

Title: TBA - Jan. 19/2005

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Abstract:

C. Eling

B. Foster

D. Mathias

(+---)

$$S = -\frac{1}{16\pi G} \int d^4x \sqrt{g} (R + L_m + \lambda(\mu_0 u^2 - 1))$$

Int. u^2

$$L_m = \int d^3x$$

$\mu_0 \mathcal{L}_m$

has parallel vector field

$$\nabla_{\mu} u^{\mu} = 0$$

$$\int d^3x (C_1 \delta^1_1 + C_2 \delta^2_2 + C_3 \delta^3_3)$$

C. Eling

B. Fischer

D. Matting

(+---)

$$S = -\frac{1}{16\pi G} \int d^4x \sqrt{g} (R + L_U + \lambda(u_\mu u^\mu - 1))$$

Gen. u^μ

$$L_U = K_{\mu\nu} \nabla_\mu u^\nu$$

↑
timelike
unit vector field

$$K_{\mu\nu} = c_1 g_{\mu\nu} \nabla_\alpha u^\alpha + c_2 \nabla_\mu u^\nu + c_3 \nabla_\nu u^\mu + c_4 u^\mu u^\nu \nabla_\alpha u^\alpha$$

C. Ulling

B. Fuster

D. Mattingly

(+---)

$$S = -\frac{1}{16\pi G} \int d^4x \sqrt{g} (R + L_m + \lambda(u_\alpha u^\alpha - 1))$$

Gen. u^α

timelike
unit vector field

$R = u^\alpha u^\beta$

$$L_m = \int d^3x \sqrt{-g} T_{\alpha\beta} u^\alpha u^\beta$$

$$T_{\alpha\beta} = \rho g_{\alpha\beta} + c_1 \delta_{\alpha\beta}^{\gamma\delta} + c_2 \delta_{\alpha\beta}^{\gamma\delta} + c_3 \delta_{\alpha\beta}^{\gamma\delta} + c_4 u^\gamma u^\delta g_{\alpha\beta}$$

$$\begin{aligned} \partial_\mu \psi &\rightarrow A^\mu \partial_\mu \psi \\ u^A &\rightarrow A^\mu u^A \end{aligned} \left. \vphantom{\begin{aligned} \partial_\mu \psi &\rightarrow A^\mu \partial_\mu \psi \\ u^A &\rightarrow A^\mu u^A \end{aligned}} \right\} \text{scales the action.}$$

$$\left. \begin{aligned} g_{\mu\nu} &\rightarrow A^2 g_{\mu\nu} \\ u^a &\rightarrow A^{-1} u^a \end{aligned} \right\} \text{scales the action.}$$

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

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

Kalman

$$+ c_4 u^a u^b g_{ab}$$

g_{ab}
 u^a } scales the action.

$$G_i(c_i')$$

most interesting:

$$g_{ab} + (B-1)u^a u^b, \quad B > 0$$

$$c_1 + c_3 = 0$$

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

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

g_{ab}, u^a

parallel
and vector field

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

$$L_u = K^{ab} \nabla_a u^b \nabla_b u^a$$

$$K^{ab} = c_1 g^{ab} g_{ab} + c_2 \delta^a_1 \delta^b_1 + c_3 \delta^a_2 \delta^b_2 + c_4 u^a u^b g_{ab}$$

$g_{ab} \rightarrow A g_{ab}$
 $u^a \rightarrow A^a u^a$ } scales the action

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

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

$G_0(c_i')$

most interesting:

$$c_1 + c_3 = 0$$

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

the action

$$C_i(C_i')$$

most interesting:

$$C_1 + C_3 = 0$$

$$(B = 1 - C_1' - C_3')$$

$(u, v), B > 0$

$\rightarrow L_{eff}$

$$C_1 \int_{\mathcal{M}} F^2 + (\nabla \cdot \psi)^2 + C_4 \dot{\psi}^2$$

the action

$$C_i(C_i')$$

most interesting:

$$C_1 + C_3 = 0$$

$$(B = 1 - C_1' - C_3')$$

→

$L =$

$$C_1 \frac{1}{2} \dot{\varphi}^2$$

$$+ C_2 (\nabla \cdot \mathbf{u})^2 + C_4 \dot{u}^2$$

$$\left. \begin{aligned} g_{ab} &\rightarrow \lambda^2 g_{ab} \\ u^a &\rightarrow \lambda^{-1} u^a \end{aligned} \right\} \text{scales the action}$$

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

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

$u \wedge du = 0$ implies

$$L_{u^a} =$$

$$e_1 \frac{\partial}{\partial x^1} + \dots$$

$$e_i \ll e'_i$$

most in

$$e_1 + e_2$$

$$(B=1=)$$

$A \sim u^2$
 $A \sim u^2$ } scales the action.

$\gamma_{ij} + (B-1)u_i u_j, B > 0$

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

$\gamma_{ij} = \delta_{ij} \rightarrow L_{ij}$

$\gamma_{ij} = \delta_{ij} = \text{flat}$

$\mathcal{L}_i(\mathcal{L}_i')$

most interesting:

$\mathcal{L}_1 + \mathcal{L}_2 = 0$

$(B=1 = \mathcal{L}_1' = \mathcal{L}_2')$

$c_1 \frac{1}{\sqrt{1+u^2}} + c_2 (\partial u)^2 + c_3 u^2$

center of mass
 in gpl symm.

Special case:

$$C_{22} = C_{44} = 0, \quad C_{12} \neq 0.$$

"Maxwell-like"

missing Gauss-law constraint

Special case:

$$c_+ = c_- = 0, \quad c_{13} = 0.$$

"Maxwell-like"

Missing Gauss-Law constraint.

Sick: Shocks, Negative Energy.

Special case: $\epsilon_{12} = 0, \epsilon_{11} = 0.$

"Maxwell-like"

Rising Gauss-law constant

Sect. shocks, negative energy.

↳ consider special case

Special case:

$$c_2 = c_4 = 0, \quad c_{13} = 0.$$

"Maxwell-like"

Missing Gauss-Law constraint.

Side: Shocks, negative energy.

→ Consider special solns.

$$u_n = \partial_n \phi$$

Consider special relativity

$$u_a = \partial_a \phi, \quad \lambda = 0$$

Einstein eqs

But action from shocks alone

$$\nabla_a u_b \text{ blows up}$$

2) The action for a system of particles

$$0 = \nabla_a (u^a u^a)$$

$$= 2 u^a \nabla_a u_a$$

$$= 2 u^a \partial_a u_a$$

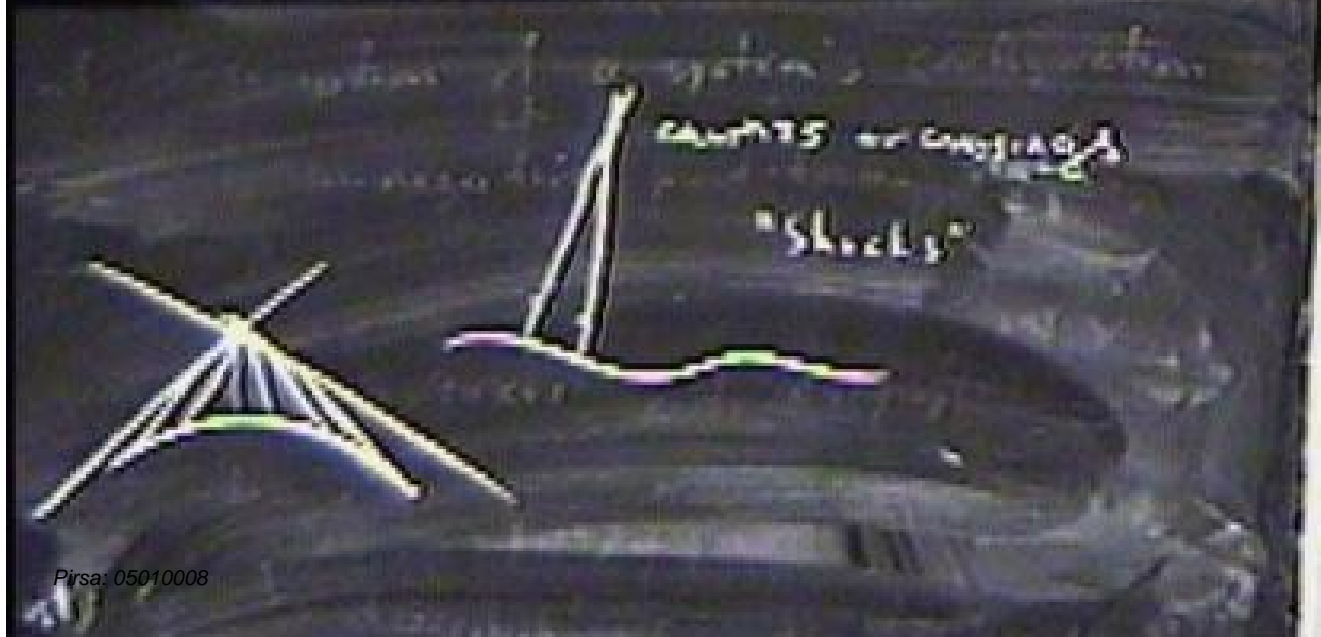
Energy

metric $u_\alpha = \partial_\alpha \phi, \lambda = 0$

Einstein eqs

no shocks where $\nabla_\alpha u_\beta$ blows up:

negative energy



the energy (C. Cuyton) \rightarrow grav. decoupling limit

$$H = \int d^3x \quad \frac{c}{2} (P^i)^2 + P^i \partial_i u_0$$

energy (Coulton) \rightarrow grav. decoupling limit

$$H = \int d^3x \left(\underbrace{\frac{1}{2} (p^i)^2 + p^i \partial_i u_0}_{\frac{1}{2} (p^i + \partial^i u_0)^2} + \frac{1}{2} (\dot{h}_{ij})^2 \right) - \frac{1}{2} (\partial^i u_0)^2$$

initial
data

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

\rightarrow reg.
entry

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

Linearized models

$$f_{y^i} = \eta_{y^i} + h_{y^i}$$

$$v^a = \underbrace{y^i}_{i} + v^a$$

gauge choice.

$$\left\{ \begin{array}{l} (1, 0, 0, 0) \\ h_{0i} = 0 \\ v_{ii} \neq 0 \end{array} \right.$$

Linearized modes (Dattagupta).

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

$$u^a = \frac{y^a}{1} + v^a$$

Gauge
choice.

$$\left\{ \begin{array}{l} (1, 0, 0, 0) \\ h_{0i} = 0 \\ v_{ii} = 0 \end{array} \right.$$

	S^2 (small ϵ_1) list	polarization
Spin = 2	$\frac{1}{1 - \epsilon_2}$	$h_{12} = h_{11} = -h_{22}$
Spin = 1	$\frac{\epsilon_1}{\epsilon_1 + \epsilon_2 + \epsilon_3}$	$h_{I3} = \frac{\epsilon_{13} \epsilon_{14}}{\epsilon_1} V_{II}$
Spin = 0	$\frac{\epsilon_{123}}{\epsilon_{14}}$	$h_{00} = -2V_0$ $h_{11} = h_{22} = -\epsilon_{14} V_0$ $h_{33} = \frac{2\epsilon_{14}}{\epsilon_{12}} (1 + \epsilon_{12}) V_0$

Spin = 2

S^2 (small ϵ_1)
list

polarization

Spin = 1

$$\frac{1}{1 - \epsilon_2}$$

$$h_{12} = h_{11} = -h_{22}$$

Spin = 0

$$\frac{\epsilon_1}{\epsilon_1 + \epsilon_2 + \epsilon_3}$$

$$h_{I3} = \frac{\epsilon_{13} \epsilon_{14}}{\epsilon_1} V_{II}$$

$$\frac{\epsilon_{123}}{\epsilon_{14}}$$

$$h_{00} = -2V_0$$

$$h_{11} = h_{22} = -\epsilon_{14} V_0$$

$$h_{33} = \frac{2\epsilon_{14}}{\epsilon_{12}} (1 + \epsilon_{12}) V_0$$

S^2 (small ϵ)
 list
 polarizability

Spin-2

$$\frac{1}{1 - \epsilon_{13}}$$

$$h_{12} = h_{11} = -h_{22}$$

Spin-1

$$\frac{\epsilon_1}{\epsilon_1 - \epsilon_{13} - \epsilon_{14}}$$

$$h_{13} = \frac{\epsilon_{13} \epsilon_{14}}{\epsilon_1} V_{II}$$

Spin-0

$$\frac{\epsilon_{123}}{\epsilon_{14}}$$

$$\begin{aligned}
 h_{10} &= -2V_0 \\
 h_{11} &= h_{12} = -\epsilon_{14} V_0 \\
 h_{23} &= \frac{2\epsilon_{14}}{\epsilon_{12}} (1 + \epsilon_{13}) V_0
 \end{aligned}$$

energy of linearized modes

positive $\Rightarrow c_1 \geq 0, c_2 \geq 0$

(Clayton) \rightarrow grav. decoupling limit

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

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

$$\frac{1}{2} (P^i + \partial^i u_0)^2 - \frac{1}{2} (\partial^i u_0)^2$$

$$\begin{cases} u_i = \partial_i \phi \\ \partial_0 \phi = 0 \end{cases} \rightarrow \text{no. entropy} \quad P^i = \partial_i u^i - \partial^i u_0$$

PPN



$= 1,$

same as

GR

PPN

yembel \emptyset
(wall)



d_1, d_2

$= 1,$

same as

GR

PPN

probability 0
(will)



α_1, α_2

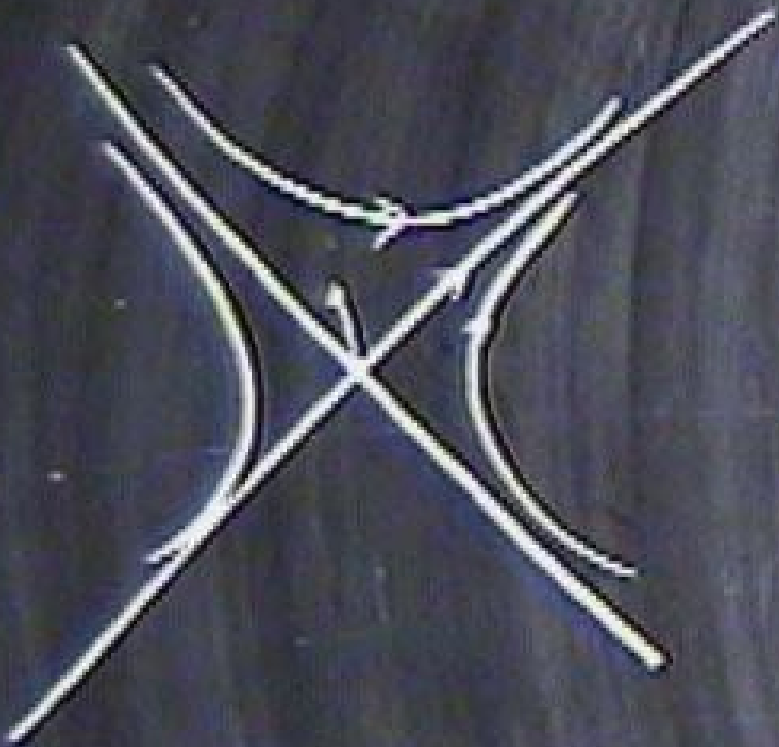
$\leq 10^{-7}$ $\leq 10^{-7}$

$y \geq 0$

$= 1$

same as

GP



no static BL \checkmark
action regular at bif. surface



no static LL w
action regular at bif. surface