

Title: What's Interesting These Days (With Gravity)?

Date: Jul 23, 2014 10:30 AM

URL: <http://pirsa.org/14070028>

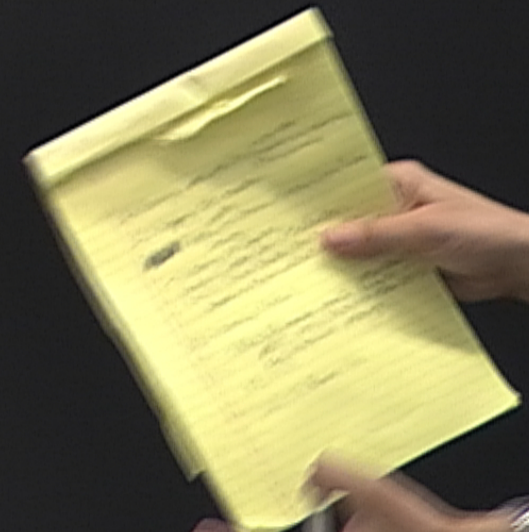
Abstract: Many of the most interesting open issues in physics today are related in one way or another to gravity. For the past 100 years, we have described spacetime and gravity via Einstein's theory of "General Relativity." But when we try to mesh General Relativity with the rest of physics, and use it to describe the cosmos, we encounter a range of puzzles. I'll describe some of these puzzles, and some routes to attacking them that look exciting to me.



M. Gardner: "Colossal B. of M."

Knuth

Conway $\rightarrow$ surreal



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→ surreal
←

Knuth → Surreal Numbers

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Knuth → "Surreal Numbers"

i) "Partially-massless grav."

ii) Connes' NCG, SM

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ii) Connes' NCG, $\mathcal{U}$ of

iii) 4D Penrose T

i) If GR is correct

→ 5% ←

→ 25% D.M.

→ 70% D.E.

} Gravitation

i) If GR is correct ←

→ 5% ←

graviton spin 2
 $m=0$

→ 25%

D.M.

→ 70%

D.E.

G

1 dRGT Theory 1 spin-2 $m \neq 0$

Fierz-Hellmann-Rosen

1 dRGT Theory 1 spin-2 $m \neq 0$

Hinterbichler - Rosen

dRGT Theory $\rightarrow$ 1 spin-2 $m \neq 0$

Hinterbichler-Rosen

- 2 polarizations, $S = \pm 2$ $\uparrow \hat{z}$
- 5 $\dots$ $S = \pm 2, \pm 1, 0$

dRGT Theory $\rightarrow$ 1 spin-2 $m \neq 0$

Hinterbichler-Rosen

○ 2 polarizations, $S = \pm 2 \uparrow \hat{z}$
○ 5 ... $S = \pm 2, \pm 1, 0$
○ 4 $S = \pm 2, \pm 1$
○ ?

dRGT Theory $\rightarrow$ 1 spin-2 $m \neq 0$

Hinterbichler-Rosen

○ 2 polarizations, $S = \pm 2 \uparrow \hat{z}$
○ 5 ... $S = \pm 2, \pm 1, 0$
○? 4 $S = \pm 2, \pm 1 \leftarrow$

ii) Connes NCG

L

ii) Connes NCG

L =

ii) Connes NCG

Lagrangian
Hamiltonian

Lagrangian: $\underline{\underline{L(x, \frac{dx}{dt})}}$

Hamiltonian: $\underline{\underline{H(x, p)}}$

$$\vec{F} = m\vec{a}$$
$$\frac{GMm}{r^2}$$

$$L =$$

Lagrangian: $\underline{\underline{L(x, \frac{dx}{dt})}}$

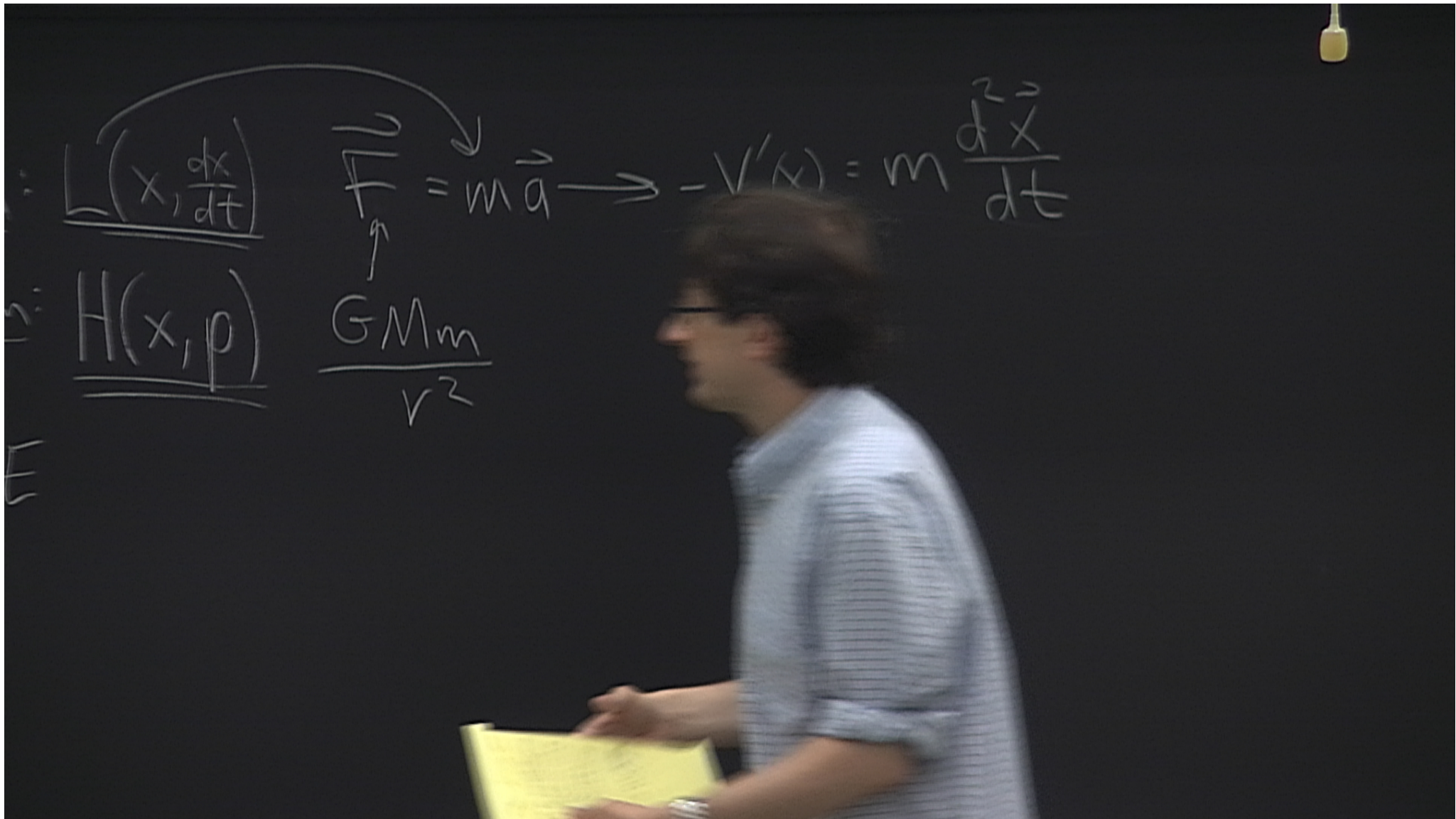
Hamiltonian: $\underline{\underline{H(x, p)}}$

$$\vec{F} = m\vec{a} \rightarrow -V'(x)$$

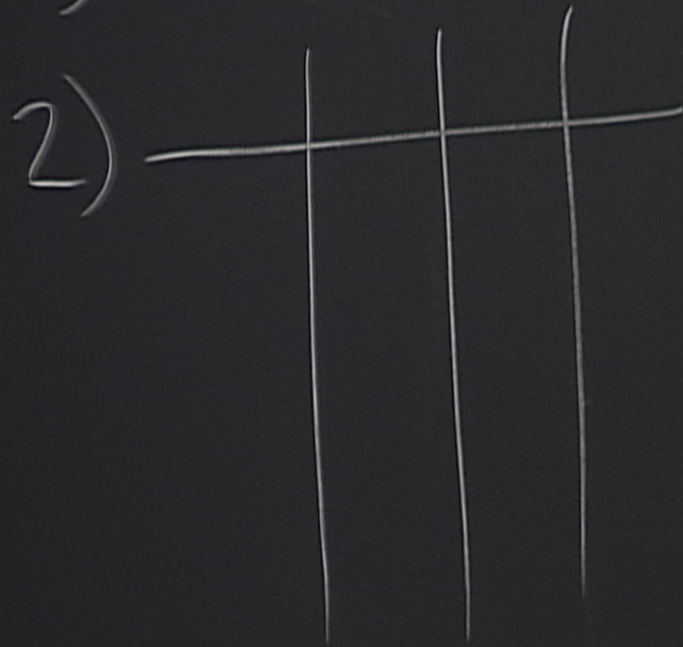
$\uparrow$

$$\frac{GMm}{r^2}$$

$V(x)$ $L =$



1) Poincare, $SU(3) \times SU(2) \times U(1)$



$S=1$ (gauge)

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$S=1$ (gauge bosons)

$S=\frac{1}{2}$ (fermions)

$S=0$ $S \rightarrow$ Higgs

2)

	$SU(3)$	$SU(2)$	$U(1)$
$\begin{pmatrix} u_L \\ d_L \end{pmatrix} = q_L$			
u_R			
d_R			
$\begin{pmatrix} \nu_L \\ e_L \end{pmatrix} = l_L$			
ν_R			
e_R			

1) Poincare, $SU(3) \times SU(2) \times U(1)$

2)

	$SU(3)$	$SU(2)$	$U(1)$
$\begin{pmatrix} u_L \\ d_L \end{pmatrix} = q_L$	3	2	$+1/6$
u_R	3	1	$+2/3$
d_R	3	1	$-1/3$
$\begin{pmatrix} \nu_L \\ e_L \end{pmatrix} = l_L$	1	2	$-1/2$
ν_R	1	1	0
e_R	1	1	-1

$S=1$ (gauge bosons)

$S=\frac{1}{2}$ (fermions)

$S=0$ (scalars $\rightarrow H$)

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ν_R	1	1	0
e_R	1	1	-1
h	1	2	$\frac{1}{2}$

3)

$S=1$ (gauge bosons)

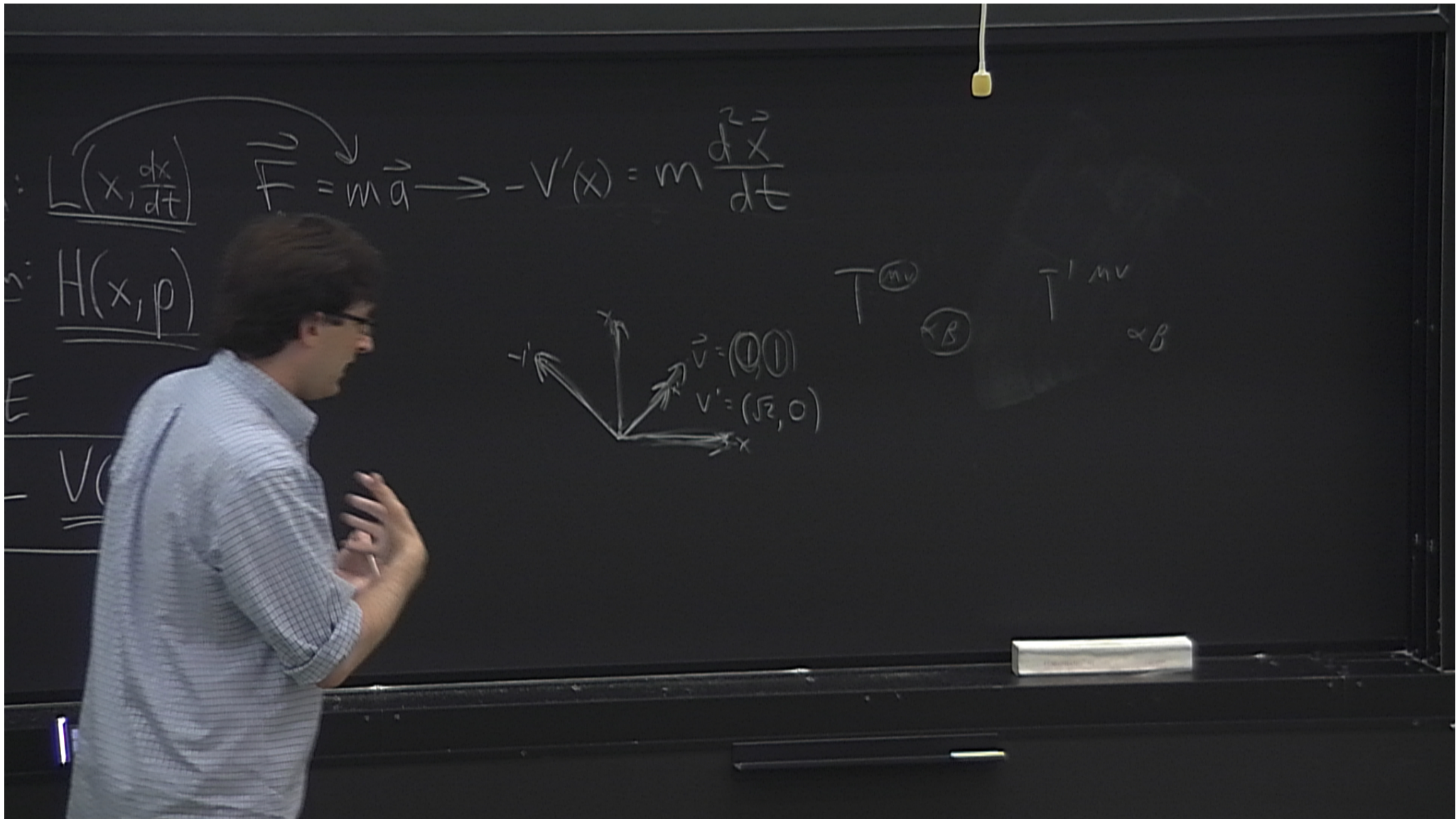
$S=\frac{1}{2}$ (fermions)

$S=0$ (scalars $\rightarrow$ Higgs boson)

$L=$

$$L = -\frac{1}{4} [G_{\mu\nu} G^{\mu\nu}] - \frac{1}{4} [W_{\mu\nu} W^{\mu\nu}] - \frac{1}{4} B_{\mu\nu} B^{\mu\nu}$$

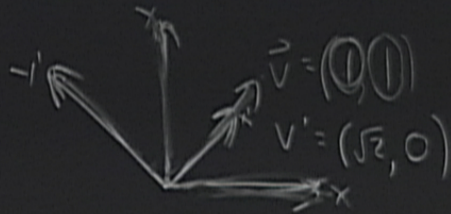
$S \rightarrow \text{Higgs boson}$



$$L(x, \frac{dx}{dt}) \quad \vec{F} = m \vec{a} \rightarrow -V'(x) = m \frac{d^2 x}{dt^2}$$

$$H(x, p) \quad \frac{GMm}{r^2}$$

$$V(x)$$



$$T^{(mv)}$$

$$\otimes B$$

$$T$$

$$T^{(mv)}$$

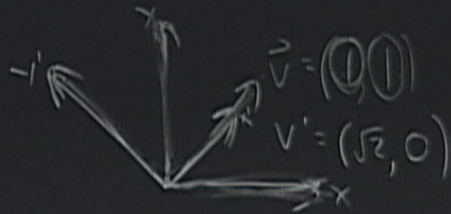
$$\propto B$$

$$T_{\propto B}$$

$$L(x, \frac{dx}{dt}) \quad \vec{F} = m\vec{a} \rightarrow -V'(x) = m \frac{d^2x}{dt^2}$$

$$H(x, p) \quad \frac{GMm}{r^2}$$

$$V(x)$$



$$T^{(m)}$$

$$\otimes B$$

$$T$$

$$T^{(m)}$$

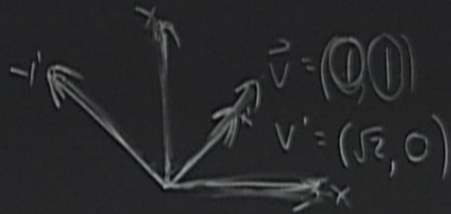
$$\propto B$$

$$T \propto B \propto$$

$$L(x, \frac{dx}{dt}) \quad \vec{F} = m\vec{a} \rightarrow -V'(x) = m \frac{d^2x}{dt^2}$$

$$H(x, p) \quad \frac{GMm}{r^2}$$

$$V(x)$$



$$T^{(mv)}$$

$$\otimes B$$

$$T$$

$$T^{(mv)}$$

$$\propto B$$

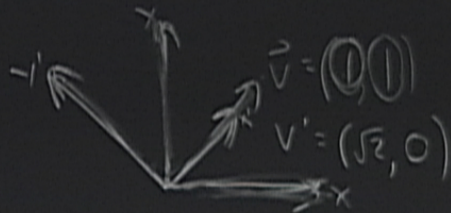
$$T_{\otimes B}$$

$$\otimes B \propto \delta$$

$$L(x, \frac{dx}{dt}) \quad \vec{F} = m\vec{a} \rightarrow -V'(x) = m \frac{d^2 x}{dt^2}$$

$$H(x, p) \quad \frac{GMm}{r^2}$$

$$E \quad \underline{V(x)}$$



$$T^{(mv)}$$

$$\otimes B$$

$$T^{(mv)}$$

$$\propto B$$

$$T$$

$$T$$

$$\otimes B \quad \otimes \delta$$

$$S = T \otimes T = T^{\otimes 2}$$

