

Title: Particle Physics Lecture

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Collection: Particle Physics

Date: March 11, 2024 - 11:30 AM

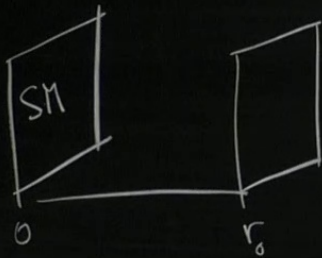
URL: <https://pirsa.org/24030020>

# Large Extra Dimensions

(+, -, -, - ...)

$$ds^2 = g_{\mu\nu} dx^\mu dx^\nu + r_0^2 d\Omega_n^2 + dr^2$$

$\frac{4+n}{4}$  dim



$$S_{4+n} = -M_*^{n+2} \int d^{4+n}x \sqrt{g^{(4+n)}} R^{(4+n)}$$

$$\sqrt{g^{(4+n)}} = r_0^n \sqrt{g^{(4)}}$$

$$R^{(4+n)} = R^{(4)}$$

$$\int d^n x = \int d\Omega_n r_0^n$$

$$S_{4\text{eff}} = - M_*^{n+2} \int d\sigma_{(n)} r_0^n \int d^4x \sqrt{g^{(4)}} R^{(4)}$$

$$M_{\text{Pl}}^2 = M_*^{n+2} (2\pi r_0)^n$$

$$\tau_0^{-1} = M_* \left( \frac{M_*}{M_{\text{Pl}}} \right)^{2/n}$$

$$n=1, \quad M_* = \text{TeV} = 10^{12} \text{ eV}$$

$$\tau_0^{-1} = 10^{12} \text{ eV} \left( \frac{10^{12}}{10^{28}} \right)^2 = 10^{12} \cdot 10^{-32} \text{ eV} = 10^{-20} \text{ eV} = (10^5 \text{ s})^{-1}$$

$$n=2, \quad \tau_0^{-1} = 10^{-4} \text{ eV} \sim \text{mm}^{-1}$$

$$n=3, \quad \tau_0^{-1} = 10 \text{ eV} \sim \mu\text{m}^{-1}$$

$R^{(4)}$

$$M_* = \text{TeV} = 10^{12} \text{ eV}$$

$$\begin{aligned} \lambda &= 10^{12} \text{ eV} \left( \frac{10^{12}}{10^{28}} \right)^2 = \\ &= 10^{12} \cdot 10^{-32} \text{ eV} = 10^{-20} \text{ eV} \\ &= (10^5 \text{ fs})^{-1} \end{aligned}$$

$$\lambda^{-1} = 10^{-4} \text{ eV} \sim \text{mm}^{-1}$$

$$\lambda_0^{-1} = 10 \text{ eV} \sim \mu\text{m}^{-1}$$

$$4-d \quad F = G_N \frac{m_1 m_2}{r^2}$$

$$5-d \quad F = \frac{1}{M_*^3} \frac{m_1 m_2}{r^3}$$

$$6-d \quad F = \frac{1}{M_*^4} \frac{m_1 m_2}{r^4}$$

$$F^{(4+n)} = \frac{1}{M_*^{2+n}} \frac{m_1 m_2}{r^{2+n}}$$

$$g_{\text{eff}} = - M_*^{n+2} \int d\phi_{(n)} v_0^n \int d^4x \sqrt{g^{(4)}} R^{(4)}$$

$$M_{\text{Pl}}^2$$

$$M_{\text{Pl}}^2 = M_*^{n+2} (2\pi\alpha')^n$$

$$\tau_0^{-1} = M_* \left( \frac{M_*}{M_{\text{Pl}}} \right)^{2/n}$$

$$n=1, \quad M_* = \text{TeV} = 10^{12} \text{ eV}$$

$$\tau_0^{-1} = 10^{12} \text{ eV} \left( \frac{10^{12}}{10^{28}} \right)^2 = 10^{12} \cdot 10^{-32} \text{ eV} = 10^{-20} \text{ eV} = (10^5 \text{ s})^{-1}$$

$$n=2$$

$$\tau_0^{-1} = 10^{-4} \text{ eV} \sim \text{mm}^{-1} \rightarrow \text{close to exclusion} \rightarrow \text{Solar system}$$

$$n=3 \quad \tau_0^{-1} = 10 \text{ eV} \sim \mu\text{m}^{-1} \checkmark$$

$$ds^2 = \left(1 - \frac{r_s}{r}\right) dt^2 + \left(1 - \frac{r_s}{r}\right)^{-1} dr^2 - r^2 d\Omega$$

$$r_s = \frac{2G_N m}{c^2}$$

$$1 - \frac{2G_N M}{r} \rightarrow 1 - \frac{2M}{M_*^{n+2} r^{1+n}}$$

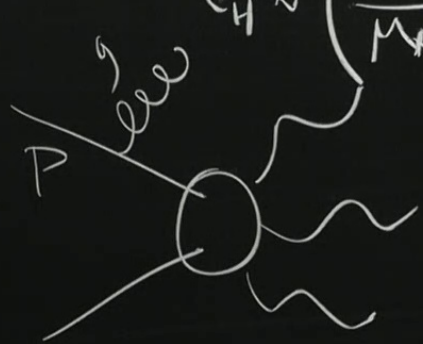
$$\tau_H \sim \left(\frac{M}{M_*}\right)^{\frac{1}{1+n}} \frac{1}{M_*}$$

$$\sigma \sim \pi r_H^2$$

BH @ LHC

~~SM p + E~~

$1 - \frac{2G_N M}{r} \rightarrow 1 - \frac{2M}{M_*^{n+2} r^{1+n}}$   
 $\tau_H \sim \left(\frac{M}{M_*}\right)^{\frac{1}{1+n}} \frac{1}{M_*}$   
 $\sigma \sim \pi r_H^2$   
 BH @ LHC  
~~SM p + E~~



monojet + ~~E~~

$(4, 1, 0) \rightarrow u + d + \dots$

$$\Delta m \sim \frac{1}{r} \ll M^*$$

$$\frac{d^2 \sigma}{dt dm} \propto \frac{m^{n-1}}{M_*^{n+2}}$$

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$$\left| \frac{\dot{T}}{T} \right| = H = \frac{T^2}{M_{pl}}$$

$n = 2$        $\dots$        $6$       ev.

$$\left| \frac{\dot{T}}{T} \right| \sim \frac{T^{n+3}}{M_*^{n+2}}$$

$T_* \ll 20 \text{ MeV}$        $T_* \ll \text{few GeV}$

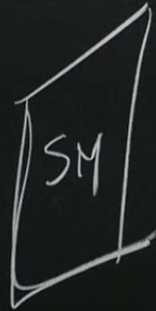


Randall-Sundrum

$$ds^2 = e^{-2ky} \eta_{\mu\nu} dx^\mu dx^\nu - dy^2$$



UV  $y=0$



IR  $y=y_0$

$$M_{pl}^2 = \frac{M_3}{k} (1 - e^{-2ky_0})$$

$$g_{\mu\nu} = e^{-2ky_0} g_{\mu\nu}^{SM}$$

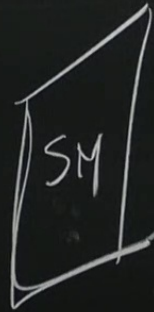
$$V_{eff} = e^{-ky_0} V_{uv}$$

$$ds^2 = e^{-2ky} \eta_{\mu\nu} dx^\mu dx^\nu - dy^2$$

Randall - Sundrum



$UV \ y=0$



$IR \ y=y_0$

$$M_{\text{eff}} = M_3 e^{-ky_0} M_{\text{pl}}^2 = \frac{M_3}{k} (1 - e^{-2ky_0})$$

R.S.I

$$g_{\mu\nu}^{\text{SM}} = e^{-2ky_0} g_{\mu\nu}$$

$$V_{\text{eff}} = e^{-ky_0} V_{uv}$$