

Title: Can Lorentz Symmetry be Emergent?

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Abstract: I will begin by discussing some of the strongest observational evidence for Lorentz symmetry, and the essential role that Lorentz symmetry appears to play in the consistency of black hole thermodynamics. Next I will discuss some reasons for suspecting that Lorentz symmetry may nevertheless be emergent. And finally I will discuss difficulties with the concept of emergent Lorentz symmetry, and how such difficulties might conceivably be overcome.



Can Lorentz Symm be Emergent?

Lorentz symm

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Lorentz symm $SO(D-1, 1)$
rotations & boosts

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sphere

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Lorentz symm : $SO(D-1, 1)$

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Can Lorentz Symm be Emergent?

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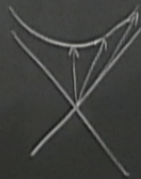


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Inv. under chg
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Why question it?

UV div, $\neq$ spacetime?

empiricism,

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$$p_\mu \rightarrow \Lambda^\nu_\mu p_\nu$$

$\in$ dim'l Hilbert space

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Why question it?

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time of flight

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thresholds for particle reactions

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maximum speed

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loops diverge

Why question it?

UV div, ∇ spacetime?

empiricism, BH entropy $< \infty$?

1) non-compact

Conf. grp
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Lorentz Symm

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for particle reactions

parisons

speed

eg. $E^2 = p^2 c^2 + m^2 c^4 + \frac{p^4}{M^2} + \dots$

Lorentz Symm

light

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10^2 MeV

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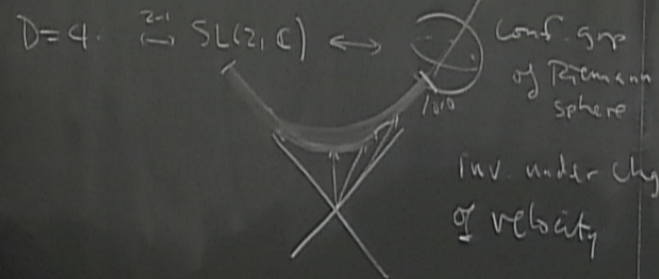
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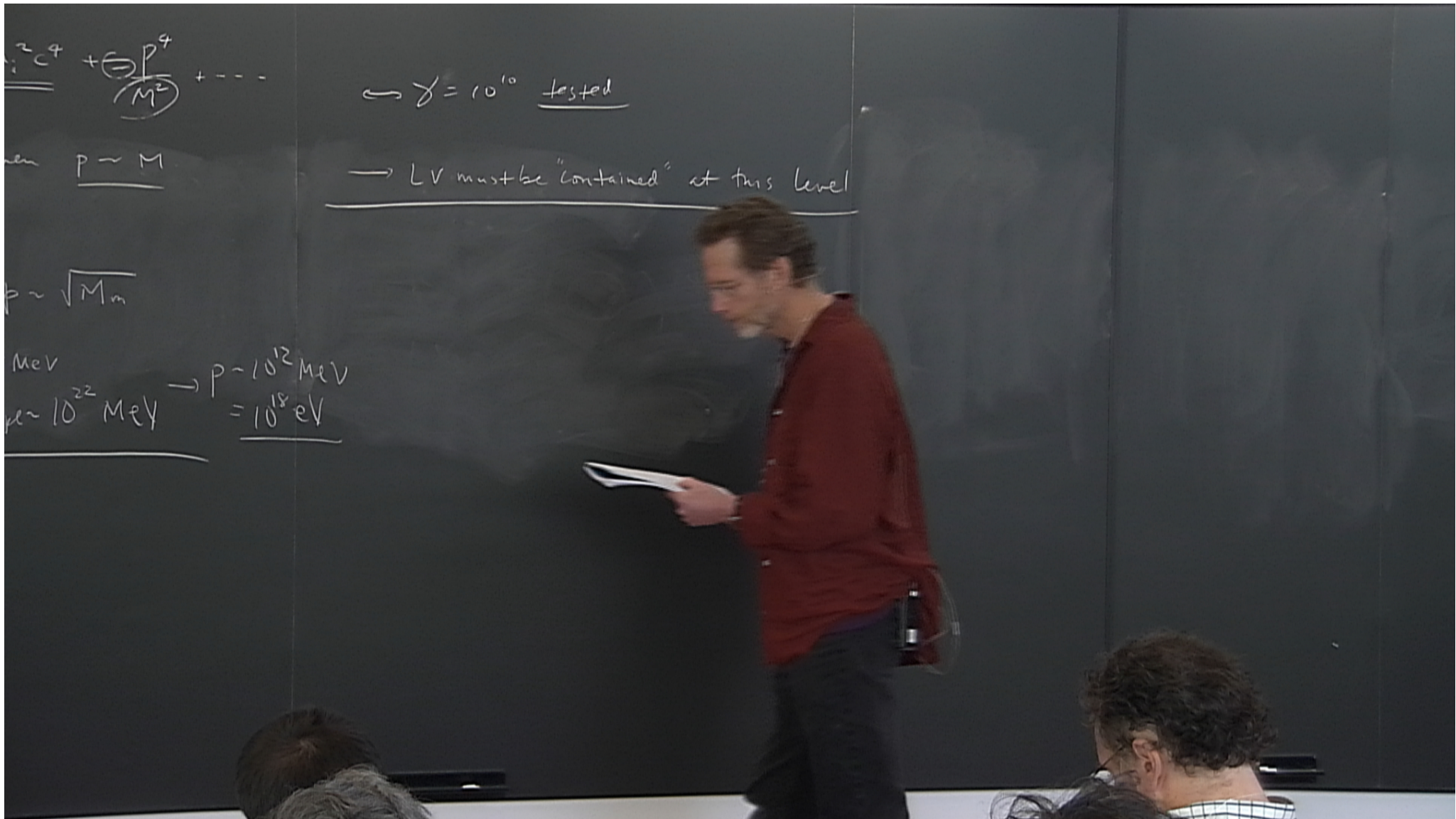
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UV div, ∇ spacetime?

empiricism, BH entropy $\propto \infty$



$$\bar{\nu}_e + e^+ + \bar{\nu}_e + \dots$$

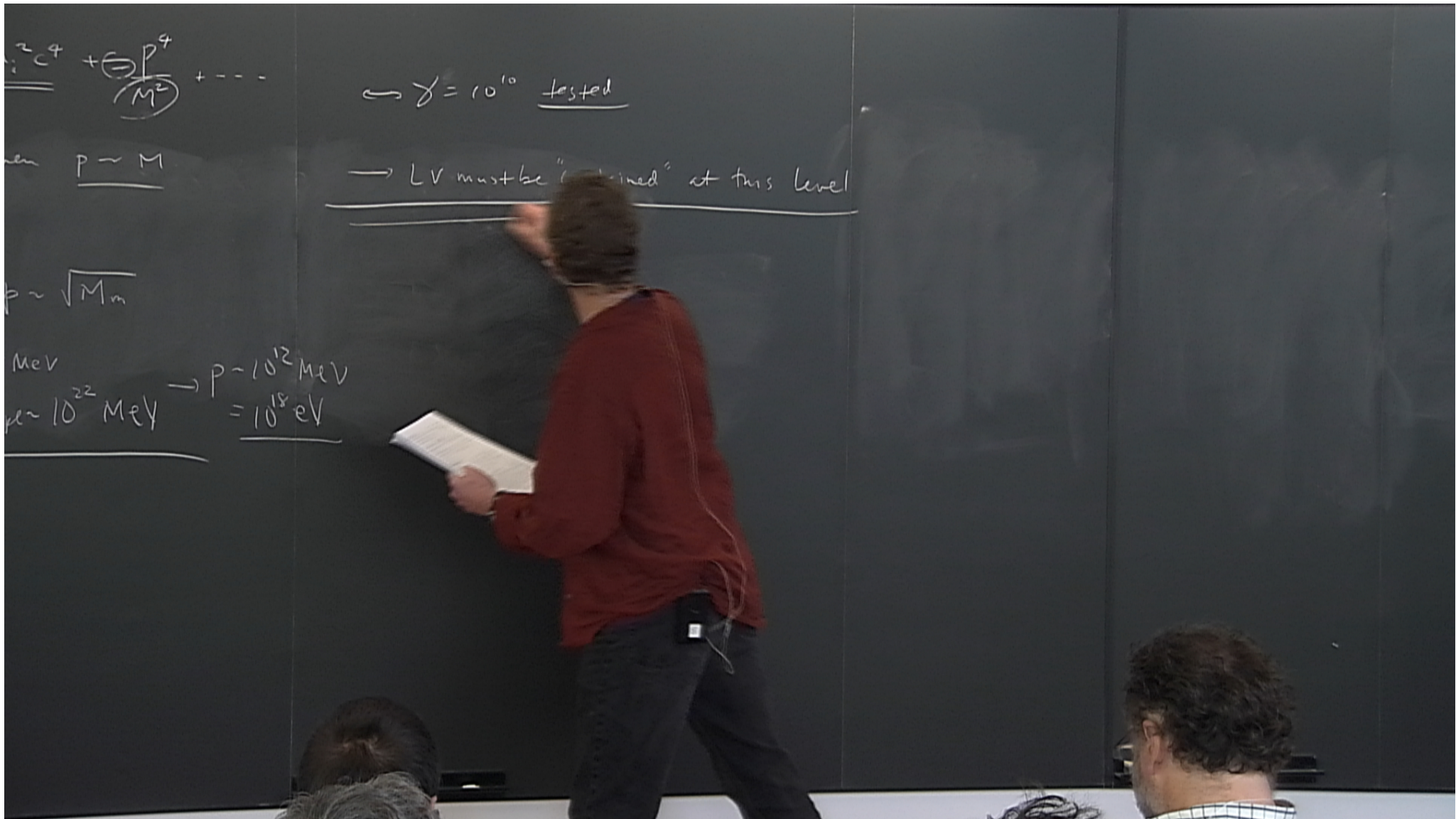
$$p \sim M$$

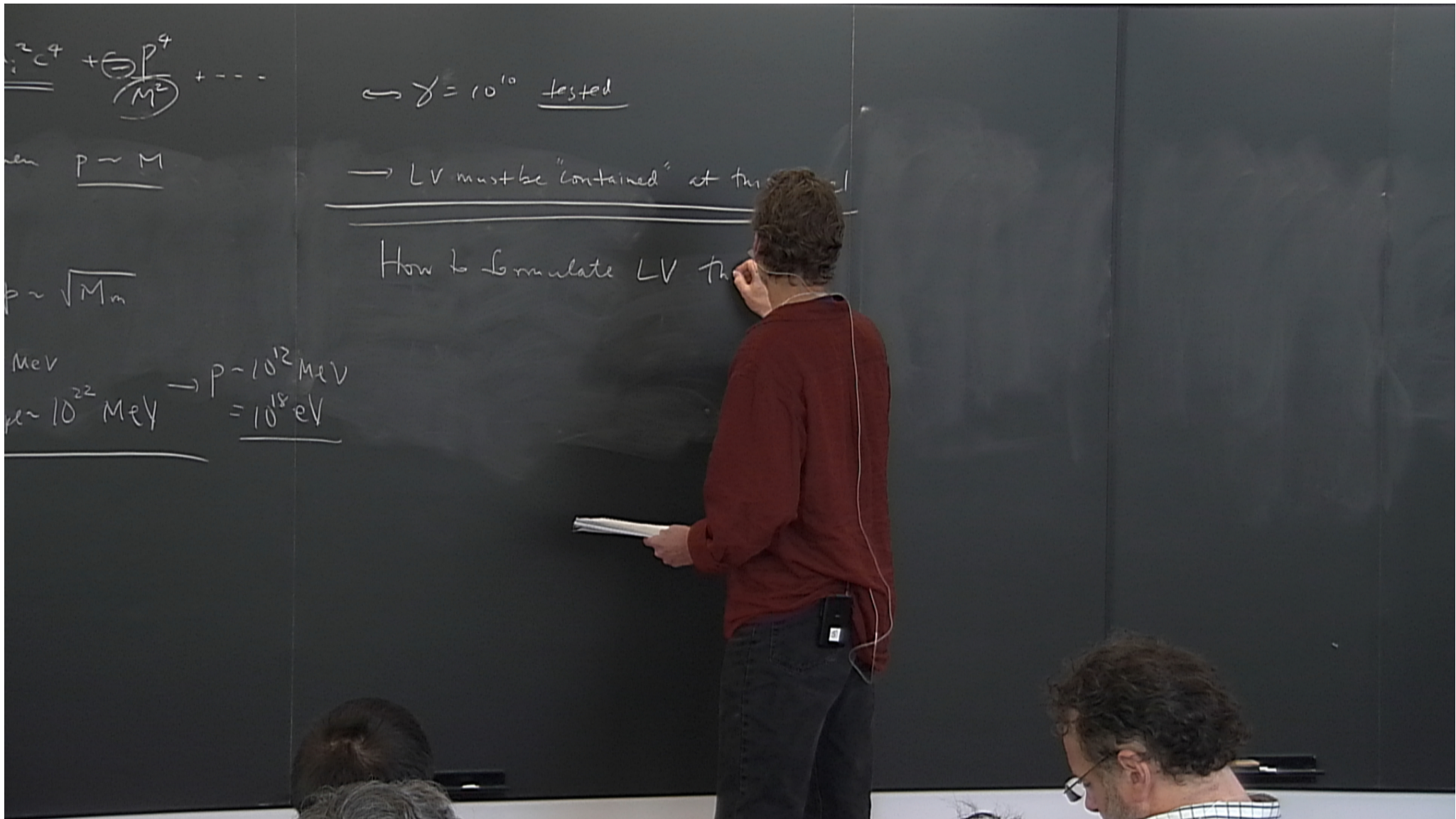
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$$\hookrightarrow \gamma = 10^{10} \text{ tested}$$

$\rightarrow$ LV must be "contained" at this level





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- start w/ less - Structure
- Condensed matter

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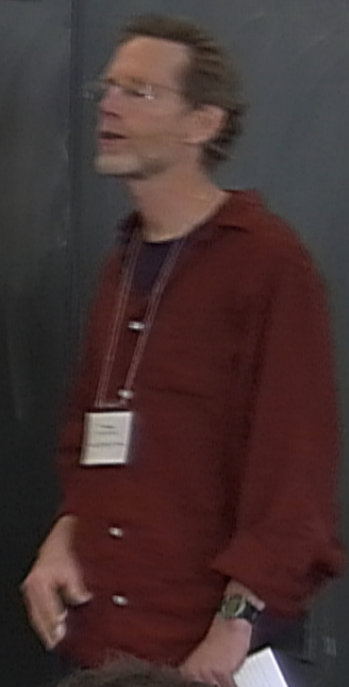
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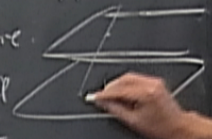
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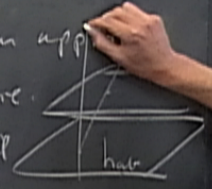
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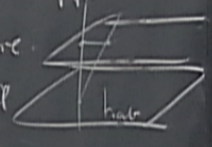
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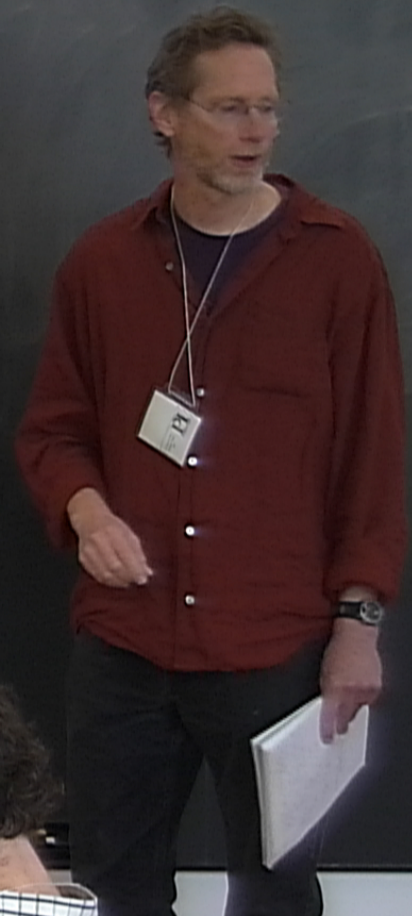
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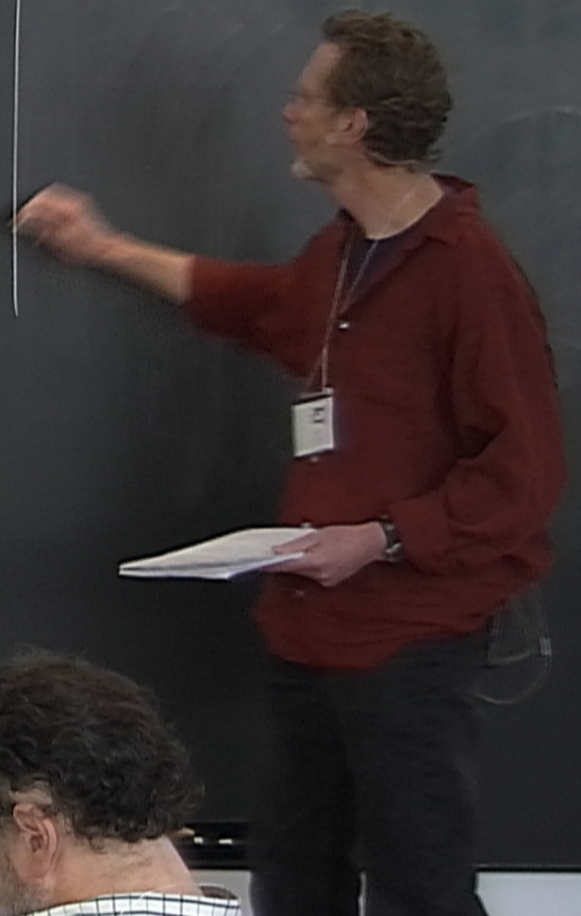
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Structure

Horava-Lifshitz



$\gamma = 10^{10}$ tested

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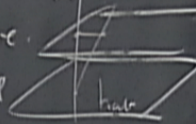
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Structure

Horava-Lifshitz

N, N^a

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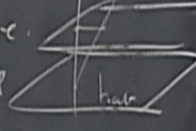
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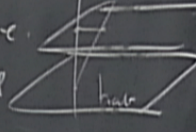
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Structure

Horava-Lifshitz

(N, N^a)

$$g_{\mu\nu} = N_{\mu\nu} \partial_\mu \partial_\nu + h_{\mu\nu}$$

$\gamma = 10^{10}$ tested

LV must be "contained" at this level

how to formulate LV theory

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Condensed matter.

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structure frame

Structure

Horava-Lifshitz

$$(N, N^a)$$

$$g_{\mu\nu} = N_{(\mu} \nabla_{\nu)} u + h_{\mu\nu}$$

$$P_\mu \rightarrow \Lambda^\mu_\nu P_\nu$$

∞ dim'l Hilbert space

∞ density of states

$\rightarrow$ UV div of QFT

loops diverge

question if?

UV div, of spacetime?

empiricism, BH entropy $< \infty$?

ways to obtain universal low energy

$$\text{e.g. } E^2 = p^2 c^2 + \underline{m^2 c^4} + \mathcal{O}\left(\frac{p^4}{M^2}\right)$$

$$\frac{p^4}{M^2} \sim p^2 \text{ term when } \underline{p \sim M}$$

$$\frac{p^4}{M^2} \sim m^2 \text{ when } p \sim \sqrt{Mm}$$

$$\text{e.g. } m \sim 10^2 \text{ MeV}$$

$$M \sim M_{\text{Pl}} \sim 10^{22} \text{ MeV}$$

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Lorentz symm

• discrete subgroup $\Rightarrow$ $SO(3,1)$

• SUSY

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Subgroup $\Rightarrow$ $SO(3,1)$

(too slow)

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• RG - (unless strong interactions)

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ways to obtain universal low energy
Lorentz symm.

- discrete subgroup $\Rightarrow$ $SO(3,1)$
- SUSY
- RG flow (too slow unless strong interactions)
- Causal sets

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$\rightarrow$ UV $\rightarrow$ FT

loop

entropy $< \infty$?

ways to obtain universal low energy
Lorentz symm

- discrete subgroup $\Rightarrow$ $SO(3,1)$
- SUSY
- RG flow (too slow unless strong interactions)
- Causal sets
- Spin foams

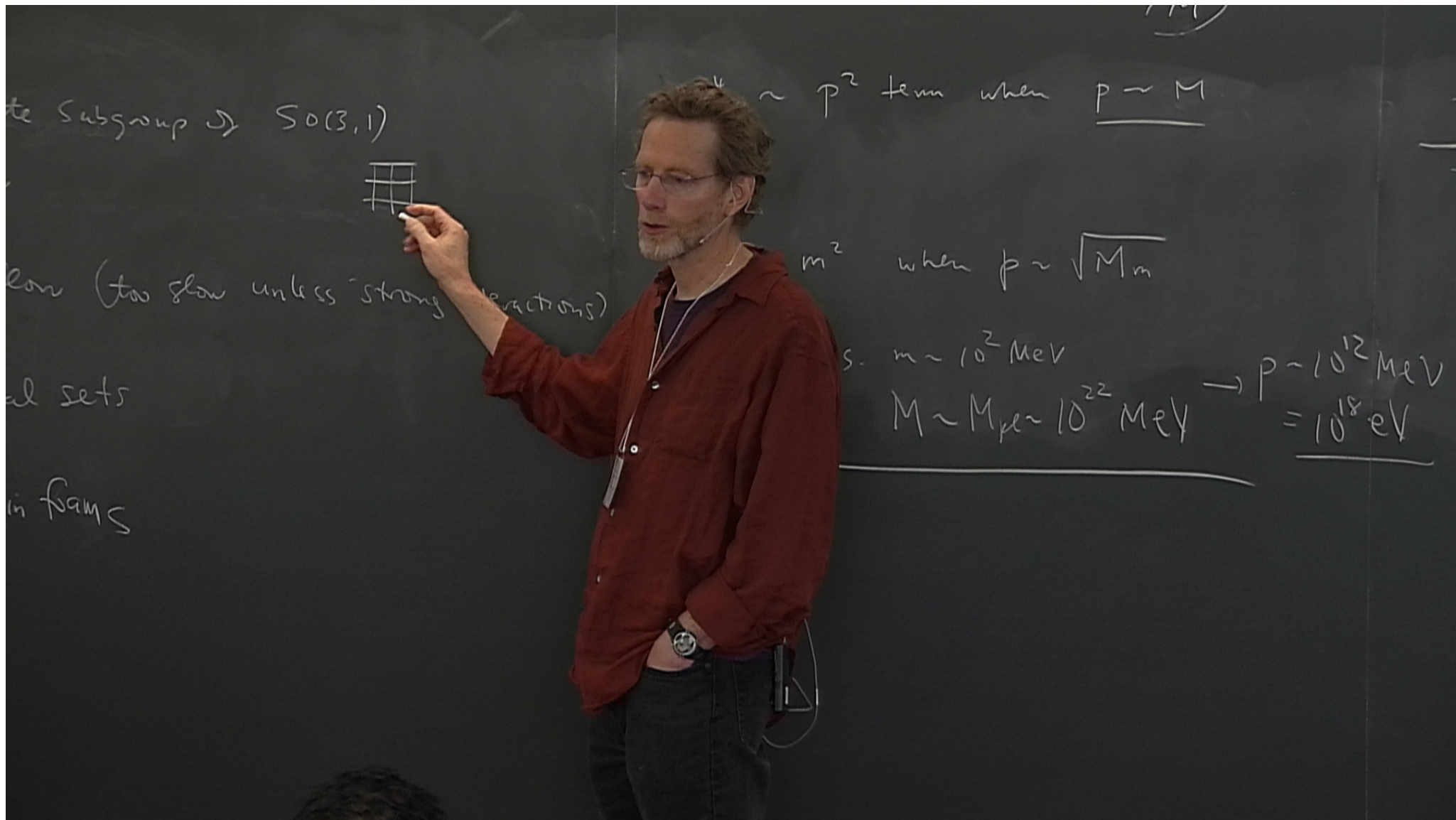
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the subgroup $\rightarrow SO(3,1)$



low (too slow unless "strong" interactions)

- sets

in fam S

$\sigma_4 \sim p^2$ term when $p \sim M$

$$m^2 \quad \text{when } p \sim \sqrt{Mm}$$

5. $m \sim 10^2 \text{ MeV}$

the Subgroup $\Rightarrow SO(3,1)$



low (too slow unless strong interactions)

al sets

in forms

$\frac{p^4}{M^4}$ p^2 term when $\underline{p \sim M}$

$\frac{p^4}{M^4}$ when $p \sim \sqrt{Mm}$

$\sim 10^2 \text{ MeV}$

$\sim M_{\text{Pl}} \sim 10^{22} \text{ MeV}$

$\rightarrow p \sim 10^{12} \text{ MeV}$
 $= \underline{10^{18} \text{ eV}}$