

Title: PSI - Research Skills 1C

Date: Aug 24, 2009 01:00 PM

URL: <http://pirsa.org/09080045>

Abstract:

$$\frac{G_{mm}}{r} \left(1 - \frac{1917}{\pi^3} \frac{h_{p1}^2}{r^2} + \dots \right)$$

$$\int_0^{\infty} (r)$$

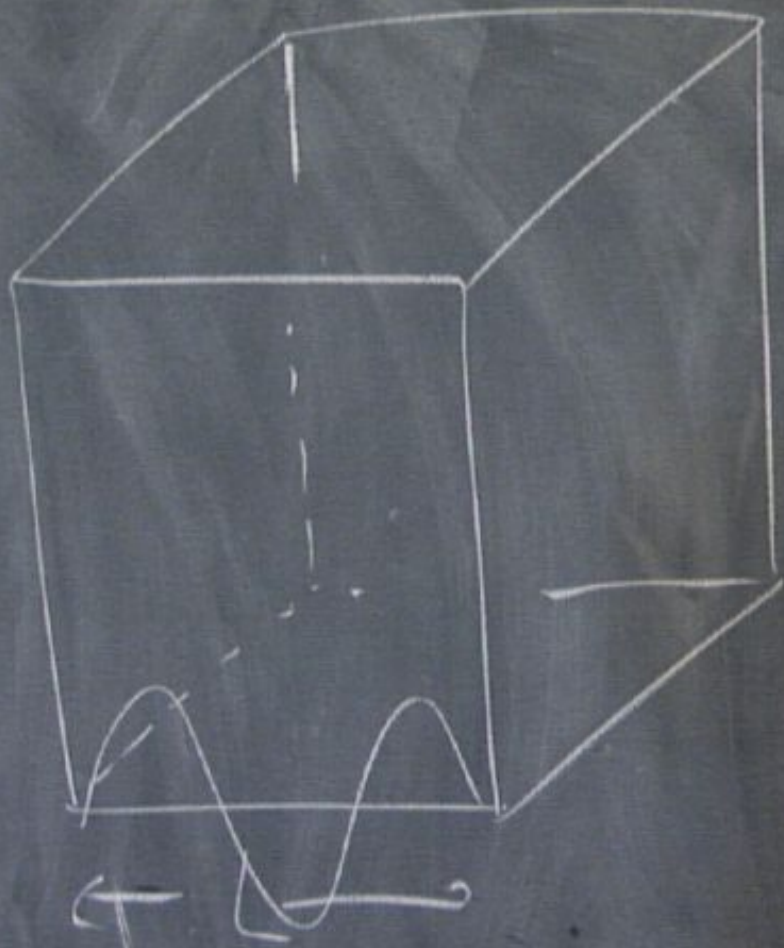
$$h \sim 10^{-33} \text{ cm}$$

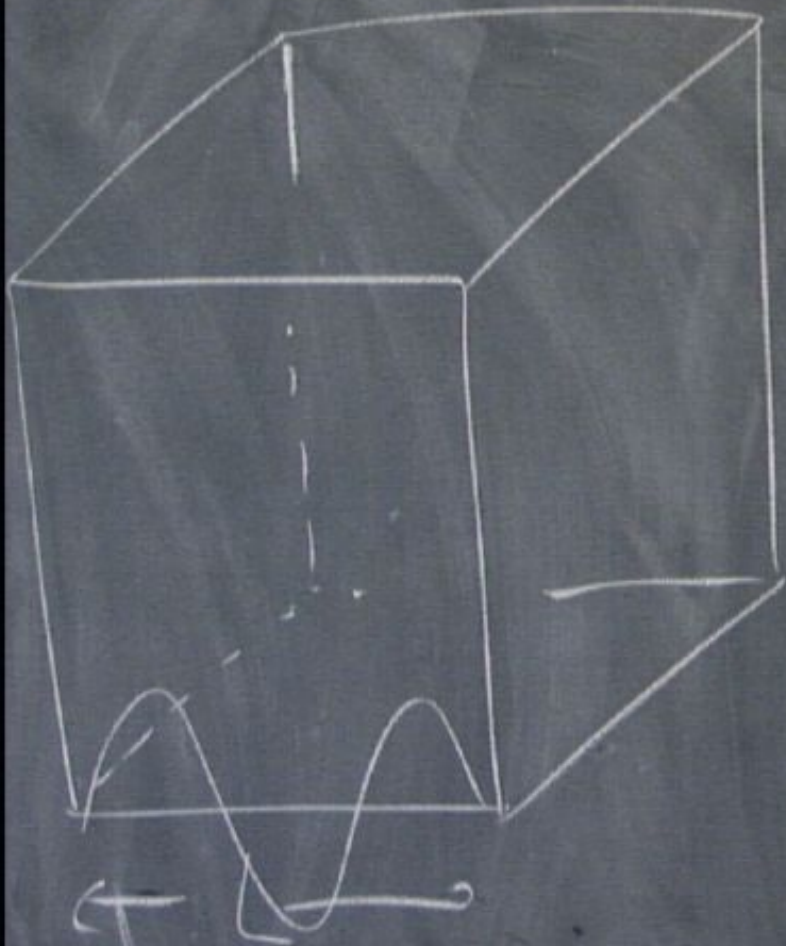
$$l_{EW} \sim 10^{-17} \text{ cm}$$

$$l_{\text{Hubble}} \sim 10^{+28} \text{ cm}$$



Vacuum Energy





$$\vec{p} = \frac{\hbar}{\lambda} \vec{v}$$

$$\vec{p} = \frac{\vec{m}}{L} = \frac{(n_1, n_2, n_3)}{L}$$

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$$\omega = \sqrt{p^2 + m^2}$$

$$\vec{p} = \frac{\vec{n}}{L} = \frac{(n_1, n_2, n_3)}{L}$$

$$\omega = \sqrt{p^2 + m^2} = \sqrt{\left(\frac{\vec{n}}{L}\right)^2 + m^2}$$

$$E^{\text{vac}} = \sum \frac{1}{2} \omega$$

$$= \sum_{\vec{k}} \sqrt{\frac{\hbar^2 \vec{k}^2}{L^2} + m^2}$$

$\frac{1}{2}$

"

$$\int \frac{d^3 p}{(2\pi)^3} \sqrt{\frac{\hbar^2 p^2}{2m} + m^2}$$

"

$$\int \frac{d^3 p}{(2\pi)^3} \sqrt{p^2 + m^2}$$

$$\rho_{vac} = \frac{E_{vac}}{V}$$

$$= \int d^3p \sqrt{p^2 + m^2}$$

$$\rho_{\text{vac}} = \frac{E_{\text{vac}}}{V}$$

$$= \int d^3 p \sqrt{p^2 + m^2}$$

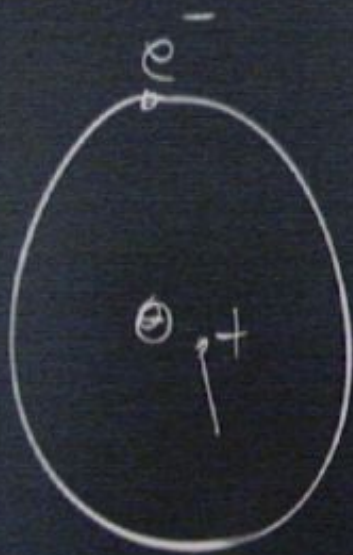
$$= \int d^3 p \sqrt{p^2 + m^2}$$

$$E_{\text{vac}} = \int d^3 p \left(\sum_B \sqrt{p^2 + m^2} - \sum_F \sqrt{p^2 + m^2} \right)$$

$$E_{vac} = \frac{E}{V}$$

$$= \int \frac{d^3 p}{(2\pi)^3} \sqrt{p^2 + m^2}$$

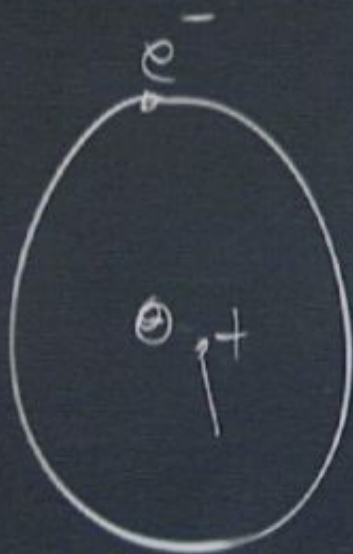
$$E_{vac} = \int \frac{d^3 p}{(2\pi)^3} \left(\sum_B \sqrt{p^2 + m^2} - \sum_F \sqrt{p^2 + m^2} \right)$$



$$\begin{array}{c} X^2 + p^2 \\ \quad \quad \quad | \\ aa^\dagger + a^\dagger a \end{array}$$



$$\begin{aligned}
 & X^2 + p^2 \\
 & \frac{1}{2}(a a^\dagger + a^\dagger a) \\
 & = a^\dagger a + \frac{1}{2} \hbar \omega.
 \end{aligned}$$



$$\begin{aligned}
 & \left. \begin{array}{l} X^2 + P^2 \\ \frac{1}{2}(aa^\dagger + a^\dagger a) \end{array} \right\} \\
 & = a^\dagger a + \frac{1}{2}\hbar\omega.
 \end{aligned}$$

$$\rho_{\text{vac}} = \int d^3 p \sqrt{p^2 + m^2}$$

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$$\int_x^y \frac{dt}{t}$$

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$$\int_x^y \frac{dt}{t} = \log y/x$$

$$\rho_{\text{vac}} = \int d^3 p \sqrt{p^2 + m^2}$$

$$\int_x^y dt \, t$$

$$\int_x^y \frac{dt}{t} = \log \frac{y}{x}$$

$$\rho_{\text{vac}} \equiv \int_{p_{\text{max}}} d^3 p \sqrt{p^2 + m^2}$$

p_{max}

$$\int d^3 p \sqrt{p^2 + m^2}$$

\sim

$$\rho_{\text{vac}} = \int_0^{p_{\text{max}}} d^3 p \sqrt{p^2 + m^2}$$

$$\int d^3 p p^2 \sqrt{p^2 + m^2}$$

$$\sim p_{\text{max}}^4$$

$$\rho_{\text{vac}} \equiv \int_0^{p_{\text{max}}} d^3 p \sqrt{p^2 + m^2}$$

$$\int d^3 p \sqrt{p^2 + m^2}$$

$$\sim p_{\text{max}}^4 + p_{\text{max}}^2 m^2$$

$$\rho_{\text{vac}} \equiv \int_0^{p_{\text{max}}} d^3 p \sqrt{p^2 + m^2}$$

$$\int d^3 p p^2 \sqrt{p^2 + m^2}$$

$$\sim p_{\text{max}}^4 + p_{\text{max}}^2 m^2 + m^4$$

$$\rho_{\text{vac}} = \int_{p_{\text{max}}}^{\infty} d^3 p \sqrt{p^2 + m^2}$$

$$\int d^3 p p^2 \sqrt{p^2 + m^2}$$

$$\sim p_{\text{max}}^4 + p_{\text{max}}^2 m^2 + m^4 \log$$

$$\int dp \, p^3 \sqrt{1 + \frac{m^2}{p^2}}$$

$$= \int dp \, p^3 \left[1 + \frac{m^2}{p^2} + \frac{m^4}{p^4} + \dots \right]$$

$$\int dp \, p^3 \sqrt{1 + \frac{m^2}{p^2}}$$

$$= \int dp \, p^3 \left[1 + \frac{1}{2} \frac{m^2}{p^2} - \frac{1}{8} \frac{m^4}{p^4} + \dots \right]$$

$$\int_{p_{\max}} dp \, p^3 \sqrt{1 + \frac{m^2}{p^2}}$$

$$\int \frac{dp}{p}$$

$$= \int_{p_{\max}} dp \, p^3 \left[1 + \frac{1}{2} \frac{m^2}{p^2} - \frac{1}{8} \frac{m^4}{p^4} + \dots \right]$$

$$\sim p_{\max}^4 + p_{\max}^2 m$$

$$\int_{P_{max}} dp \, P^3 \sqrt{1 + \frac{m^2}{P^2}}$$

$$= \int_{P_{max}} dp \, P^3 \left[1 + \frac{1}{2} \frac{m^2}{P^2} - \frac{1}{8} \frac{m^4}{P^4} + \dots \right]$$

$$\approx P_{max}^4 + P_{max}^2 m^2 + m^4 \log \frac{P_{max}}{m}$$

$$P_{\text{max}} \sim M_{\text{pl}}$$

$$\rho_{\text{vac}} \sim M_{\text{pl}}^4$$





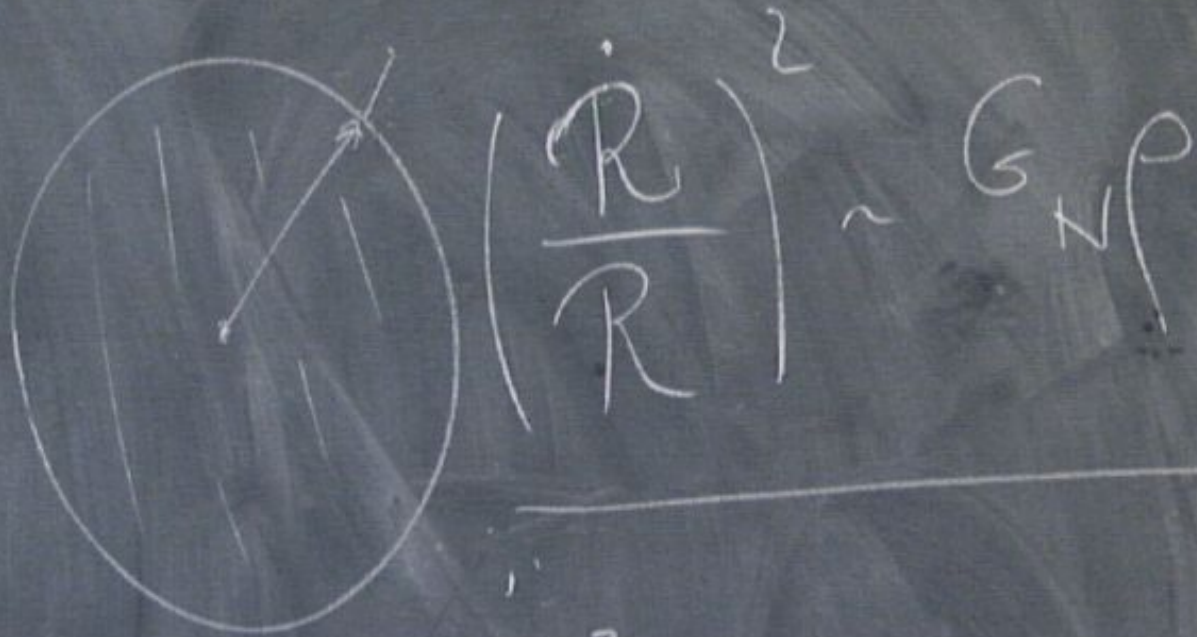


$$\left(\frac{\dot{R}}{R} \right)^2 \sim G_{NP}$$



$$\left(\frac{\dot{R}}{R} \right)^2 \sim G_{NP}$$

$$\dot{R}^2 \sim \frac{G_N (\rho R^3)}{R}$$



$$\left(\frac{R}{R}\right)^2 \sim G_{NP}$$

$$\left(\frac{R}{R}\right)^2 = G_{NP}^{vac}$$

$$R(t) = R_0$$

$$\rho \sqrt{G_{NP} t}$$



$$\left(\frac{\dot{R}}{R} \right)^2 \sim$$

$$\left(\frac{\dot{R}}{R} \right)^2 = G_{NP} \rho^2$$

$$\rho_{\text{max}} \sim M_{\text{pl}}$$

$$\rho_{\text{vac}} \sim M_{\text{pl}}^4$$

$$P = -\rho$$

$$T_{\text{M}}^{\text{M}}$$

$$\rho_{\text{max}} \sim M_{\text{pl}}^4$$

$$\rho_{\text{vac}} \sim M_{\text{pl}}^4$$

$$P = -\rho$$

$$T^{\mu\nu} = \Lambda g^{\mu\nu}$$

$\rho_{\text{max}} \sim M_{\text{pl}}$
 $\rho_{\text{vac}} \sim M_{\text{pl}}^4$

$$P = -\rho$$

$$T_{\mu\nu}^{\text{M}} = \frac{1}{2} g^{\mu\nu} \rho$$

The diagram shows a tensor $T_{\mu\nu}^{\text{M}}$ on the left, followed by an equals sign, and then a diagram of a metric tensor $g^{\mu\nu}$ on the right. The metric tensor is represented by a circle with a vertical line through its center, and three upward-pointing arrows below it, indicating its components.

$$\rho_{\text{vac}} \sim M_{\text{pl}}^4$$

$$P = -\rho$$

$$T_{\mu\nu} = \Delta g_{\mu\nu}$$

$$\Delta < 10^{-120} M_{pl}^4$$
$$\sim (10^{-3} \text{ eV})^4$$

$$\Delta_{\text{est}} < 10^{-120} M_{\text{pl}}^4$$
$$\sim (10^{-3} \text{ eV})^4$$

$$\Delta = \Delta_{cl} + \Delta_{\text{quantum}}$$

$$\Delta = \Delta_{cl} + \Delta_{\text{quantum}}$$

2.367 469.
lab list

$$\text{triangle} = \text{triangle} \text{cl} + \text{triangle quantum}$$

$$= -2.3617 \dots$$

$$2.3617 \dots \quad 469 \dots$$

~~~~~  
lab      list

Cosmological Const. Problem:

$4 \pi r^2$



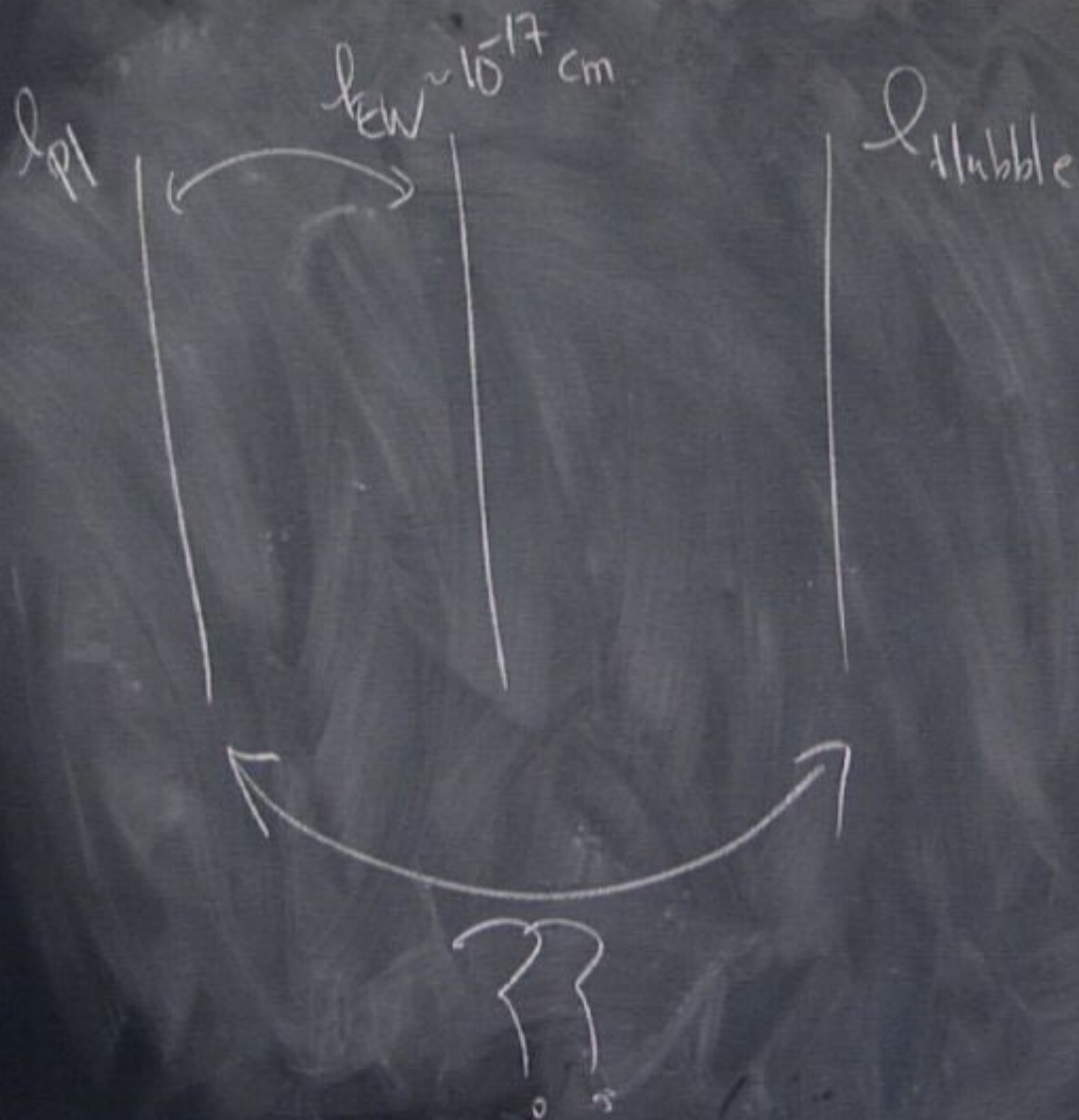
# Cosmological Const. Problem:

$$\Lambda \sim P_{\max}^4 + P_{\max}^2 m^2 + \dots$$

# Cosmological Const. Problem:

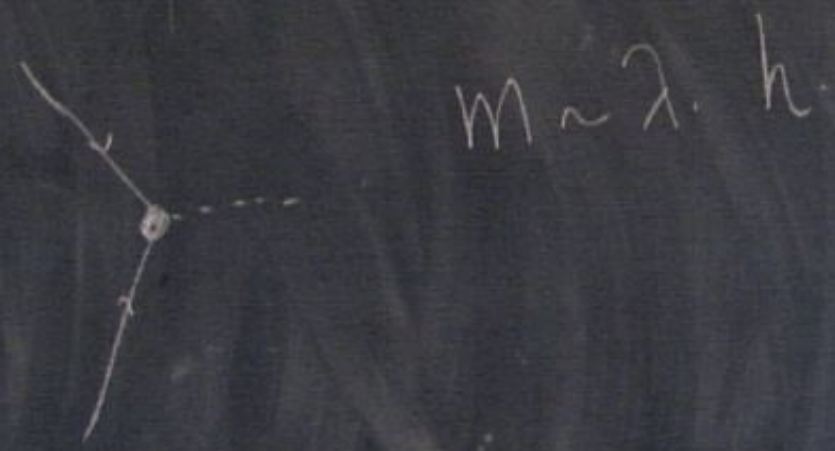
$$\Lambda \sim \rho_{\text{max}}^4 + \rho_{\text{max}}^2 m^2 + \dots$$

$$\rho_{\text{vac}} = \int d^3 p \left( \frac{1}{F} \sqrt{p^2 + m^2} - \frac{1}{F} \sqrt{p^2 + m^2} \right)$$



$$P_{\text{vac}} \sim P_{\text{max}}^4 + P_{\text{max}}^2 m^2$$

$\sigma_{vac} \sim P_{max}^4 + P_{max}^2 m^2$



$m \sim \lambda \cdot h$

$$P_{\text{vac}} \sim P_{\text{max}}^4 + P_{\text{max}}^2 m^2$$



$$m_e \sim \lambda_e(h)$$

$$m_t \sim \lambda_t(h)$$

$$P_{\text{vac}} \sim P_{\text{max}}^2$$

$$+ P_{\text{max}}^2 m^2$$



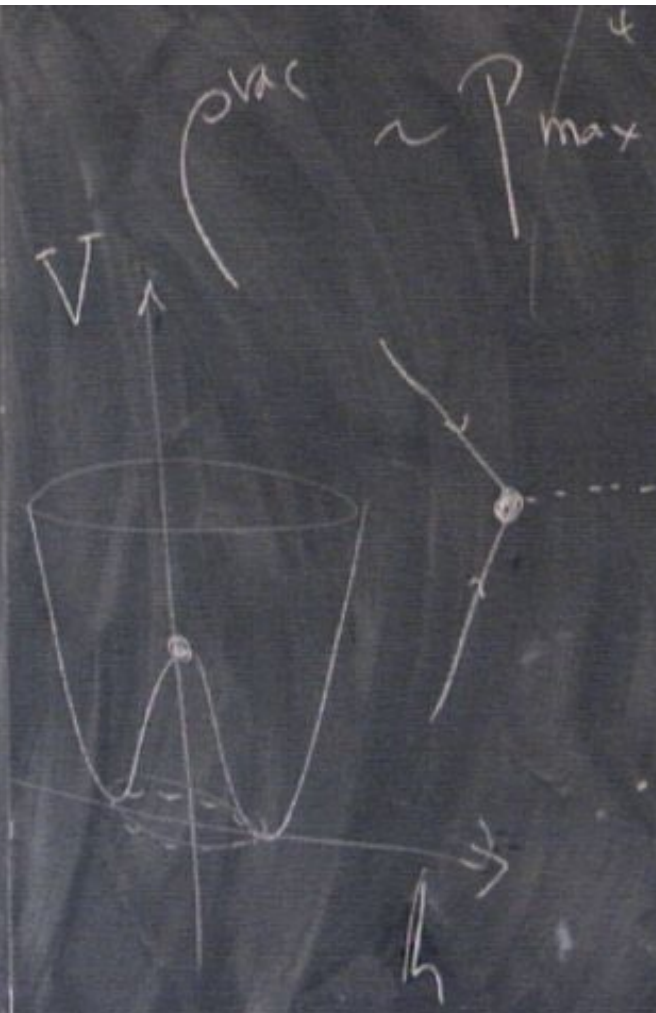
$$m_e \sim \lambda_e(h)$$

$$m_t \sim \lambda_t(h)$$

$l_{\text{Hubble}}$

$$V \sim -M^2 h^2$$

$$+ \lambda h^4$$
$$+ \frac{h^6}{\Lambda^2}$$





$l_{\text{Hubble}}$

$$V \sim -M^2 h^2$$

$$+ \lambda h^4$$

$$M \sim \sqrt{100 \text{ GeV}}$$

$V$

vac

$\sim P_{\text{max}}$



$$V_{(m)} = -M \hbar^2 + \lambda \hbar^4$$

$$+ V_{\text{quantum}}$$

$$V_{(n)} = -M \hbar^2 + \lambda \hbar^4$$

+  $V_{\text{quantum}}$

$$p_{\text{max}}^2 \lambda \hbar^2$$

$$V_{(n)} = -M \hbar^2 + \lambda \hbar^4$$

+  $V_{\text{quantum}}$

$$p_{\text{max}}^2 \lambda \hbar^2$$

$$M_{\text{actual}} = M_{cl} + p_{\text{max}}^2 \lambda$$

$$-1.3467 \dots \quad 1.3467 \dots$$

$$V_{(m)} = -M^2 h^2 + \lambda h^4$$

+  $V_{\text{quantum}}$

$$p_{\text{max}}^2 \lambda^2 h^2$$

$$M_{\text{actual}}^2 = M_{cl}^2 + p_{\text{max}}^2 \lambda^2$$

$$-1.3467 \dots$$

??

$$+1.3467 \dots$$

??

$$P_{\text{vac}} \sim P_{\text{max}}^4 + P_{\text{max}}^2 m^2$$
$$m \sim \lambda \cdot h$$

$$P_{\text{vac}} \sim P_{\text{max}}^4 + P_{\text{max}}^2 m^2$$

$$m \sim \lambda \cdot h$$

$$\sim P_{\text{max}}^4 + 2 P_{\text{max}}^2 h^2$$

adjust  $10^{32}$   
to acc.

$$= -Mh^2 + \lambda h^4$$

$V_0$  ← adjust  
to  $10^{120}$

+  $V_{\text{quantum}}$

$$p_{\text{max}}^2 \lambda^2 h^2$$

$$M_{\text{actual}}^2 = M_4^2 + p_{\text{max}}^2 \lambda^2$$

1.3467...

$10^{32}$

1.3467...

$10^{32}$



$l_{pl} \sim 10^{-33}$  cm

$l_{ew} \sim 10^{-17}$  cm

$l_{universe} \sim 10^{28}$  cm

Where does  
spacetime  
come from?

Hierarchy Prob

Why is Gravity  
Weak?

C.C. Pallen Why is Uni  
Big