Research Institute for Fundamental Physics
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$$\frac{1}{16}x^2 - \frac{1}{8}\left[2+r+\frac{6}{C}\right]x + \frac{1}{4}(2+r^2) - \left(\frac{1}{4}+\frac{1}{4}r+\frac{r^2}{16}\right) = 0$$

$$\frac{1}{4}\left[1-r+\frac{3}{4}r^2\right]$$

$$x^2 - 2\left(2+r+\frac{6}{C}\right)x + 4\left(1-r+\frac{3}{4}r^2\right) = 0$$

$$\frac{36}{3C} \equiv t = \frac{36}{3}\cdot 16\pi^2/\ln\Lambda^2 = \frac{96\pi^2}{\ln\Lambda^2}$$

$$= 96\pi^2/\ln\Lambda = \frac{\cancel{48}\,24\,\pi^2}{\ln\Lambda}$$

GUT $\frac{\Lambda}{m} = 10^{13}$ $\ln \cong 30$ $t \cong \cancel{30}\ 16$

Planck $\frac{\Lambda}{m} = 10^{17}$ $\ln \sim 40$ $t \sim \cancel{40}\ 12$

$\Lambda/m = 1.3\times10^4$ $\ln \sim 9.5$ $t \sim 50$

$$x = (2+r+t) \pm \sqrt{(2+r+t)^2 - 4\left(1-r+\frac{3}{4}r^2\right)}$$

$$= (2+r+t) + \sqrt{2r(4-r) + 2(2+r)t + t^2}$$

$t \sim \cancel{30}\ 16$ dominant $x^2 - 2tx \sim 0$

$x \sim 2t$ too large?

at GUT ~ 30 $\sqrt{x} \sim 5\ldots$

at Planck ~ 25 $\sqrt{x} \sim 5$

$\frac{\Lambda}{m} = 10^{17}$	$t = 12$:	$x = 30.5$ ($x_- = .127$	$\sqrt{x} = 5.5$ $\sqrt{x_-} = .35$	$m_h = 441$ 28.5	$m_t = 233$ 74)
10^{13}	$= \cancel{50}\ 16$:	$x = 38.5$ ($x_- = .10$	6.2 .32	496 25	258 73.7
$1.7\cdot10^8$	25:	$x = 56.5$	7.5	601	309
$1.3\cdot10^4$	50:	$x = 106.5$	10.3	826	419

$t = 0$ $x = 5.9$

$$m_f^2 = \frac{1}{4} m_H^2 + \frac{1}{4}(2m_W^2 + m_Z^2)$$

$$f^2 m_f^{2\,*} = \frac{1}{8} G^2 m$$

$$f^2 = G^2 + \frac{1}{4}(2g^2 + g_Z^2) \quad \rightarrow \quad m_f^2 = \frac{1}{4} m_H^2 + \frac{1}{4}(2m_W^2 + m_Z^2) \quad (1)$$

$$f^2 m_f^2 = \frac{1}{2} G^2 m_H^2 + \frac{1}{4}(2g^2 m_W^2 + g_Z^2 m_Z^2)$$

$$m_f^4 = \frac{1}{8} m_H^4 + \frac{1}{4}(2m_W^4 + m_Z^4) \quad (2)$$

$$\begin{cases} z = \frac{1}{4}x + \frac{1}{4}(2+\xi) \\ z^2 \overset{<}{=} \frac{1}{8}x^2 + \frac{1}{4}(2+\xi^2) \quad ? \end{cases}$$

$\xi =$ $(\sin^2\theta = .23)$

$$\xi = \frac{1}{\cos^2\theta} = \frac{1}{0.78} = 1.282$$

$$\xi^2 = 1.644$$

$$\begin{cases} x_0 = .73 \\ z_0 = 1. \end{cases}$$

$$2+\xi = 3.282$$
$$2+\xi^2 = 3.644$$

$$\frac{1}{4}(2+\xi) = 0.821$$
$$\frac{1}{4}(2+\xi^2) = 0.911$$

If $x = 1.$ $\quad z = .25 + .82 = 1.07$

$$1.14 = z^2 \overset{<}{=} .125 + .911 = 1.16$$

I, II ~~equals~~ equality $\quad \xi = 1.282$

$\sin^2\theta = .228$

$$\begin{cases} x = .64 \\ z = .98 \end{cases}$$

~~$\sin^2\theta = 0.23$~~

$$\begin{cases} x = .649 \\ z = .987 \end{cases}$$

$\sin^2\theta = .23$

$\xi = 1.299 \qquad 2+\xi = 3.3$

$\xi^2 = 1.6866 \qquad 2+\xi^2 = 3.69$

$$\frac{2+\xi}{4} = .8247$$

$$\frac{2+\xi^2}{4} = .9216$$

$\cancel{\gamma\cdot a\, k},$

$$\gamma_\lambda F_{\lambda\mu} \rightarrow (\gamma\cdot a\, k_\mu - \gamma\cdot k\, a_\mu) \qquad (\gamma\cdot a' k_\nu - \gamma\cdot k\, a'_\nu)$$

$$\rightarrow \frac{\gamma\cdot\gamma\, k_\mu k_\nu - \gamma_\nu k_\mu \gamma\cdot k - \gamma\cdot k\, k_\nu \gamma_\mu + (\gamma\cdot k)^2 g_{\mu\nu}}{[(p-k)^2 - m_f^2]\ [k^2 - m_V^2]}$$

$$k \rightarrow k' + \alpha p$$

$$\rightarrow \quad 4\left(\frac{k'^2}{4} g_{\mu\nu} + \alpha^2 p_\mu p_\nu\right) - \left(\gamma_\nu \gamma_\mu \frac{1}{4} k'^2 + \alpha^2 \gamma_\nu p_\mu \gamma\cdot p\right) - \left(\gamma_\nu \gamma_\mu \frac{k'^2}{4} + \alpha^2 \gamma\cdot p\, \gamma_\mu p_\nu\right)$$

$$+ \ g_{\mu\nu}\,(k'^2 + \alpha^2 p^2)$$

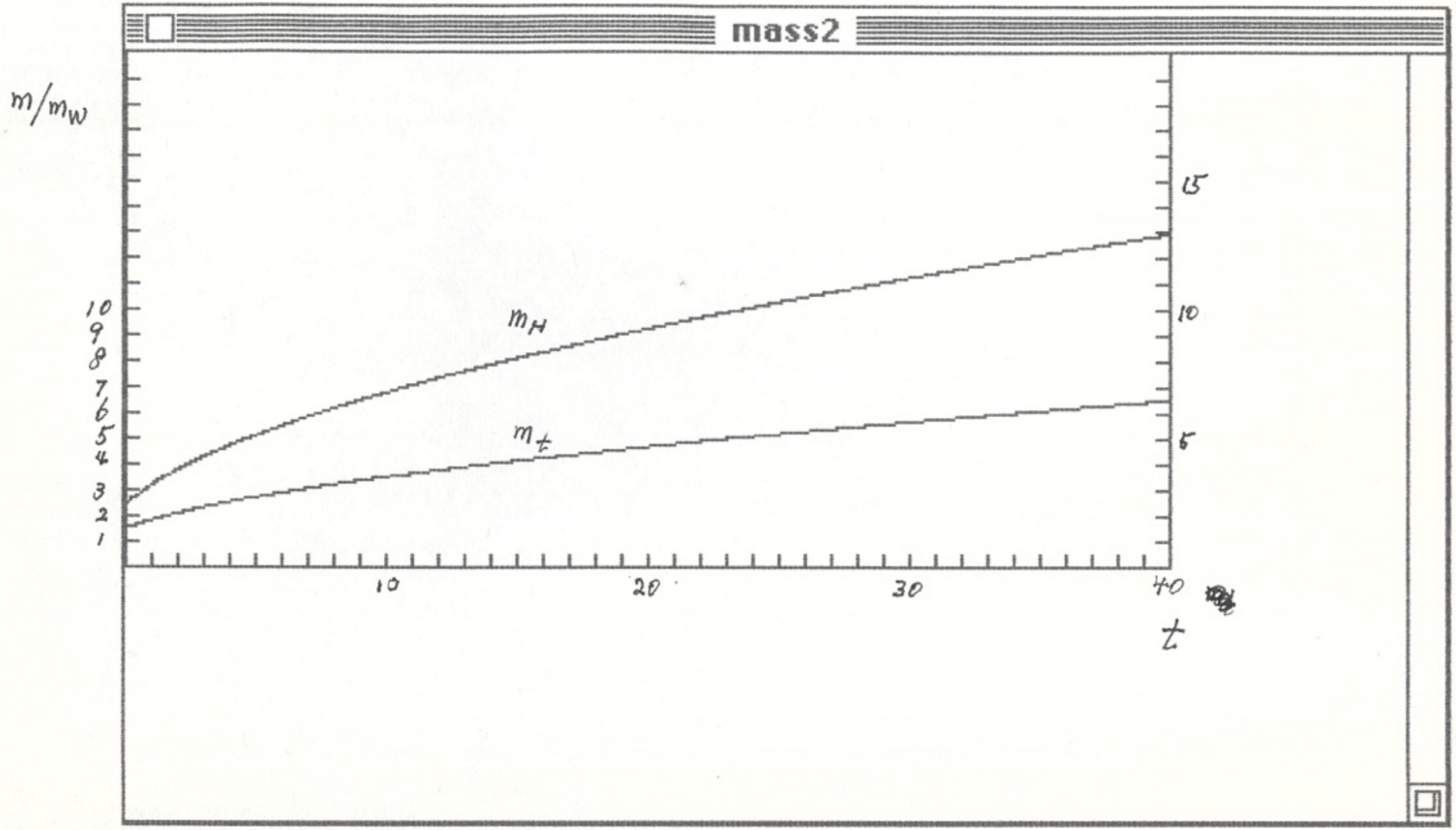
$$= (5k'^2 + \alpha^2 p^2)\, g_{\mu\nu} + 4\alpha^2 p_\mu p_\nu - \gamma_\nu \gamma_\mu \frac{k'^2}{2} - \alpha^2 \gamma_\nu p_\mu \gamma\cdot p - \alpha^2 \gamma\cdot p\, \gamma_\mu p_\nu$$

$$(\gamma\cdot a\, k_\mu - \gamma\cdot k\, a_\mu)\ \gamma\cdot \overset{(p-k)}{p}\ (\gamma\cdot a' k_\nu - \gamma\cdot k\, a'_\nu)$$

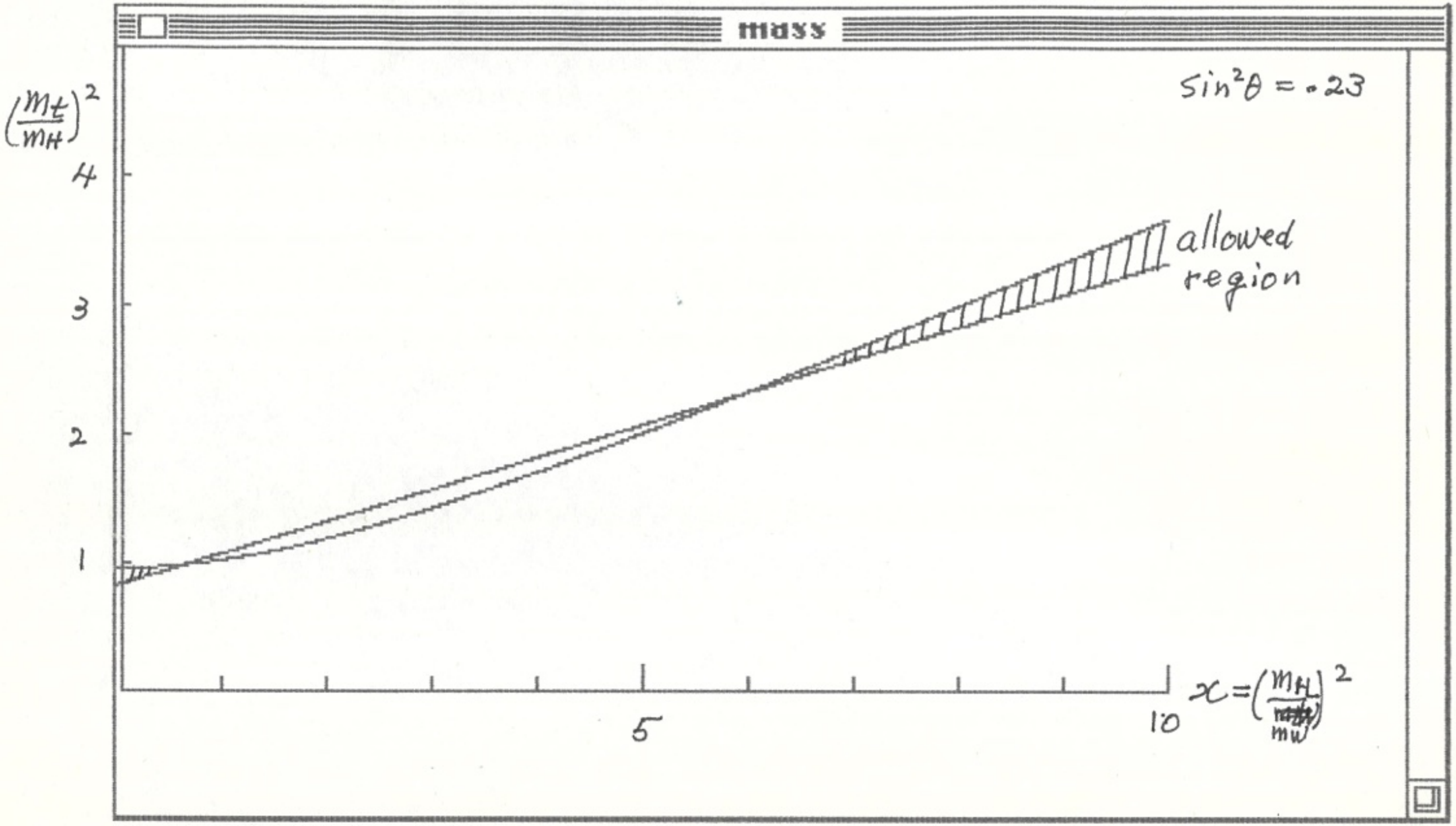
$$\rightarrow (1-\alpha)\ (\gamma\cdot a\, k_\mu - \gamma\cdot k\, a_\mu)\ \gamma\cdot p\ (\gamma\cdot a' k_\nu - \gamma\cdot k\, a'_\nu)$$

$$- \quad (\qquad\qquad)\ \gamma\cdot k'\ (\qquad\qquad)$$

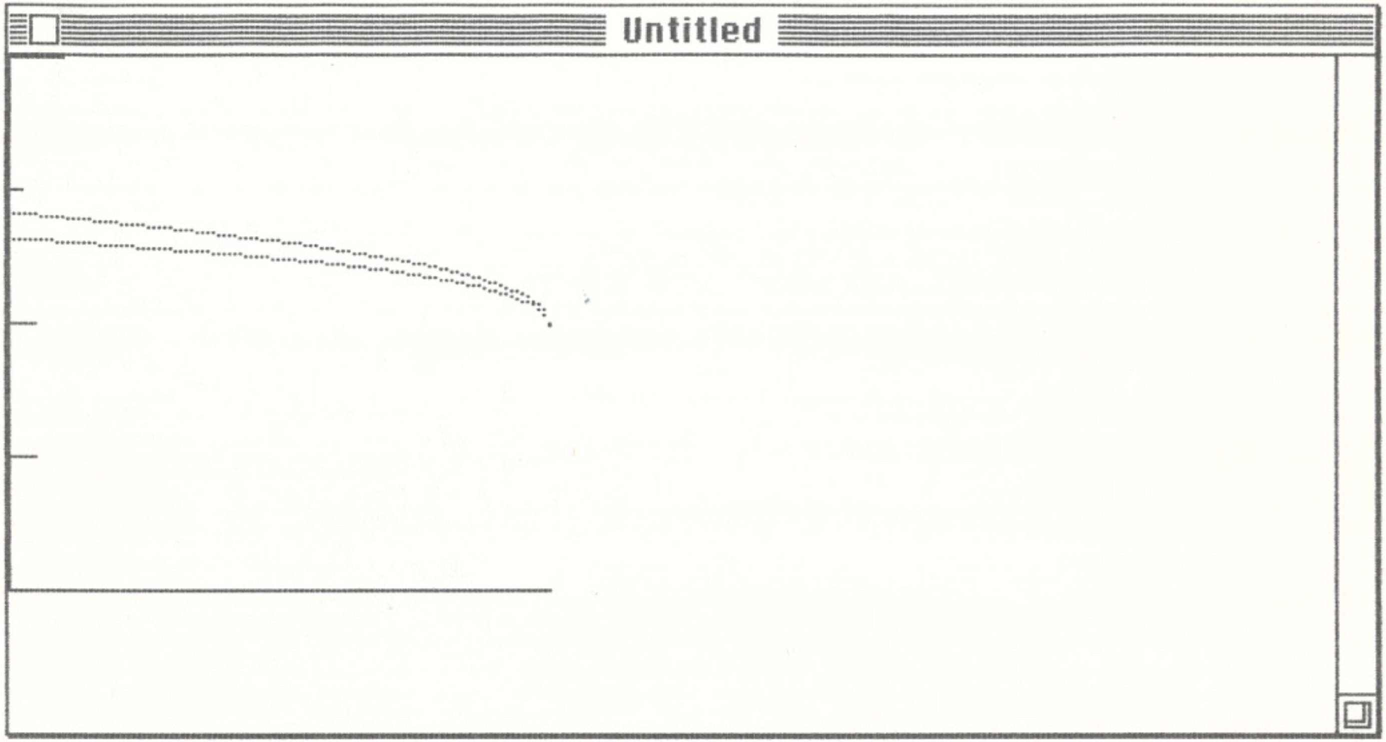
$$\rightarrow (1-\alpha)\ [-2 k_\mu k_\nu\, \gamma\cdot p - 2\alpha^2 p_\mu p_\nu\, \gamma\cdot p$$



mass2
m/mW
10
9
8
7
6
5
4
3
2
1
15
10
5
10
20
30
40
mH
mt
t



mass
$\sin^2\theta = .23$
$\left(\frac{m_t}{m_H}\right)^2$
4
3
2
1
allowed region
5
10
$x = \left(\frac{m_H}{m_W}\right)^2$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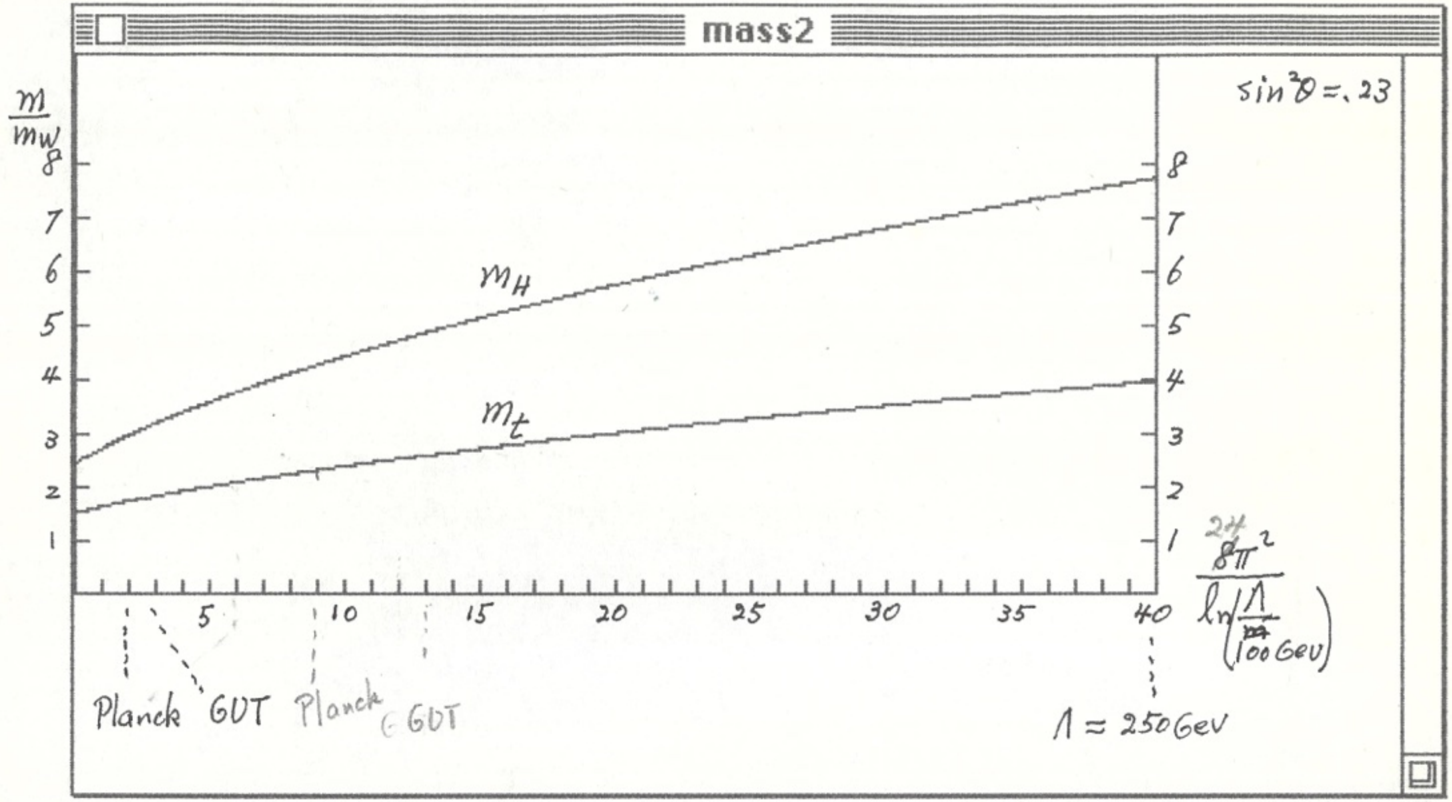
mass2
$\frac{m}{m_W}$
$\sin^2\theta = .23$
m_H
m_t
8
7
6
5
4
3
2
1
5
10
15
20
25
30
35
40
$\frac{24\pi^2}{\ln\left(\frac{\Lambda}{100\,GeV}\right)}$
Planck
GUT
Planck
GUT
$\Lambda = 250\,GeV$