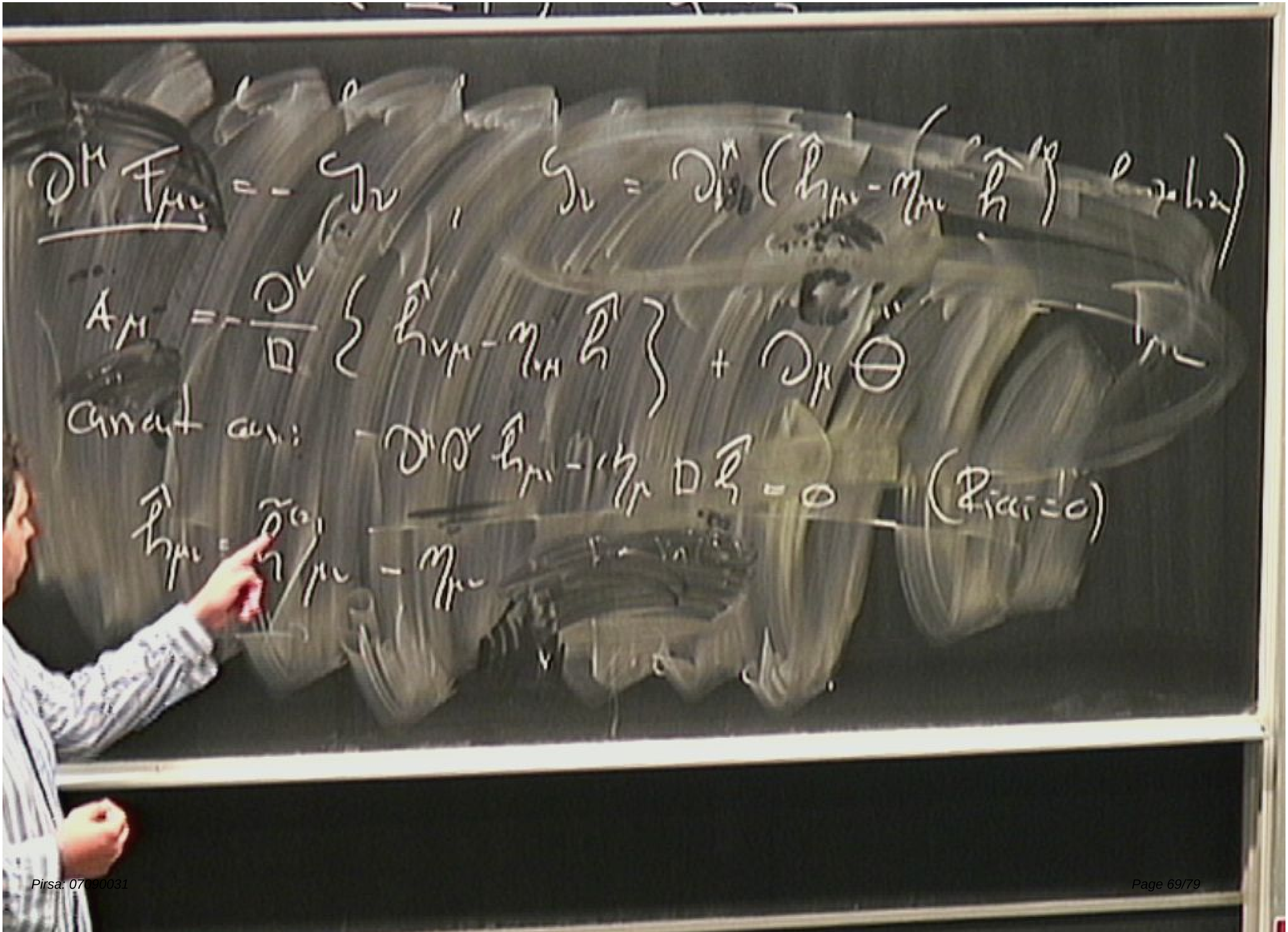
$$A_\mu = -\frac{\partial^\nu}{\Box} \left\{ \hat{h}_{\nu\mu} - \eta_{\nu\mu} \hat{h} \right\} + \partial_\mu \Theta$$

current cons: $-\partial^\mu \partial^\nu \hat{h}_{\mu\nu} - \eta_{\mu\nu} \Box \hat{h} = 0$

$$\partial^\mu F_{\mu\nu} = -J_\nu \,, \quad J_\nu = \partial^\mu \left(\hat{h}_{\mu\nu} - \eta_{\mu\nu} \hat{h}^\rho{}_\rho \ldots \right)$$

$$A_\mu = -\frac{\partial^\nu}{\Box} \left\{ \hat{h}_{\nu\mu} - \eta_{\nu\mu} \hat{h} \right\} + \partial_\mu \Theta$$

current cons: $-\partial^\mu \partial^\nu \hat{h}_{\mu\nu} + \eta_{\mu\nu} \Box \hat{h} = 0 \quad (\text{Ricci}=0)$



∂^μ F_μν = - J_ν , J_ν = ∂^μ (ĥ_μν - η_μν ĥ)
A_μ = - ∂^ν/□ { ĥ_νμ - η_νμ ĥ } + ∂_μ Θ
constraint eqn: - ∂^μ ∂^ν ĥ_μν - η □ ĥ = 0 (Ricci = 0)

$$\partial^\mu F_{\mu\nu} = -J_\nu \, , \quad J_\nu = \partial^\mu \left(\hat{h}_{\mu\nu} - \eta_{\mu\nu} \hat{h} \right)$$

$$A_\mu = -\frac{\partial^\nu}{\Box} \left\{ \hat{h}_{\nu\mu} - \eta_{\nu\mu} \hat{h} \right\} + \partial_\mu \Theta$$

Einstein eqn: $-\partial^\mu \partial^\nu \hat{h}_{\mu\nu} - \eta_{\mu\nu} \Box \hat{h} = 0$ (Ricci = 0)

$$\hat{h}_{\mu\nu} = \tilde{h}^{(i)}_{\mu\nu} - \eta_{\mu\nu} \frac{1}{3} P^{\alpha\beta} \tilde{h}_{\alpha\beta}$$

gauge - slemy

$$h_{\mu\nu} = \hat{h}^{(0,1)}_{\mu\nu} + \partial_{(\mu} A^{(0,1)}_{\nu)}$$

$$(\mathcal{E}\hat{h})_{\mu\nu} - m^2(\square)\left\{ \hat{h}_{\mu\nu} - \eta_{\mu\nu}\hat{h} + \partial_{(\mu}A_{\nu)} - \eta_{\mu\nu} 2\partial\cdot A \right\} = -T_{\mu\nu}$$

$$\hat{h}_{\mu\nu} \to \hat{h}_{\mu\nu} + \partial_{(\mu}\xi_{\nu)}$$

$$A_\mu \to A_\mu - \xi_\mu$$

$$\boxed{\left\{1 - \frac{m^2(\square)}{\square}\right\}(\mathcal{E}\hat{h})}$$

gauge - sleeny

$$h_{\mu\nu} = \hat{h}^{(0,1)}_{\mu\nu} + \partial_{(\mu} A^{(0,1)}_{\nu)}$$

$$\mathcal{E}\hat{h})_{\mu\nu} - m^2(\Box)\left\{ \hat{h}_{\mu\nu} - \eta_{\mu\nu}\hat{h} + \partial_{(\mu}A_{\nu)} - \eta_{\mu\nu} 2\partial\cdot A \right\} = T_{\mu\nu}$$

$$\hat{h}_{\mu\nu} \to h_{\mu\nu} + \partial_{(\mu} \xi_{\nu)}$$

$$A_\mu \to A_\mu - \xi_\mu$$

$$\left\{1 - \frac{m^2(\Box)}{\Box}\right\}(\mathcal{E}\hat{h})_{\mu\nu} + \mathcal{F}(\hat{h}, A,$$

$$-\eta_\mu \hat{h} + \partial_{(\mu} A_{\nu)} - \eta_{\mu\nu} 2\partial\cdot A \Big\} = -T_{\mu\nu}$$

$$\partial_{(\mu} \overset{\downarrow}{\xi}_{\nu)}$$

$$\boxed{\Big\{1 - \frac{m^2 \omega}{\Box}\Big\}\big(\mathcal{E}\tilde{h}\big)_{\mu\nu} + \mathcal{F}(\hat{h}, A, \sigma) = -T_{\mu\nu}}$$

$$\ldots - \eta_\mu h + \partial_{(\mu} A_{\nu)} - \eta_{\mu\nu}\, \partial \cdot A \} \ldots$$

$$\ldots \partial_{(\mu} \overset{\downarrow}{\xi}_{\nu)}$$

$$\boxed{\begin{aligned} &\{ - \frac{m^2(\sigma)}{\Box} \} (\epsilon \tilde{h})_{\mu\nu} + \mathcal{F}(\tilde{h}, A, \sigma) \\ &= -T_{\mu\nu}. \quad \exists \sigma^* \; \mathcal{F}(\sigma^*) = 0 \end{aligned}}$$

$0 \leq \alpha \leq 1, \quad \alpha < \frac{1}{3}$

$\partial^\mu F_{\mu\nu} = -J_\nu, \quad J_\nu = \partial^\mu(\hat{h}_{\mu\nu} - \eta_{\mu\nu}\hat{h})$

$A_\mu = -\frac{\partial^\nu}{\Box}\{\hat{h}_{\nu\mu} - \eta_{\nu\mu}\hat{h}\} + \partial_\mu \Theta$

Current cons: $\partial^\mu\partial^\nu \hat{h}_{\mu\nu} - \eta_{\mu\nu}\Box\hat{h} = 0 \quad (R_{icci} = 0)$ $\quad \Box P^{\mu}{}_{\alpha\rho} h^{\alpha\rho} = 0$

$\hat{h}_{\mu\nu} = h^{(1)}_{\mu\nu} - \eta_{\mu\nu}\frac{1}{3} P^{\mu}{}_{\alpha\rho} h^{\alpha\rho} K^{(1)}$

$$A_\mu = -\frac{\partial^\nu}{\Box}\left\{\hat{h}_{\nu\mu} - \eta_{\nu\mu}\hat{h}\right\} + \partial_\mu \Theta \qquad \Box P^{\mu}$$

covariant cov.: $-\partial^\mu\partial^\nu \hat{h}_{\mu\nu} - \eta_{\mu\nu}\Box \hat{h} = 0 \qquad (R_{\mu\nu}=0)$

$$\hat{h}_{\mu\nu} = \tilde{h}^{(1)}_{\mu\nu} - \eta_{\mu\nu}\frac{1}{3}\left(P^{\alpha}{}_{\sigma\rho}\, h^{\sigma\rho}\right) \sim \chi^{(1)}$$

$$g_{\mu\nu} = \eta_{\mu\nu} + h^{(1)}_{\mu\nu} + \frac{1}{3}\eta_{\mu\nu}\chi^{(1)} + \frac{1}{3}\frac{\partial_\mu\partial_\nu}{\Box}\chi + \dots$$

$$\mathcal{E} h_{\mu\nu} = \Lambda \eta_{\mu\nu}$$

$$\mathcal{E} h|_{\mu\nu} = \Lambda \eta_{\mu\nu} \quad (\Lambda \neq 0)$$

$$\mathcal{E} h|_{\mu\nu} - m^2(\Box)\{h_{\mu\nu} - \eta_{\mu\nu} h\} = \Lambda \eta_{\mu\nu}$$

$$\mathcal{E}h|_{\mu\nu} = \Lambda \eta_{\mu\nu} \qquad (\Lambda \neq 0)$$

$$\mathcal{E}h|_{\mu\nu} - m^2(\Box)\{h_{\mu\nu} - \eta_{\mu\nu} h\} = \Lambda \eta_{\mu\nu}$$

$$g_{\mu\nu} = \left(1 + \frac{\Lambda}{3m^2}\right)\eta_{\mu\nu}$$