Title: PSI 2018/2019 - Beyond Standard Model - Lecture 10

Speakers: Latham Boyle

Collection: PSI 2018/2019 - Beyond Standard Model (Boyle)

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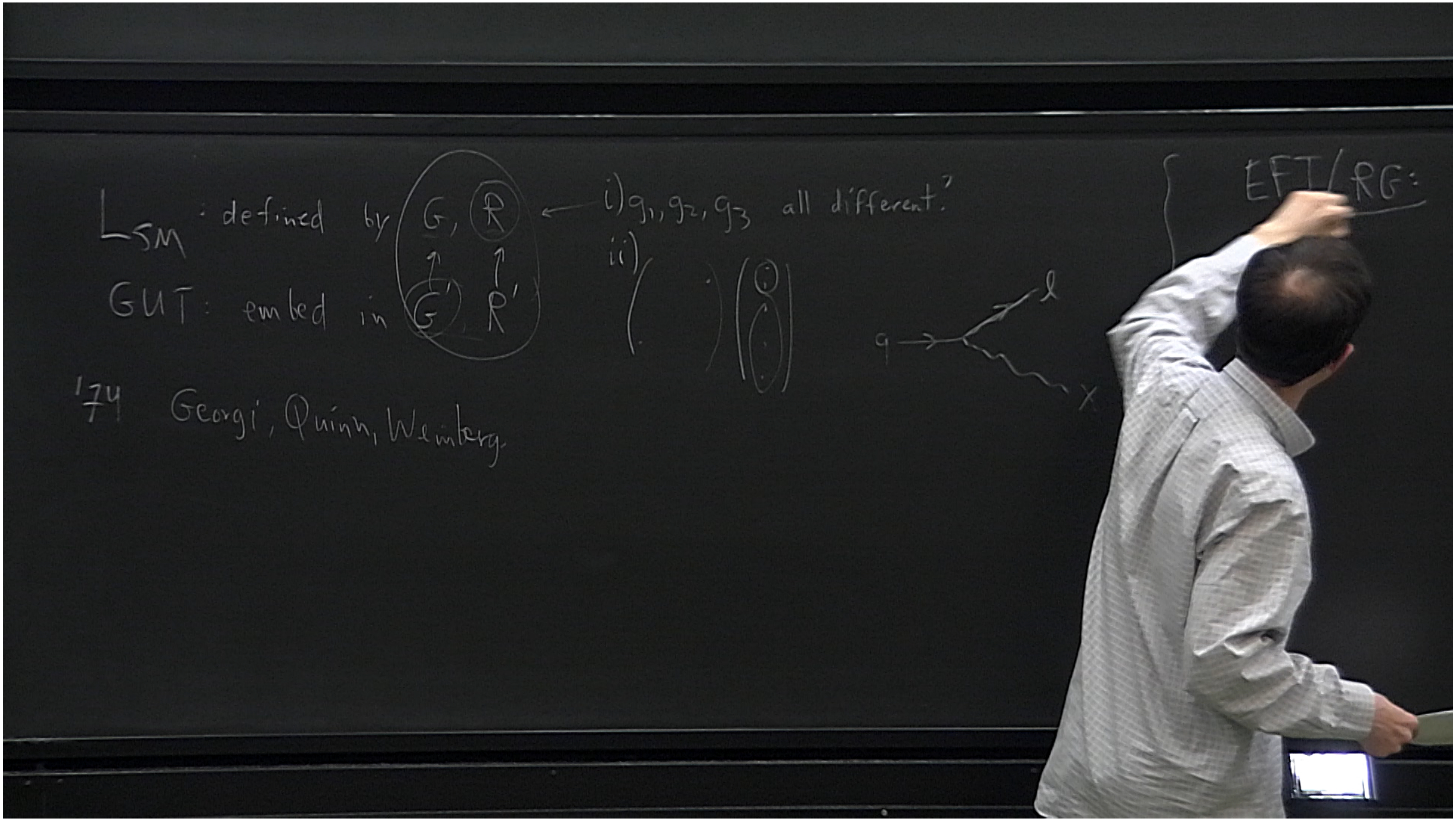
URL: http://pirsa.org/19040026


L_SM : defined by G, R
GUT : embed in G', R'
i) g1, g2, g3 all different?
ii)
q
l
X
'74 Georgi, Quinn, Weinberg
EFT/RG:

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$$\int dx\,dy\; e^{-f(x,y)} = \int dx\; e^{-\tilde{f}(x)}$$

$$Z = \int_{p^2 \leq \Lambda^2} \mathcal{D}[\varphi]\, e^{-S_\Lambda[\varphi]} = \int_{p^2 \leq \Lambda'^2} \mathcal{D}[\varphi] \underbrace{\int_{\Lambda'^2 \leq p \leq \Lambda^2} \mathcal{D}[\varphi]\, e^{-S_\Lambda[\varphi]}}_{e^{-S_{\Lambda'}[\varphi]}} = \int_{p^2 \leq \Lambda^2} \mathcal{D}[\varphi]\, e^{-S_{\Lambda'}[\varphi]}$$

EFT/RG:

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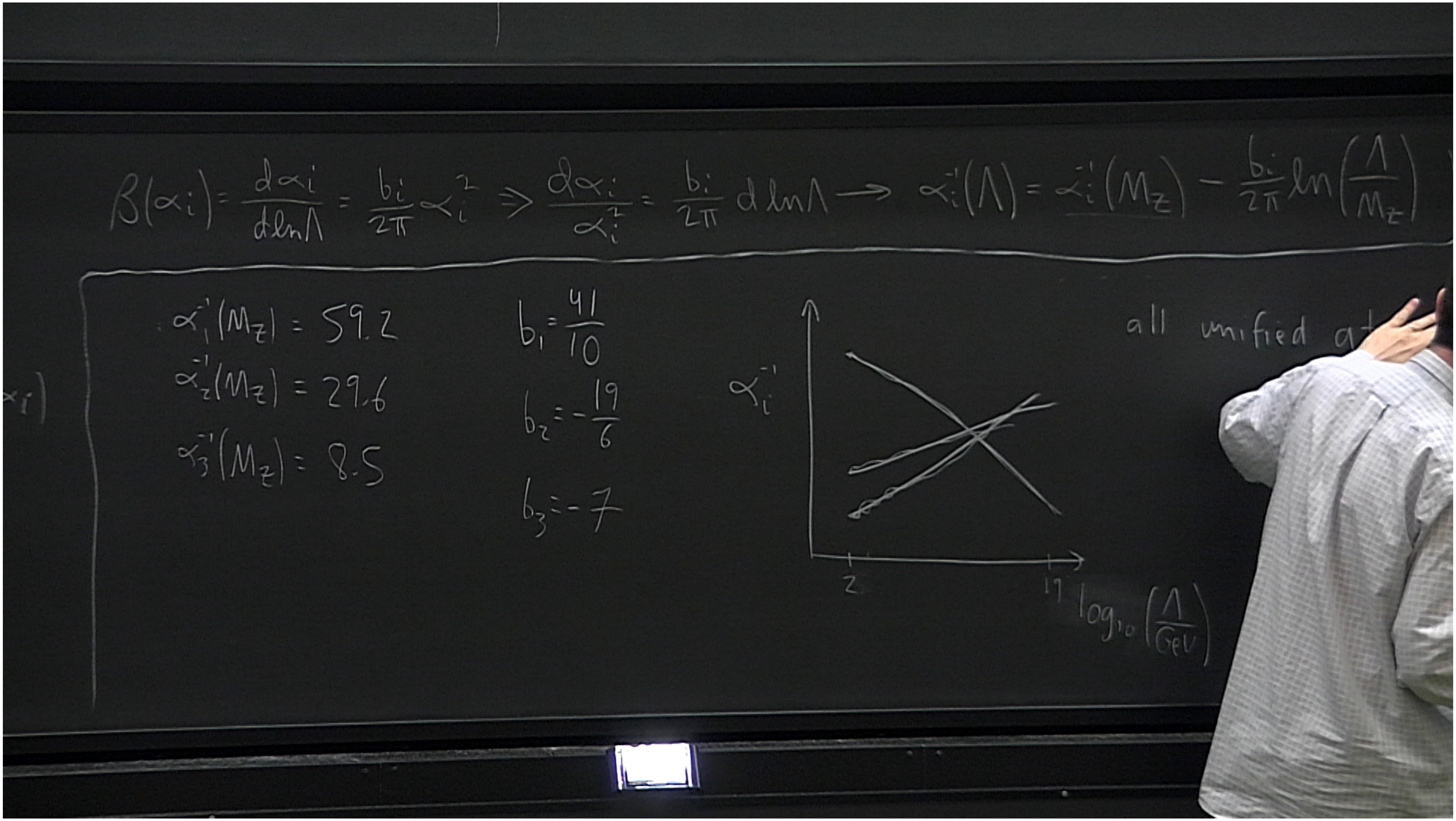
$$Z = \int_{p^2 \le \Lambda^2} \mathcal{D}[\varphi]\, e^{-S_\Lambda[\varphi]} = \int_{p^2 \le \Lambda'^2} \mathcal{D}[\varphi] \underbrace{\int_{\Lambda'^2 \le p \le \Lambda^2} \mathcal{D}[\varphi]\, e^{-S_\Lambda[\varphi]}}_{e^{-S_{\Lambda'}[\varphi]}} = \int_{p^2 \le \Lambda'^2} \mathcal{D}[\varphi]$$

$$g(\Lambda)$$

$$\beta(g) = \Lambda \frac{dg}{d\Lambda} = \frac{dg}{d(\ln \Lambda)}$$

$$\beta(g_i) = b_i \frac{g_i^3}{16\pi^2} \qquad \alpha_i = \frac{g_i^2}{4\pi} \qquad \beta(\alpha_i) = \frac{d\alpha_i}{d\ln\Lambda} = \frac{b_i}{2\pi}\alpha_i^2 \Rightarrow \frac{d\alpha_i}{\alpha_i^2} = \frac{b_i}{2\pi}\, d\ln\Lambda$$

$$g_i \frac{dg_i}{d\ln\Lambda} = \frac{1}{2}\frac{d(g_i^2)}{d\ln\Lambda} = 2\pi \frac{d\alpha_i}{d\ln\Lambda} = 2\pi\,\beta(\alpha_i)$$

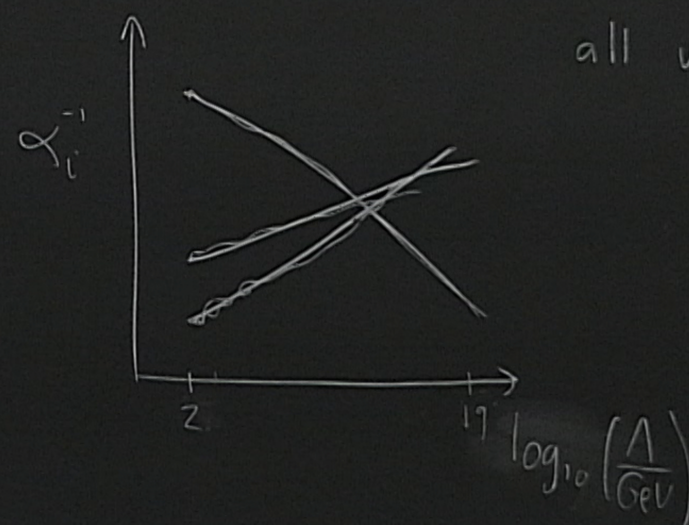

$\beta(\alpha_i) = \frac{d\alpha_i}{d\ln\Lambda} = \frac{b_i}{2\pi}\alpha_i^2 \Rightarrow \frac{d\alpha_i}{\alpha_i^2} = \frac{b_i}{2\pi} d\ln\Lambda \rightarrow \alpha_i^{-1}(\Lambda) = \alpha_i^{-1}(M_Z) - \frac{b_i}{2\pi}\ln\left(\frac{\Lambda}{M_Z}\right)$
$\alpha_1^{-1}(M_Z) = 59.2$
$\alpha_2^{-1}(M_Z) = 29.6$
$\alpha_3^{-1}(M_Z) = 8.5$
$b_1 = \frac{41}{10}$
$b_2 = -\frac{19}{6}$
$b_3 = -7$
α_i^{-1}
2
17
$\log_{10}\left(\frac{\Lambda}{GeV}\right)$
all unified at

$$\frac{\ \ i}{\ \Lambda} = \frac{b_i}{2\pi}\alpha_i^2 \Rightarrow \frac{d\alpha_i}{\alpha_i^2} = \frac{b_i}{2\pi}\, d\ln\Lambda \longrightarrow \alpha_i^{-1}(\Lambda) = \alpha_i^{-1}(M_Z) - \frac{b_i}{2\pi}\ln\left(\frac{\Lambda}{M_Z}\right)$$

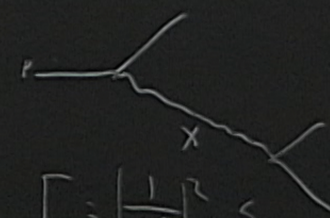
59.2 $\qquad b_1 = \frac{41}{10}$

29.6 $\qquad b_2 = -\frac{19}{6}$

8.5 $\qquad b_3 = -7$



all unified at $\Lambda \sim 10^{15}$ GeV



$$\Gamma_{p^+} = \left|\frac{1}{M_X^2}\right|^2 m_p^5$$

Bad news: i) no p^+ decay. rule out $SU(5)$

ii)

Bad news:

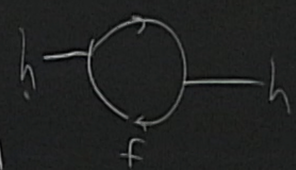
i) no p^+ decay. rule out $SU(5)$

ii) coupling don't unify

iii) $M_{EW} \sim 10^2\,\mathrm{GeV}$, $M_{Pl} \sim 10^{19}\,\mathrm{GeV}$

$M_{GUT} \sim 10^{16}\,\mathrm{GeV}$

$m^2 (h^\dagger h)$



$\leftarrow m^2 \sim \underline{\Lambda}^2$

$\int^{\Lambda}$

Bad news: i) no p^+ decay. rule out SU(5)

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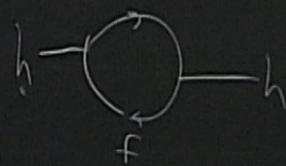


$\leftarrow m^2 \sim \Lambda^2$

$\int^\Lambda$

1981: Dimopoulos/Raby/Wilczek

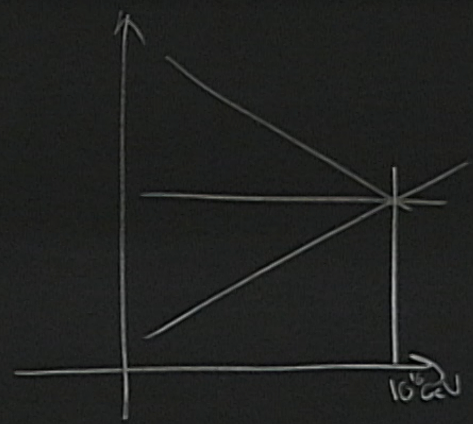
MSSM

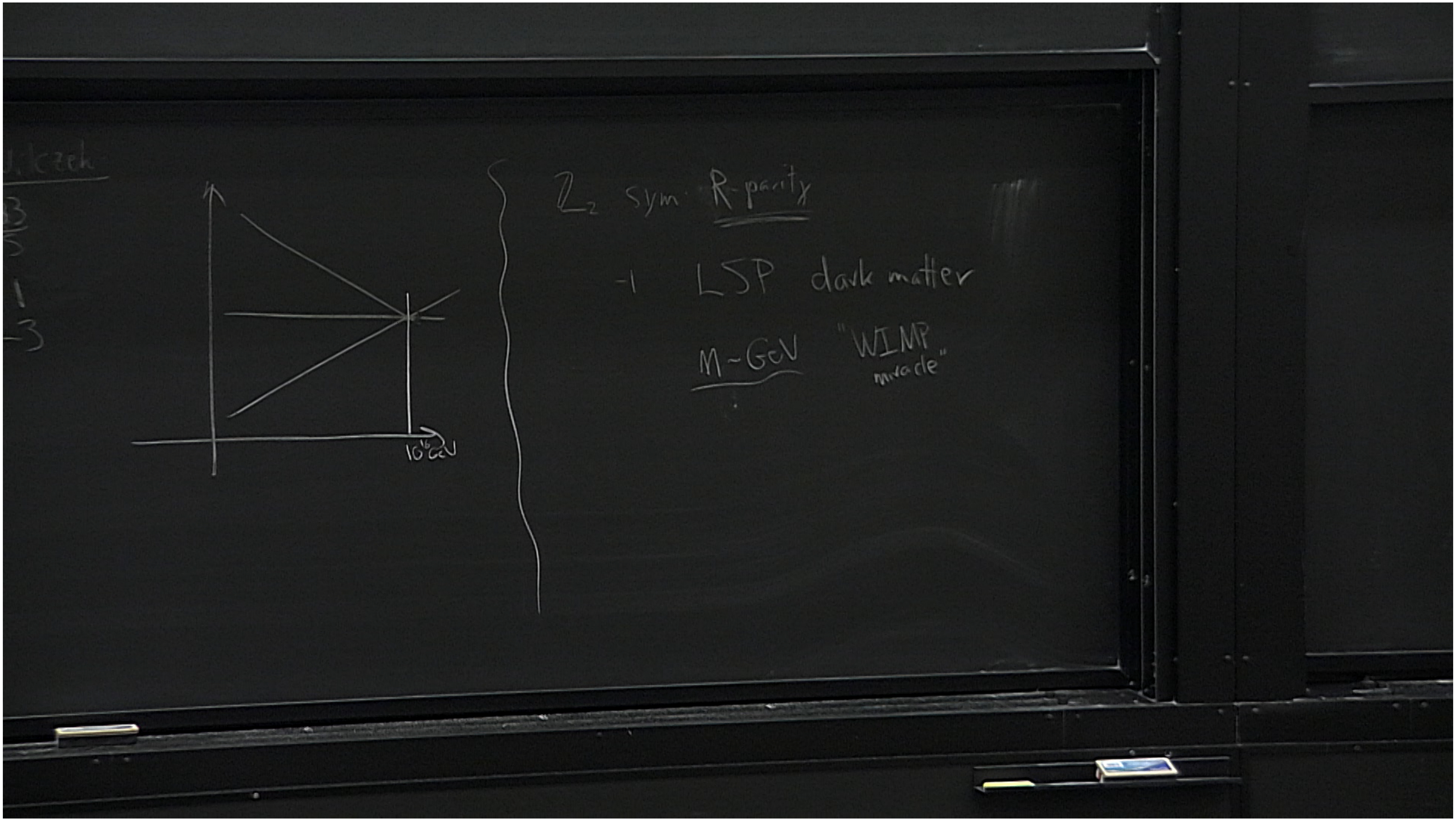
SUSY GUT

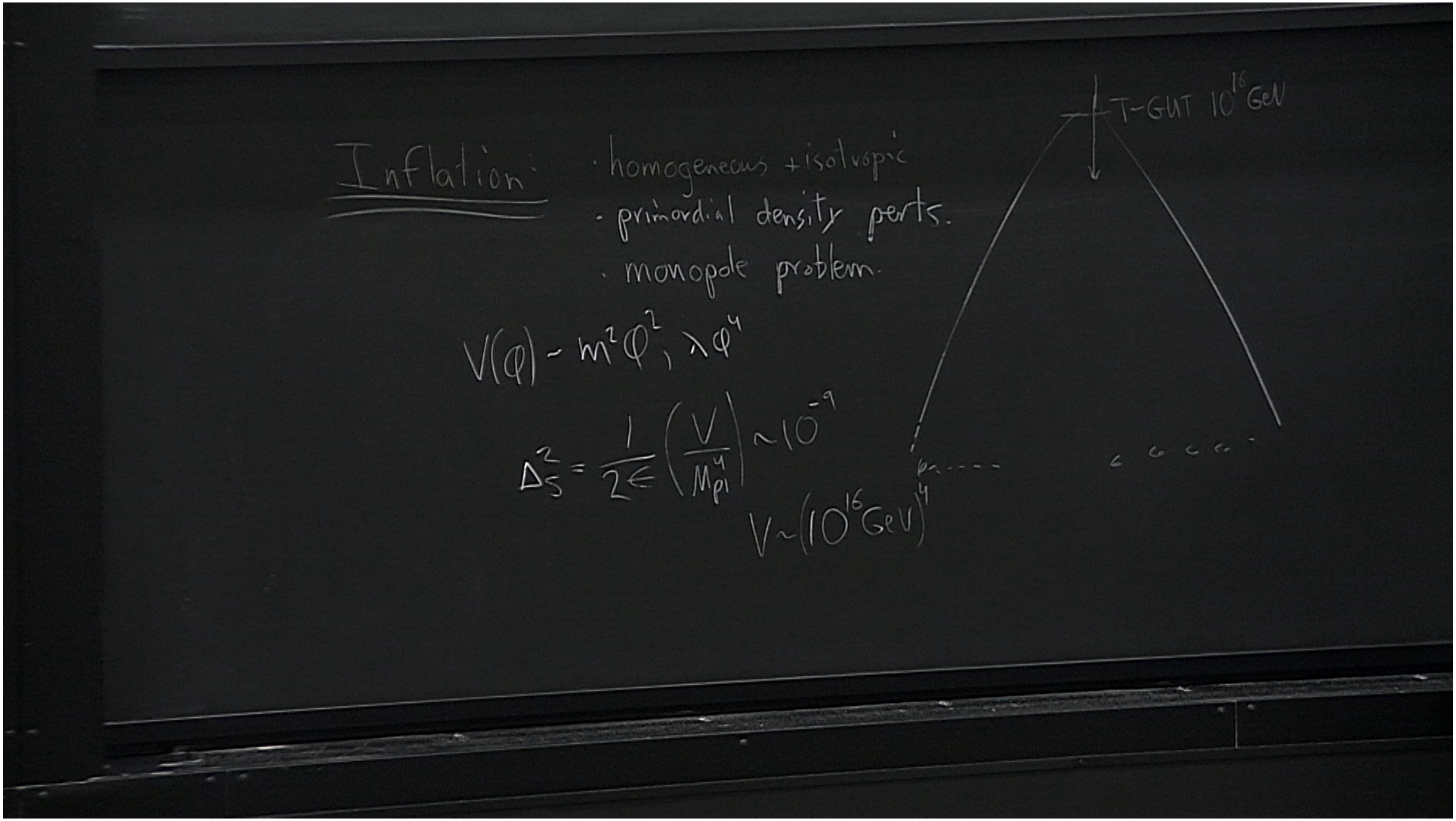
$b_1 = \frac{33}{5}$

$b_2 = 1$

$b_3 = -3$




Z_2 sym: R-parity
-1 LSP dark matter
M~GeV "WIMP miracle"
10^{16} GeV


Inflation:
· homogeneous + isotropic
· primordial density perts.
· monopole problem.
$V(\varphi) \sim m^2\varphi^2, \lambda\varphi^4$
$\Delta_S^2 = \frac{1}{2\epsilon}\left(\frac{V}{M_{pl}^4}\right) \sim 10^{-9}$
$V \sim (10^{16}\,\mathrm{GeV})^4$
$T \sim$ GUT 10^{16} GeV

<u>bad news</u>: i) no SUSY partners at EW scale.

ii) no SUSY DM

iii) $\Delta_t^2 \sim 8\left(\frac{V}{M_{pl}^4}\right)$

i)