Title: TBA - Jan. 19/2005

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URL: http://pirsa.org/05010008

Abstract:

C. Eling

B. Foster

D. Mattingly

$(+---)$

$$S = -\frac{1}{16\pi G}\int d^4x \sqrt{g}\,\left(R + L_u + \lambda(u_a u^a - 1)\right)$$

$g_{ab},\ u^a$

unit timelike vector field

$$L_u = K^{ab}{}_{mn} \nabla_a u^m \nabla_b u^n$$

$$K^{ab}{}_{mn} = c_1 g^{ab} g_{mn} + c_2 \delta^a_m \delta^b_n + c_3 \delta^b_m \delta^a_n$$

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g_{ab}, u^a — timelike vector field

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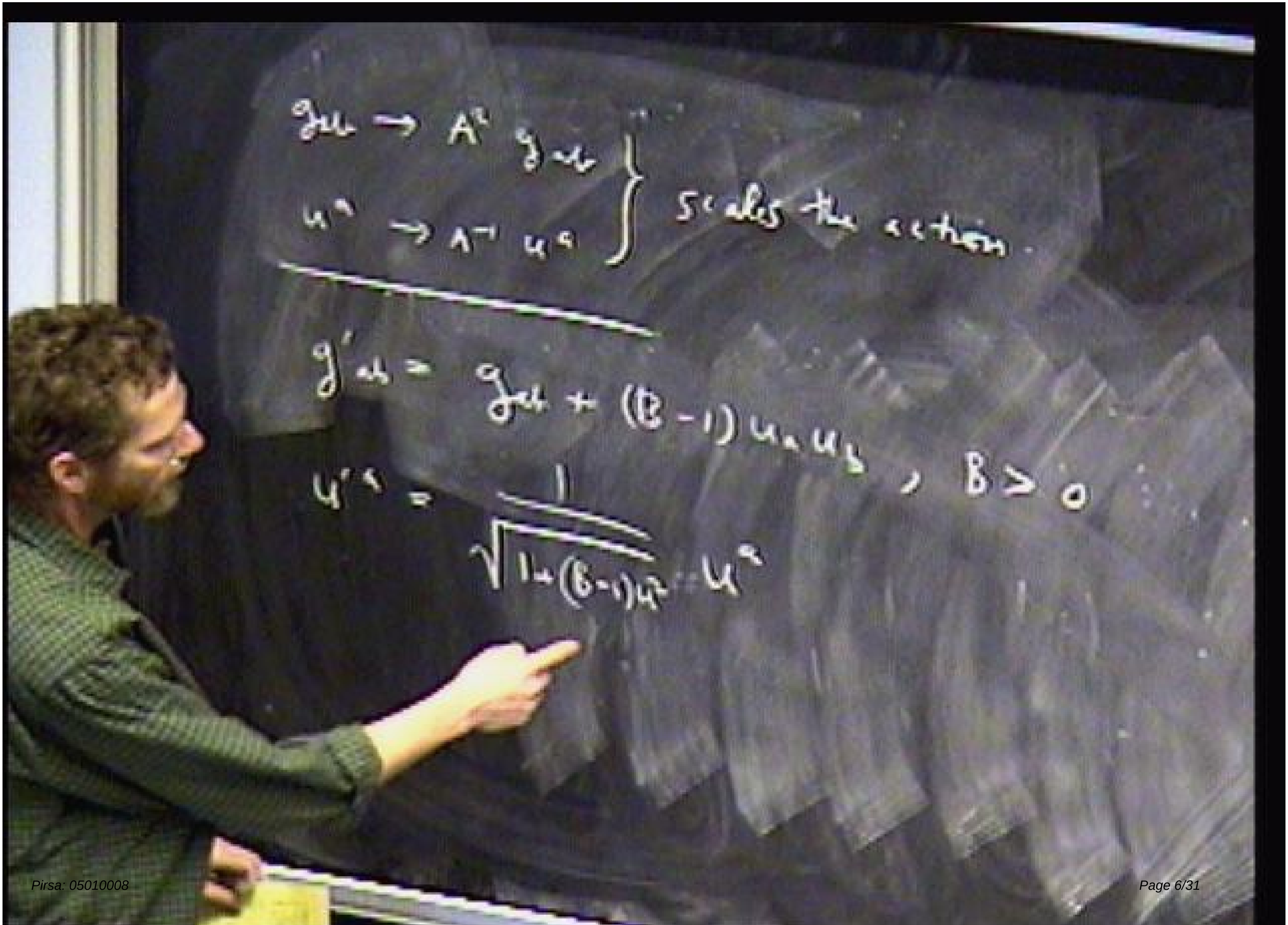
$R_{ab}u^a u^b$

$$\left.\begin{array}{l} g_{ab} \to A^2 g_{ab} \\ u^a \to A^{-1} u^a \end{array}\right\} \text{ scales the action.}$$


g_ab → A^2 g_ab
u^a → A^-1 u^a
scales the action
g'_ab = g_ab + (B - 1) u_a u_b , B > 0
u'^a = 1/√(1 + (B - 1)u^2) u^a

$K_{ab} u^a u^b \quad + \; c_4 u^a u^b g_{ab}$

g_{ab}

u^a } scales the action.

$c_i \, (c_i')$

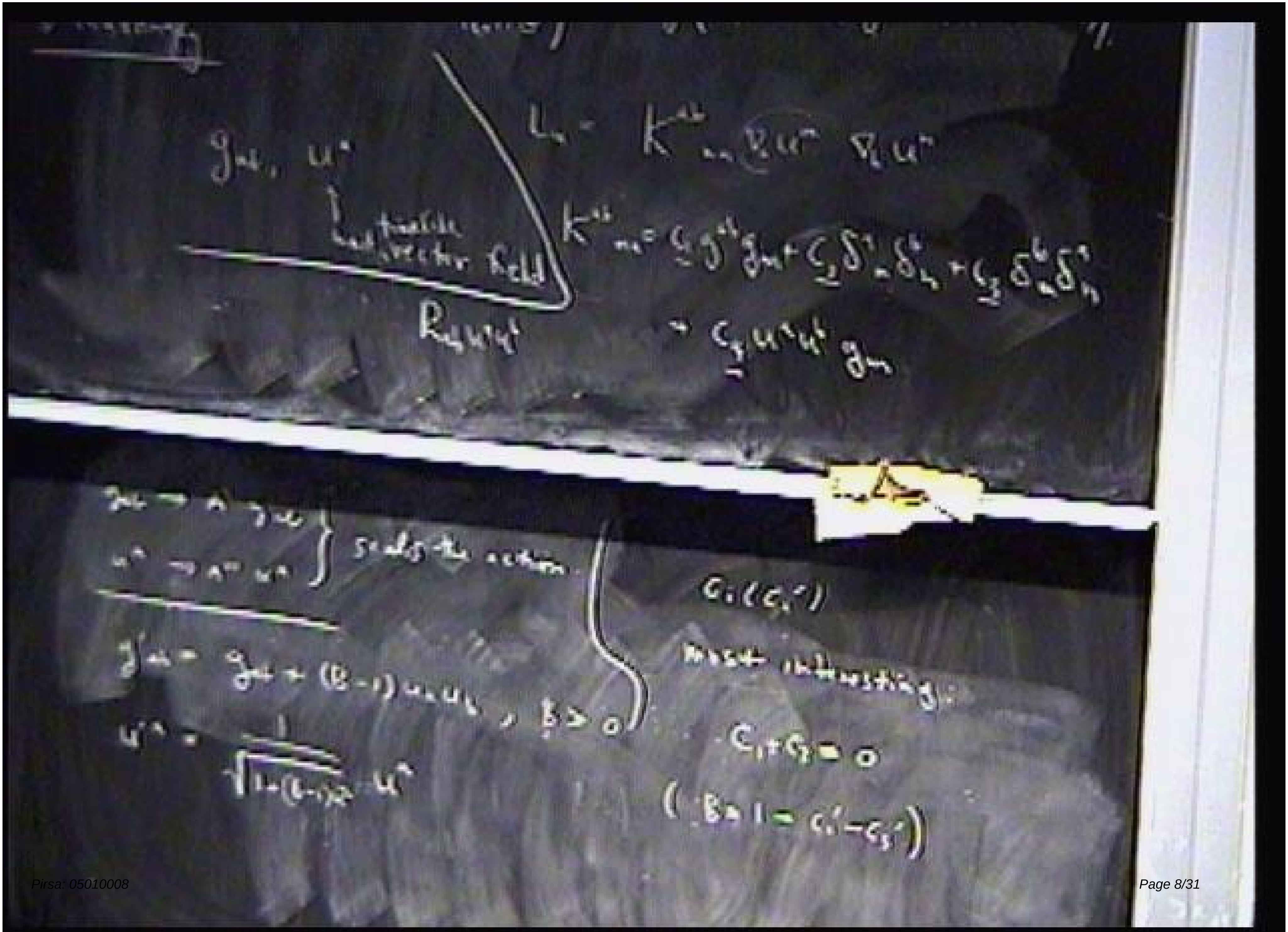
$g_{ab} + (B-1) u_a u_b \;, \quad B > 0$

most interesting:

$c_1 + c_3 = 0$

$(B = 1 - c_1' - c_3')$

$$\frac{1}{\sqrt{1+(B-1)u^2}} \, u^a$$


$g_{ab},\ u^a$
timelike unit vector field
$L_u = K^{ab}{}_{mn} \nabla_a u^m \nabla_b u^n$
$K^{ab}{}_{mn} = c_1 g^{ab} g_{mn} + c_2 \delta^a_m \delta^b_n + c_3 \delta^b_m \delta^a_n$
$+ c_4 u^a u^b g_{mn}$
$R_{ab}u^a u^b$
$g_{ab} \to A\, g_{ab}$
$u^a \to A^{-1/2} u^a$
scales the action.
$g'_{ab} = g_{ab} + (B-1) u_a u_b,\ B > 0$
$u'^a = \frac{1}{\sqrt{1+(B-1)u^2}} u^a$
$c_i\ (c_i')$
Most interesting:
$c_1 + c_3 = 0$
$(B = 1 - c_1' - c_3')$

the action

$c_i\,(c_i')$

most interesting:

$u_3\ ,\ B > 0$

$C_1 + C_3 = 0$

$(B = 1 - c_1' - c_3')$

$\rightarrow L_u = c_1 F_{ab} F^{ab} + \ldots c_2 (\nabla \cdot u)^2 + c_4 \dot{u}^2$

the action

$c_i(c_i')$

most interesting:

$\ldots u_b$, $\beta > 0$

$c_1 + c_3 = 0$

$(\beta = 1 - c_1' - c_3')$

$\rightarrow L_u = c_1 F_{ab} F^{ab} + c_2 (\nabla \cdot u)^2 + c_4 \dot{u}^2$

$g_{ab} \to A\, g_{ab}$

$u^a \to A^{-1} u^a$ } scales the action

$g'_{ab} = g_{ab} + (B-1)\, u_a u_b \,, \quad B > 0$

$u'^a = \frac{1}{\sqrt{1+(B-1)u^2}}\, u^a$

$u \wedge du = 0$ o.i.e. ph sym

$\to L_u = c_1 F_{ab} F^{ab} +$

$c_1, (c_1',$

most in

$c_1 + c_3$

$(B = 1 -$

scales the action

$c_i(\zeta_i^{-1})$

most interesting:

$$g_{ab} + (B-1)\,u_a u_b\ ,\quad B > 0$$

$$c_1 + c_3 = 0$$

$$\frac{1}{\sqrt{1+(B-1)\ldots}}\, u^a$$

$$\left(B = 1 - c_1' - c_3' \right)$$

$$\longrightarrow L_u = c_1 F_{ab}F^{ab} + c_2(\nabla \cdot u)^2 + c_4 \dot{u}^2$$

$u \wedge du = 0$ ... sym

can be eliminated in sph. symm.

<u>Special case:</u> $c_2 = c_4 = 0$, $c_{13} \neq 0$.

"Maxwell-like".

missing Gauss-law constraint.

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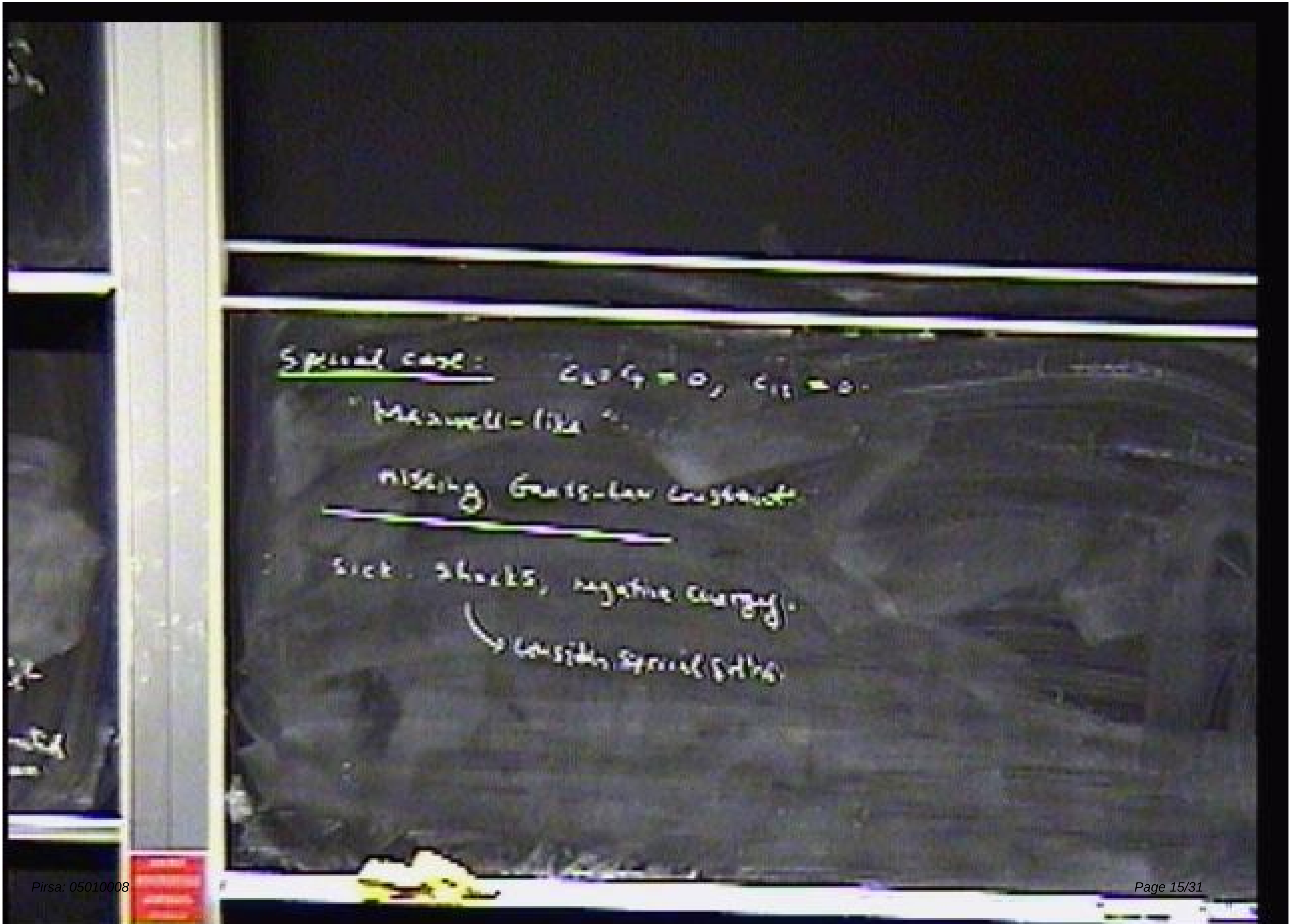
sick: shocks, negative energy.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Sick: shocks, negative energy.

consider special solns. $u_a = \partial_a \phi$

→ Consider special solns $u_a = \partial_a \phi$, $\lambda = 0$

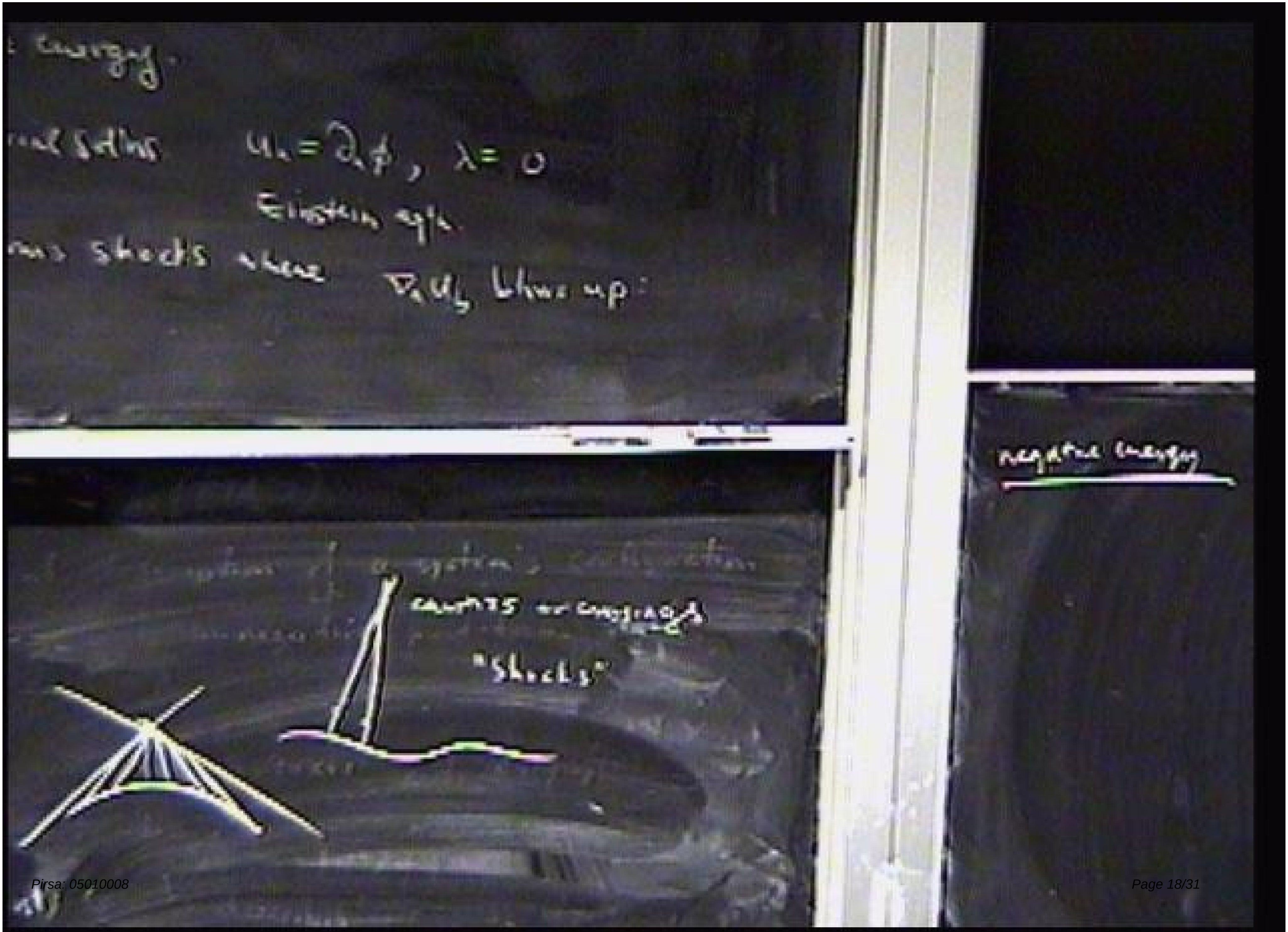
Einstein eq's

But rather forms shocks where $\nabla_a u_b$ blows up

$$0 = \nabla_a^b (u_b u^b)$$

$$= 2 u^b \nabla_a u_b$$

$$= 2 u^b \nabla_b u_a$$


energy.
$u_a = \partial_a \phi$, $\lambda = 0$
Einstein eqn.
shocks where $\nabla_a u_b$ blows up:
negative energy
caustics or crossings
"Shocks"

...ne energy ((Clayton)) → grav. decoupling limit

$$H = \int d^3x \quad \tfrac{1}{2}(p^i)^2 + p^i \partial_i u_0$$

energy ((Clayton)) → grav. decoupling limit

$$H = \int d^3x \left[\underbrace{\tfrac{1}{2}(p^i)^2 + p^i \partial_i u_0}_{\tfrac{1}{2}(p^i + \partial^i u_0)^2 - \tfrac{1}{2}(\partial^i u_0)^2} + \tfrac{1}{4}(F_{ij})^2 \right]$$

initial data

$$\begin{cases} u_i = \partial_i \phi \\ \partial_0 \phi = 0 \end{cases}$$

→ neg. energy

$$p^i = \partial_0 u^i - \partial^i u_0$$

linearized modes

$$g_{ab} = \eta_{ab} + h_{ab}$$

$$u^a = \underline{u}^a + v^a$$

$$\underline{u}^a = (1, 0, 0, 0)$$

gauge choice.
$$\begin{cases} h_{0i} = 0 \\ v^i{}_{,i} = 0 \end{cases}$$

Linearized modes (D. Mattingly).

$$g_{ab} = \eta_{ab} + h_{ab}$$

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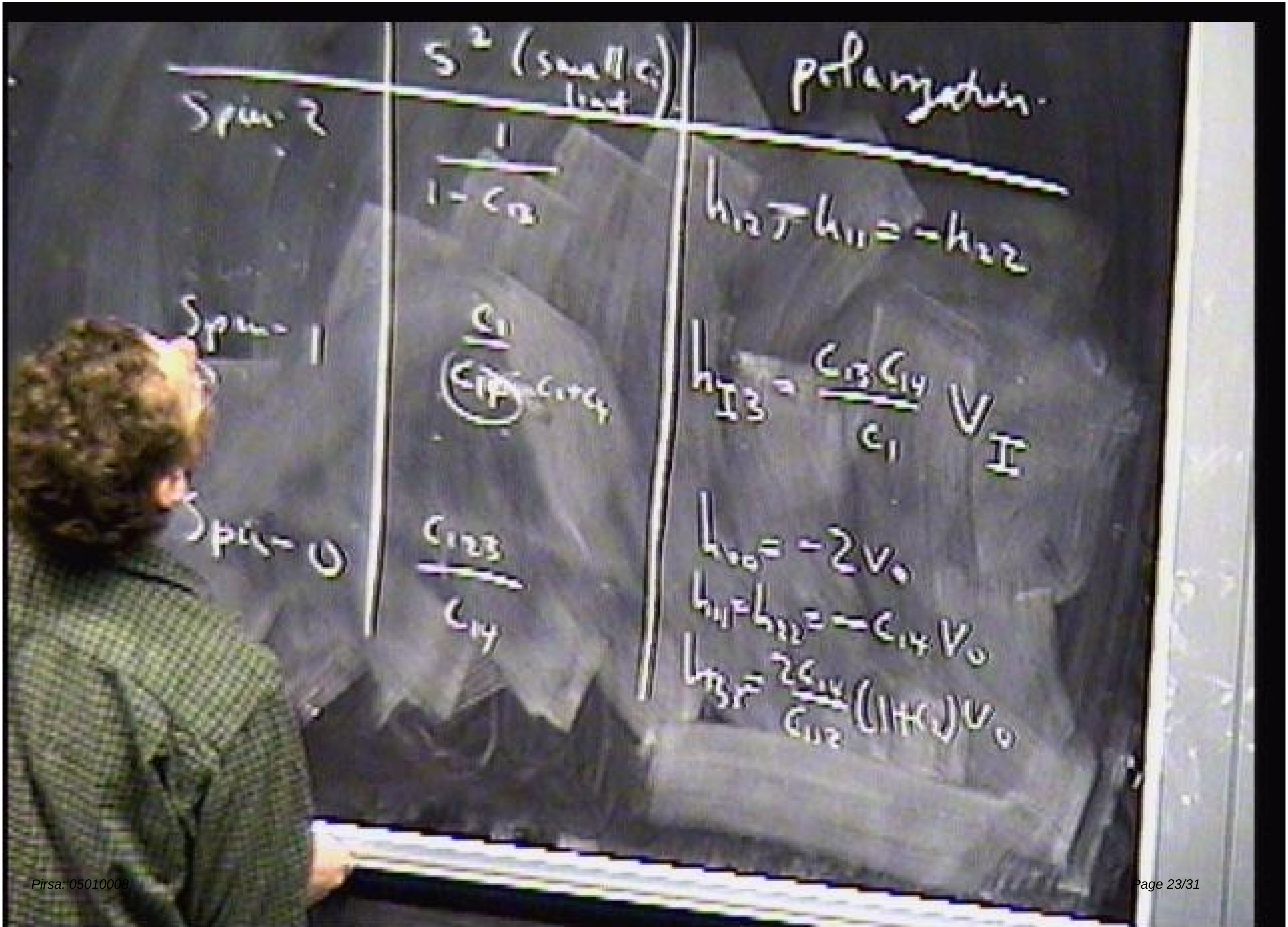

S^2 (small c_i limit)
polarization
Spin 2
1 / (1 - c_13)
h_12 ; h_11 = -h_22
Spin-1
c_1
h_I3 = (c_13 c_14 / c_1) V_I
Spin-0
c_123 / c_14
h_00 = -2V_0
h_11 = h_22 = -c_14 V_0
h_3I = (2c_14 / c_12)(1+c_2) V_0

	s^2 (small c_i limit)	polarization
Spin-2	$\frac{1}{1-c_{13}}$	h_{12}, $h_{11} = -h_{22}$
Spin-1	$\frac{c_1}{c_{14}-c_1+c_3}$	$h_{I3} = \frac{c_{13} c_{14}}{c_1} V_I$
Spin-0	$\frac{c_{123}}{c_{14}}$	$h_{00} = -2V_0$ $h_{11} = h_{22} = -c_{14} V_0$ $h_{33} = \frac{2c_{14}}{c_{123}}(1+c_2) V_0$

energy of linearized modes

positive $\Rightarrow$ $c_1 \geq 0$, $c_{14} \geq 0$

((Clayton)) → grav. decoupling limit

$$\left[\underbrace{\tfrac{1}{2}(p^i)^2 + p^i \partial_i u_0} + \tfrac{1}{4}(F_{ij})^2 \right]$$

$$u_0^2 - u_i^2 = 1$$

$$\tfrac{1}{2}\left(p^i + \partial^i u_0\right)^2 - \tfrac{1}{2}\left(\partial^i u_0\right)^2$$

$$p^i = \partial_0 u^i - \partial^i u_0$$

$$\begin{cases} u_i = \partial_i \phi \\ \partial_0 \phi = 0 \end{cases}$$

→ neg. entropy

≥ 0

PPN

$\beta, \gamma, \xi, \alpha_1, \alpha_2$

$= 1,$

same as GR

≥ 0

PPN

probably 0 (will)

$\beta, \gamma, \xi, \underbrace{\alpha_1, \alpha_2}$

$= 1$, same as GR

$\gamma \geqq 0$

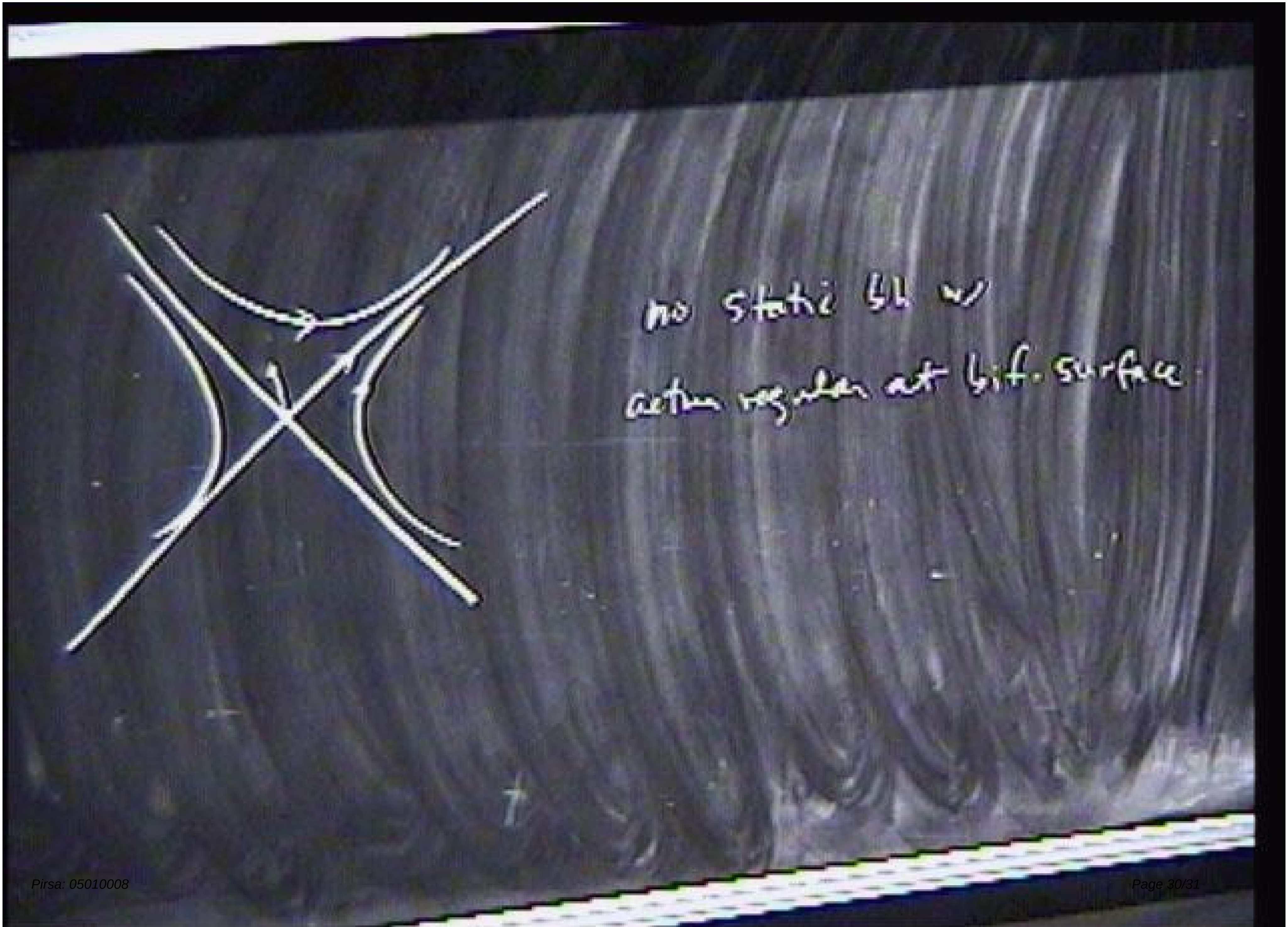
PPN

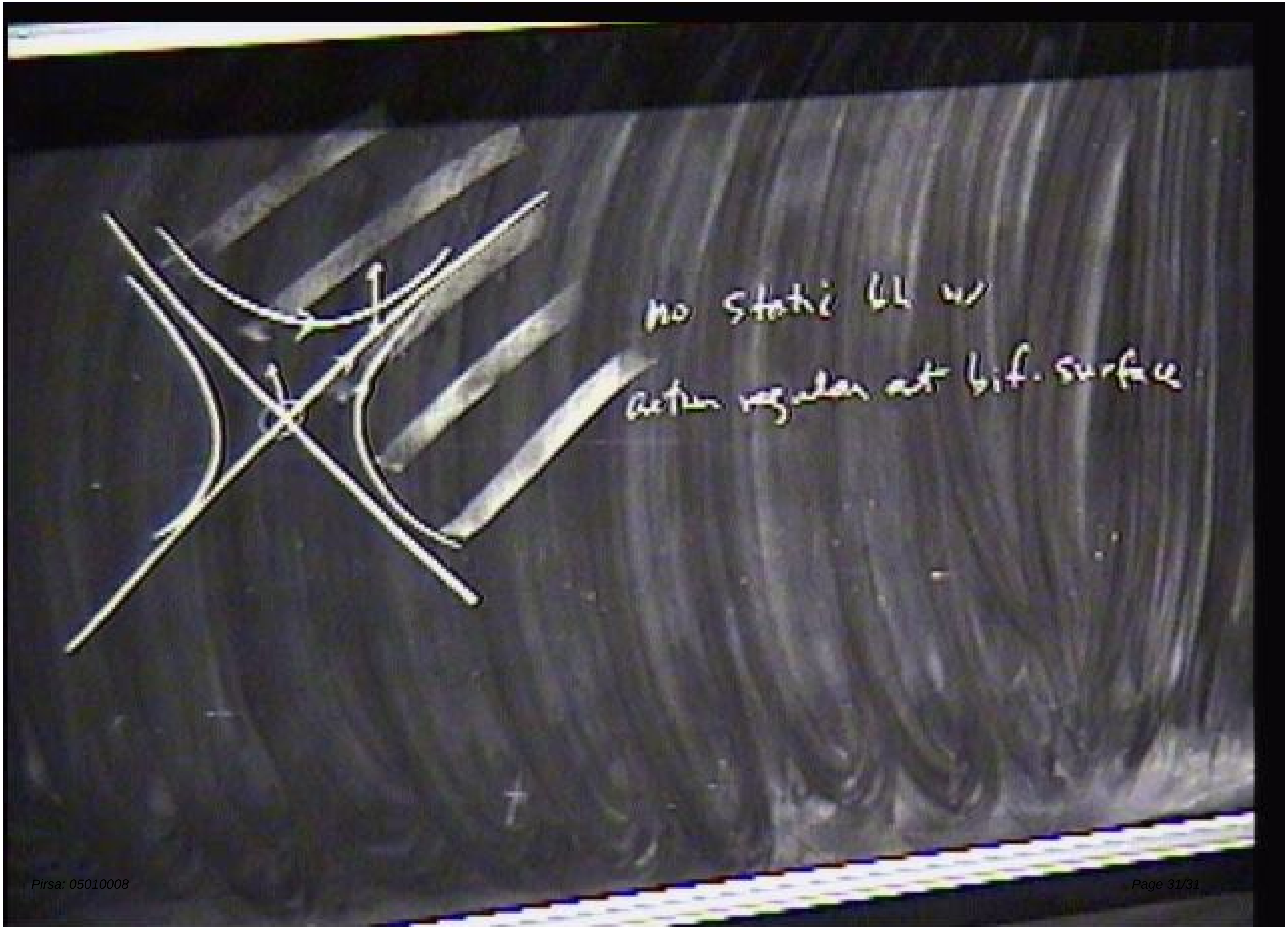
probably 0 (Will)

$\beta, \gamma, \xi, \alpha_1, \alpha_2$

$\beta, \gamma = 1$, same as GR

$\alpha_1 \leq 10^{-4}$, $\alpha_2 \leq 10^{-7}$


no static bh w/
action regular at bif. surface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