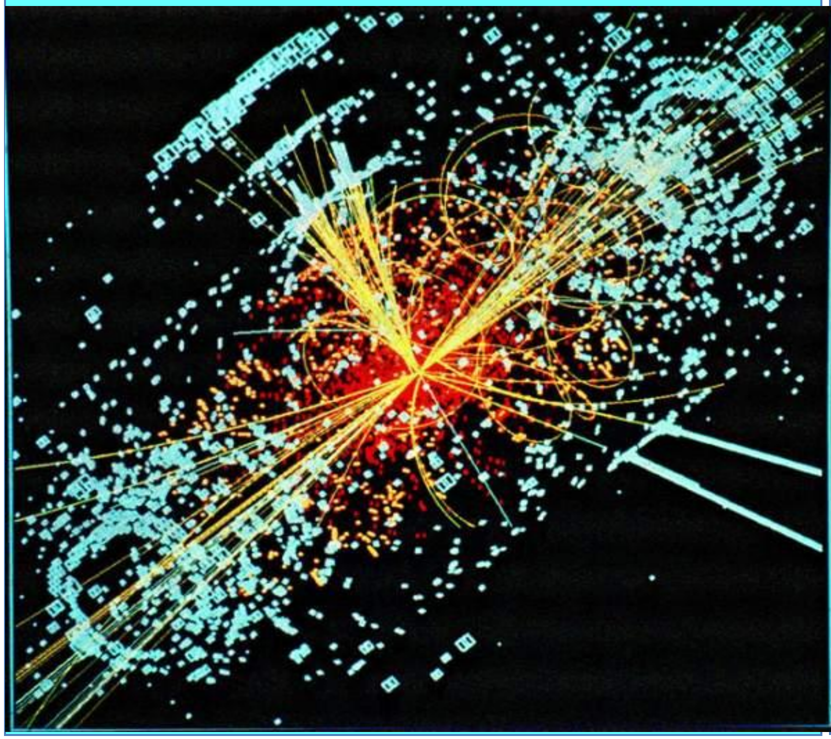
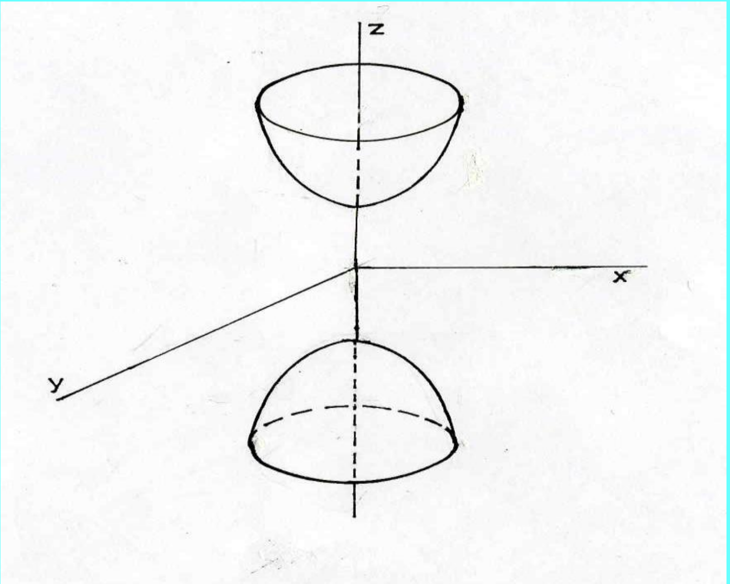
A MAXIMAL MASS MODEL

Matey Mateev, University of Sofia





$$z^2 - x^2 - y^2 = R^2$$

V. G. Kadyshevsky, V. N. Rodionov and A. S. Sorin
(M. V. Chizhov, P. Danev)

Almost all detailes may be found in

Towards a Maximal Mass Model

hep-ph/30.08.2007

hep-ph/30.08.2007

CERN-TH/2007-150

TOWARDS A MAXIMAL MASS MODEL

V. G. Kadyshevsky

Joint Institute for Nuclear Research, Dubna, R-141980, Russia, and CERN, PH-TH, 1211 Geneva, Switzerland.

M. D. Mateev

Faculty of Physics, University of Sofia "St. Kliment Ohridsky", 1164 Sofia, Bulgaria, and CERN, PH-TH, 1211 Geneva, Switzerland.

V. N. Rodionov

Moscow State Geological Prospecting University, 118617 Moscow, Russia.

A. S. Sorin

Joint Institute for Nuclear Research, Dubna, R-141980, Russia.

We investigate consequences
of introduction
a new principle in local QFT:

Principle of existence of
a maximal mass M:

$m < M$

On this ground we generalize the Standard Model to a Maximal Mass Model

The three main components of the Standard Model are:

1. Local QFT
2. Local gauge SU(3)xSU(2)xU(1) invariance
3. Higgs mechanism for generation of masses

SM describes well the existing experimental data.

The fundamental physical constants

c — velocity of light

ħ — Planck constant

G — Newton gravitational constant

allow simple geometrical or group theoretical interpretation.

For instance in special relativity the 3-dimensional velocity space is a Lobachevsky space with curvature $-1/c^2$.

$$u = \left(\frac{1}{\sqrt{1-\frac{v^2}{c^2}}}, \frac{\frac{\vec{v}}{c}}{\sqrt{1-\frac{v^2}{c^2}}} \right)$$

$$u_0^2 - \vec{u}^2 = 1$$

"Lobachevsky geometry", 1826

$$(\Box + m^2)\varphi(x) = 0$$

$$\varphi(x) = \frac{1}{(2\pi)^{3/2}} \int e^{-ip_\mu x^\mu} \varphi(p) d^4 p$$

$$(p_\mu x^\mu = p^0 x^0 - \vec{p}.\vec{x})$$

$$(m^2 - p^2)\varphi(p) = 0,\ p^2 = p_0^2 - \vec{p}^2$$

$$m^2 = p_0^2 - \vec{p}^2$$

$$m \le M$$

We use Anti-De Sitter geometry of momentum space:

$$p_0^2 - \vec{p}^{\,2} + p_5^2 = M^2$$

$$p_0^2 - \vec{p}^{\,2} = m^2$$

Here we have: $m \leq M$

$$(p_0^2 - \vec{p}^{\,2} + p_5^2 - M^2)\varphi(p_0, \vec{p}, p_5) = 0$$

$$\varphi(p_0, \vec{p}, p_5) = \delta(p_0^2 - \vec{p}^{\,2} + p_5^2 - M^2)\tilde{\varphi}(p_0, \vec{p}, p_5)$$

$$\tilde{\varphi}(p_0, \vec{p}, p_5) \equiv \varphi(p, p_5) = \begin{pmatrix} \varphi(p, |p_5|) \\ \varphi(p, -|p_5|) \end{pmatrix} = \begin{pmatrix} \varphi_1(p) \\ \varphi_2(p) \end{pmatrix}, |p_5| = \sqrt{M^2 - p^2}.$$

The sign of p_5 is a new degree of freedom

$$(m^2 - p_0^2 + \vec{p}^{\,2})\varphi(p_0, \vec{p}, p_5) = 0$$

$$m^2 + p_5^2 - M^2 = p_5^2 - M^2\left(1 - \frac{m^2}{M^2}\right)$$

$$\cos\mu = \sqrt{1 - \frac{m^2}{M^2}},$$

$$(p_5 + M\cos\mu)(p_5 - M\cos\mu)\varphi(p, p_5) = 0$$

Klein-Gordon equation in Anti de Sitter momentum space

$$2M(p_5 - M\cos\mu)\varphi(p, p_5) = 0$$

$$2M(|p_5| - M\cos\mu)\varphi_1(p) = 0,$$

$$2M(|p_5| + M\cos\mu)\varphi_2(p) = 0,$$

$$\varphi_1(p) = \delta(p^2 - m^2)\tilde{\varphi}_1(p)$$

$$\varphi_2(p) = 0$$

"Flat" limit is defined as transition from Anti De Sitter to Minkowski momentum space and it corresponds to:

$$M^2 >> p^2 \quad \text{and} \quad p_5 \approx M$$

In the flat limit:

$$|p_5| = M\sqrt{1 - \frac{p^2}{M^2}} \approx M - \frac{p^2}{2M}, \cos\mu = \sqrt{1 - \frac{m^2}{M^2}} \approx 1 - \frac{m^2}{2M^2}$$

and

$$2M(p_5 - M\cos\mu) \approx p^2 - m^2$$

The action may be written in 5-dimensional form:

$$S_0(M) = 2\pi M \times$$

$$\int \varepsilon(p_5)\delta(p_L p^L - M^2) d^5p \, [\varphi^+(p, p_5) 2M(p_5 - M\cos\mu)\varphi(p, p_5)]$$

$$L = 1, 2, 3, 4, 5,$$

where

$$\varepsilon(p_5) = \frac{p_5}{|p_5|}.$$

Euclidean formulation

$$p_0 \to i p_4$$

$$-p_n^2 + p_5^2 = M^2, \qquad n = 1, 2, 3, 4$$

$$p_5 = \pm\sqrt{M^2 + p^2}$$

$$m^2 + p^2 = (p_5 + M\cos\mu)(p_5 - M\cos\mu)$$

De Sitter – O(4, 1)

We may integrate over $\boldsymbol{p}_5$

$$S_0(M) = \pi M \times$$

$$\int \frac{d^4p}{|p_5|}\left[\varphi_1^+(p)2M(|p_5| - M\cos\mu)\varphi_1(p) + \varphi_2^+(p)2M(|p_5| + M\cos\mu)\varphi_2(p)\right]$$

$$\varphi_{1,2}(p) \equiv \varphi(p, \pm|p_5|)$$

$$\varphi(p) = \frac{\varphi_1(p) + \varphi_2(p)}{|p_5|} M\,, \chi(p) = \varphi_1(p) - \varphi_2(p)$$

$$\varphi_1(p) = \frac{\varphi(p)|p_5| + M\chi(p)}{2M}, \varphi_2(p) = \frac{\varphi(p)|p_5| - M\chi(p)}{2M}$$

$$S_0(M) = \pi M \times$$

$$\times \int d^4 p \,\text{[redacted]}^{+}(p)(p^2 + m^2)\varphi(p) + (\chi(p) - M \cos \mu\varphi(p))^2$$

Fourier transform and configuration space:

$$\frac{2M}{(2\pi)^{3/2}}\int e^{-ip_K x^K}\delta(p_L p^L - M^2)\varphi(p, p_5)d^5 p = \varphi(x, x_5)$$

$$K, L = 1,2,3,4,5.$$

$$\left(\frac{\partial^2}{\partial x_5^2} - \Box + M^2\right)\varphi(x, x_5) = 0$$

$$\varphi(x, x_5) = \frac{2M}{(2\pi)^{3/2}} \int e^{ip_n x^n} \frac{d^4 p}{|p_5|} \left[e^{-i|p_5|x^5} \varphi_1(p) + e^{i|p_5|x^5} \varphi_2(p) \right]$$

$$\varphi^+(x, x_5) = \varphi(x, -x_5),$$

$$\frac{i}{M} \frac{\partial \varphi(x, x_5)}{\partial x_5} = \frac{1}{(2\pi)^{3/2}} \int e^{ip_n x^n} d^4 p \left[e^{-i|p_5|x^5} \varphi_1(p) - e^{i|p_5|x^5} \varphi_2(p) \right]$$

initial data are given at $x_5 = 0$:

$$\varphi(x, 0) \equiv \varphi(x) = \frac{2M}{(2\pi)^{3/2}} \int e^{ip_n x^n} d^4 p \frac{\varphi_1(p) + \varphi_2(p)}{|p_5|}$$

$$\frac{i}{M} \frac{\partial \varphi(x, 0)}{\partial x_5} \equiv \chi(x) = \frac{1}{(2\pi)^{3/2}} \int e^{ip_n x^n} d^4 p \left[\varphi_1(p) - \varphi_2(p) \right]$$

Why Euclidean formulation?

$$\varphi(x,x_5) \equiv \frac{2M}{(2\pi)^{3/2}} \int e^{-ip_0x_0+\boldsymbol{px}-ip_5x_5}\delta(p_0^2-\boldsymbol{p}^2+p_5^2-M^2)\varphi(p,p_5)d^5\,p$$

$$\varphi(x,0) \equiv \varphi(x) = \frac{M}{(2\pi)^{3/2}} \int_{p^2\le M^2} e^{-ipx} d^4p \frac{\varphi(p,|p_5|)+\varphi(p,-|p_5|)}{|p_5|}$$

$$\frac{i}{M}\frac{\partial\varphi(x,0)}{\partial x_5} \equiv \chi(x) = \frac{1}{(2\pi)^{3/2}} \int_{p^2\le M^2} e^{-ipx} d^4p\,[\varphi(p,|p_5|) - \varphi(p,-|p_5|)]$$

$$\left(\frac{\partial^2}{\partial x_0^2} + \frac{\partial^2}{\partial x_5^2} - \frac{\partial^2}{\partial \boldsymbol{x}^2} + M^2\right)\varphi(x,x_5) = 0$$

$$S_0(M) = \frac{1}{2}\int d^4\,x \left[\left|\frac{\partial\varphi(x,x_5)}{\partial x_n}\right|^2 + m^2|\varphi(x,x_5)|^2 + \left|i\frac{\partial\varphi(x,x_5)}{\partial x_5} - M\cos\mu\varphi(x,x_5)\right|^2\right] \equiv$$

$$\equiv \int L_0(x,x_5)d^4\,x. \tag{30}$$

$$\frac{\partial S_0(M)}{\partial x_5} = 0$$

$$S_0(M) = \frac{1}{2}\int d^4\,x \left[\left(\frac{\partial\varphi(x)}{\partial x_n}\right)^2 + m^2(\varphi(x))^2 + M^2\left(\chi(x) - \cos\mu\varphi(x)\right)^2\right]$$

$$\equiv \int L_0(x,M)d^4\,x.$$

Higgs potential:

$$U(\varphi,\chi;M)=\frac{1}{2}(M^2-\frac{\lambda^2\nu^2}{2})(\varphi(x)-\chi(x))^2+$$

$$+\frac{\lambda^2}{4}(\frac{\varphi^2(x)+\chi^2(x)}{2}-\nu^2)^2.$$

$$m=m_0\sqrt{1-\frac{m_o^2}{4M^2}}\quad , \qquad m_0=\sqrt{2}\lambda v.$$

$$1-\frac{m^2}{M^2}=\left(1-\frac{m_0^2}{2M^2}\right)^2\geq 0\rightarrow m\leq M$$

$$L_{tot}(x) = \frac{1}{2}\left(\frac{\partial\varphi(x)}{\partial x_n}\right)^2 + \frac{M^2}{2}\left(\varphi(x) - \chi(x)\right)^2 + \frac{\lambda^2}{4}\left(\frac{\varphi^2(x) + \chi^2(x)}{2} - v^2\right)^2$$

$$\varphi(x) \to -\varphi(x)$$
$$\chi(x) \to -\chi(x)$$

$$\varphi(x) = \varphi'(x) + v$$
$$\chi(x) = \chi'(x) + v$$

$$\frac{1}{2}\left(\frac{\partial\varphi'(x)}{\partial x_n}\right)^2 + \frac{1}{2}(M^2 + \frac{\lambda^2 v^2}{2})\left(\varphi'^2(x) + \chi'^2(x)\right) - (M^2 - \frac{\lambda^2 v^2}{2})\varphi'(x)\chi'(x)$$

$$M^2 \to M^2 + \frac{\lambda^2 v^2}{2}$$

$$m = \sqrt{2}\lambda v \frac{1}{\sqrt{1 + \frac{\lambda^2 v^2}{2M^2}}}$$

$$m \leq \sqrt{M^2 + \frac{\lambda^2 v^2}{2}}$$

$$L_{tot}(x) = \frac{1}{2}\left(\frac{\partial\varphi(x)}{\partial x_n}\right)^2 + \frac{1}{2}(M^2 - \frac{\lambda^2 v^2}{2})\left(\varphi(x) - \chi(x)\right)^2 +$$

$$+\frac{\lambda^2}{4}(\frac{\varphi^2(x)+\chi^2(x)}{2} - v^2)^2.$$

$$m = \sqrt{2}\lambda v \sqrt{1 - \frac{\lambda^2 v^2}{2M^2}} \equiv m_0 \sqrt{1 - \frac{m_0^2}{4M^2}}$$

Electromagnetic field

$$\delta(p_4^2 + \boldsymbol{p}^2 - p_5^2 - M^2)A_L(p, p_5), \qquad L = 1, 2, 3, 4, 5.$$

$$A_L(x, x_5) = \frac{2M}{(2\pi)^{3/2}} \int e^{-ip_N x^N} \delta(p_K p^K - M^2) A_L(p, p_5) d^5 p$$

$$K, L, N = 1, 2, 3, 4, 5.$$

$$\left(\frac{\partial^2}{\partial x_5^2} - \Box + M^2 \right) A_L(x, x_5) = 0$$

$$S_0(M) = 2\pi M \times$$

$$\times \int \varepsilon(p_5)\delta(p_L p^L - M^2) d^{\,5}p\, 2M(p_5 - M) \left| A_n(p, p_5) - \frac{p_n A_5(p,p_5)}{p_5 - M} \right.$$

$$= \int d^4x L_0(x, x_5) = \frac{1}{4} \int d^4x F^*_{KL}(x, x_5) F^{KL}(x, x_5) +$$

$$+ \frac{1}{2} \int d^4x \left| \frac{\partial(e^{iMx_5} A_L(x,x_5))}{\partial x_L} - 2iMe^{iMx_5} A_5(x, x_5) \right|^2 ,$$

$$n = 1, 2, 3, 4; \qquad K, L = 1, 2, 3, 4, 5,$$

$$F^{KL}(x, x_5) = \frac{\partial(e^{iMx_5} A_K(x, x_5))}{\partial x_L} - \frac{\partial(e^{iMx_5} A_L(x, x_5))}{\partial x_K}$$

$$D_L = \frac{\partial}{\partial x^L} - iqe^{iMx_5} A_L(x, x_5)$$

$$e^{iMx_5} A_L(x, x_5) \to e^{iMx_5} A_L(x, x_5) - \frac{\partial(e^{iMx_5} \lambda(x, x_5))}{\partial x^L}$$

$$\left(\frac{\partial^2}{\partial x_5^2} - \Box + M^2 \right) \lambda(x, x_5) = 0$$

$$A_L(x,0) = A_L(x), \qquad \frac{i}{M}\frac{\partial A_L(x,0)}{\partial x_5} \equiv X_L(x)$$

$$A_n^+(x) = A_n(x), \qquad A_5^+(x) = -A_5(x)$$

$$U(x,x_5) = \exp\left(ie^{iMx_5} q\lambda(x,x_5)\right)$$

$$\varphi'(x) = e^{iq\lambda(x)}\varphi(x)$$

$$\chi'(x) = e^{iq\lambda(x)}[\chi(x) + iq(\mu(x) - \lambda(x))\varphi(x)]$$

Fermion fields

$$\gamma^L = (\gamma^1, \gamma^2, \gamma^3, \gamma^4, \gamma^5) \qquad (\gamma^4 = i\gamma^0)$$

$$\{\gamma^L, \gamma^M\} = 2g^{LM},$$

$$g^{LM} = \begin{pmatrix} -1 & 0 & 0 & 0 & 0 \\ 0 & -1 & 0 & 0 & 0 \\ 0 & 0 & -1 & 0 & 0 \\ 0 & 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & 0 & 1 \end{pmatrix}$$

Fermion fields

I. $$m^2 - p^2 = (m + p_n\gamma^n)(m - p_n\gamma^n),\ n = 1,2,3.4$$

$$m^2 - p^2 \to 2M(p_5 - M\cos\mu),\ \cos\mu = \sqrt{1 - \frac{m^2}{M^2}}$$

I. $$2M(p_5 - M\cos\mu) = \left[2M\sin\mu/2 + p_n\gamma^n - (p_5 - M)\gamma^5\right]\left[2M\sin\mu/2 - p_n\gamma^n + (p_5 - M)\gamma^5\right]$$

$$D(p, M) = p_n\gamma^n - (p_5 - M)\gamma^5 + 2M\sin\mu/2$$

II. $$2M(p_5 - M\cos\mu) =$$

$$= \left[p_n\gamma^n - \gamma^5(p_5 + M) + 2M\cos\mu/2\right]\left[p_n\gamma^n - \gamma^5(p^5 + M) - 2M\cos\mu/2\right]$$

$$\mathbf{D_{exotic}(p, M) = p_n\gamma^n - \gamma^5(p_5 + M) + 2M\cos\mu/2}$$

$$\psi(x, x_5) = \frac{2M}{(2\pi)^{3/2}} \int e^{-ip_K x^K} \delta(p_L p^L - M^2) \psi(p, p_5) d^5\, p,$$

$$\left(\frac{\partial^2}{\partial x_5^2} - \Box + M^2 \right) \psi(x, x_5) = 0,$$

$$\psi(x, 0) \equiv \psi(x) = \tfrac{2M}{(2\pi)^{3/2}} \int e^{ip_n x^n} d^4\, p \tfrac{\psi_1(p) + \psi_2(p)}{|p_5|} =$$

$$= \tfrac{1}{(2\pi)^{3/2}} \int e^{ip_n x^n} \psi(p) d^4\, p$$

$$\tfrac{i}{M} \tfrac{\partial \psi(x,0)}{\partial x_5} \equiv \chi(x) = \tfrac{1}{(2\pi)^{3/2}} \int e^{ip_n x^n} d^4 p \left[\psi_1(p) - \psi_2(p) \right] =$$

$$= \tfrac{1}{(2\pi)^{3/2}} \int e^{ip_n x^n} \chi(p) d^4\, p.$$

$$L_E(x) = \overline{\zeta}_E(x)\left(-i\gamma_n \frac{\partial}{\partial x^n} + m\right)\psi_E(x),$$

$$\{\gamma^n, \gamma^m\} = -2\delta^{nm} \quad (m, n = 1, 2, 3, 4).$$

$$\overline{\zeta}_E(x) \;=\; \zeta_E^{+}(x)\gamma^4 \qquad\qquad\qquad \psi_E(x)$$

$$2M(p_5 - M\cos\mu) =$$

$$\left(p_n\gamma^n + (p_5 - M)\gamma^5 - 2M\sin\frac{\mu}{2}\right)\left(p_n\gamma^n - (p_5 - M)\gamma^5 + 2M\sin\frac{\mu}{2}\right)$$

$$\mathcal{D}(p, p_5) \equiv p_n \gamma^n - (p_5 - M)\gamma^5 + 2M \sin\frac{\mu}{2}$$

$$S_0(M) = 2\pi M \int \varepsilon(p_5)\delta(p_L p^L - M^2) d^5 p \times$$

$$\times \left[\ \overline{\zeta}(p, p_5)(p_n \gamma^n - (p_5 - M)\gamma^5 + 2M \sin\tfrac{\mu}{2})\psi(p, p_5) \ \right]$$

$$\psi(p) = \frac{M}{|p_5|}(\psi(p, |p_5|) + \psi(p, -|p_5|)) \equiv M\frac{\psi_1(p)+\psi_2(p)}{|p_5|}$$

$$\chi(p) = \psi_1(p) - \psi_2(p)$$

$$\overline{\zeta}(p) = M\frac{\overline{\zeta}_1(p)+\overline{\zeta}_2(p)}{|p_5|}$$

$$\overline{\xi}(p) = \overline{\zeta}_1(p) - \overline{\zeta}_2(p),$$

$$S_0^{\mathcal{D}} = -\pi \int d^4p \left(M + \frac{p_n^2}{M} \right) \overline{\zeta}(p) \gamma^5 \psi(p) +$$

$$+\pi \int d^4p \overline{\zeta}(p) \left(\not{p} + M\gamma^5 + 2M sin\frac{\mu}{2} \right) \chi(p) +$$

$$+\pi \int d^4p \overline{\xi(p)} \left(\not{p} + M\gamma^5 + 2M sin\frac{\mu}{2} \right) \psi(p) -$$

$$-\pi \int d^4p M \overline{\xi(p)} \gamma^5 \chi(p)$$

$$S_0^{\mathcal{D}} = \int L_0^{\mathcal{D}}(x, M)\, d^4x =$$

$$= \frac{1}{2} \int d^4x \overline{\zeta}(x) \left(\frac{\Box}{M^2} - 1 \right) \gamma^5 \psi(x) +$$

$$+ \frac{1}{2} \int d^4x \overline{\zeta}(x) \left(i\gamma^n \frac{\partial}{\partial x^n} + M\gamma^5 + 2M \sin\frac{\mu}{2} \right) \chi(x) +$$

$$+ \frac{1}{2} \int d^4x \overline{\xi(x)} \left(i\gamma^n \frac{\partial}{\partial x^n} + M\gamma^5 + 2M \sin\frac{\mu}{2} \right) \psi(x) -$$

$$- \frac{1}{2} \int d^4x \overline{\xi(x)} \gamma^5 \chi(x).$$

Once more the Dirac's trick (De Sitter space) :

$$M^2 - p_L p^L = M^2 + p_n^2 - p_5^2 = (M - p_L \gamma^L)(M + p_L \gamma^L) =$$

$$= (M + p^n \gamma^n - p^5 \gamma^5)(M - p^n \gamma^n + p^5 \gamma^5).$$

$$\frac{1}{2M}(M - p_K\gamma^K)\psi(p,p_5) \equiv \Pi_L\psi(p,p_5) \equiv \psi_L(p,p_5)$$

$$\frac{1}{2M}(M + p_K\gamma^K)\psi(p,p_5) \equiv \Pi_R\psi(p,p_5) \equiv \psi_R(p,p_5)$$

$$\Pi_L + \Pi_R = 1,$$

$$\Pi_L^2 = \Pi_L \qquad \Pi_R^2 = \Pi_R,$$

$$\Pi_L\Pi_R = \Pi_R\Pi_L = 0.$$

$$(M + p_K \gamma^K)\psi_L(p, p_5) = 0,$$

$$(M - p_K \gamma^K)\psi_R(p, p_5) = 0.$$

$$\psi(p, p_5) = \psi_L(p, p_5) + \psi_R(p, p_5)$$

In the flat limit
|p|<<M :

$$\Pi_{L,R} = \frac{1 \mp \gamma^5}{2}$$

Chiral fermion fields

$$\psi_r = \frac{1+\gamma_5}{2}\psi ; \psi_l = \frac{1-\gamma_5}{2}\psi$$

Weyl spinors

In our case:

$$(p^2 + p_5^2 - M^2)\psi(p, p_5) = 0$$

$$(p_K \Gamma^K + M)(p_N \Gamma^N - M)\psi(p, p_5) = 0$$

$$K, N = 0,1,2,3,4,5$$

$$\psi_L(p, p_5) = \frac{1}{2M}(M - p_K \Gamma^K)\psi(p, p_5)$$

$$\psi_R(p, p_5) = \frac{1}{2M}(M + p_K \Gamma^K)\psi(p, p_5)$$

Chirality depends on energy momentum!

In 1956 Lee ,Yang and Wu discovered parity violation in weak interactions i.e. violation of mirror symmetry. From our point of view this effect is a direct consequence of de Sitter geometry of 4-momentum space.

$$S_0^{\mathcal{D}} = \int L_0^{\mathcal{D}}(x, M) d^4x =$$

$$= \int d^4x \left[\overline{\zeta}_{(L)}(x) i\gamma^n \frac{\partial}{\partial x^n} \psi_{(L)}(x) + \overline{\zeta}_{(R)}(x) i\gamma^n \frac{\partial}{\partial x^n} \psi_{(R)}(x) \right] +$$

$$+ \int d^4x \overline{\zeta}_{(L)}(x) \left[i\gamma^n \frac{\partial}{\partial x^n} + M(1 - \gamma^5) \right] \psi_{(R)}(x) +$$

$$+ \int d^4x \overline{\zeta}_{(R)}(x) \left[i\gamma^n \frac{\partial}{\partial x^n} - M(1 + \gamma^5) \right] \psi_{(L)}(x) +$$

$$+2M \sin \frac{\mu}{2} \int d^4x \left[\overline{\zeta}_{(L)}(x) \gamma^5 \psi_{(R)}(x) - \overline{\zeta}_{(R)}(x) \gamma^5 \psi_{(L)}(x) \right]$$

Now we have all the bricks to construct a generalization of the SM based on De Sitter momentum space geometry and $SU_c(3) \times SU_L(2) \times U_Y(1)$ gauge invariance.

It is local and naturally incorporates the new physical principle – existence of a maximal mass M of the objects described by quantum fields.

For instance the term:

$$\overline{\zeta}_{(L)}\left[i\gamma^n\frac{\partial}{\partial x^n}+M(1-\gamma^5)\right]\psi_{(R)}(x)+$$

$$+\overline{\zeta}_{(R)}\left[i\gamma^n\frac{\partial}{\partial x^n}-M(1+\gamma^5)\right]\psi_{(L)}(x)$$

becomes:

$$\frac{1}{v}\left(\overline{\zeta}_{(L)}.H(x)\right)\left[i\gamma^n D_n^R+M(1-\gamma^5)\right]\psi_{(R)}(x)+$$

$$+\frac{1}{v}\overline{\zeta}_{(R)}\left\{H^+(x).\left[i\gamma^n D_n^L-M(1+\gamma^5)\right]\psi_{(L)}(x)\right\}+conj.,$$

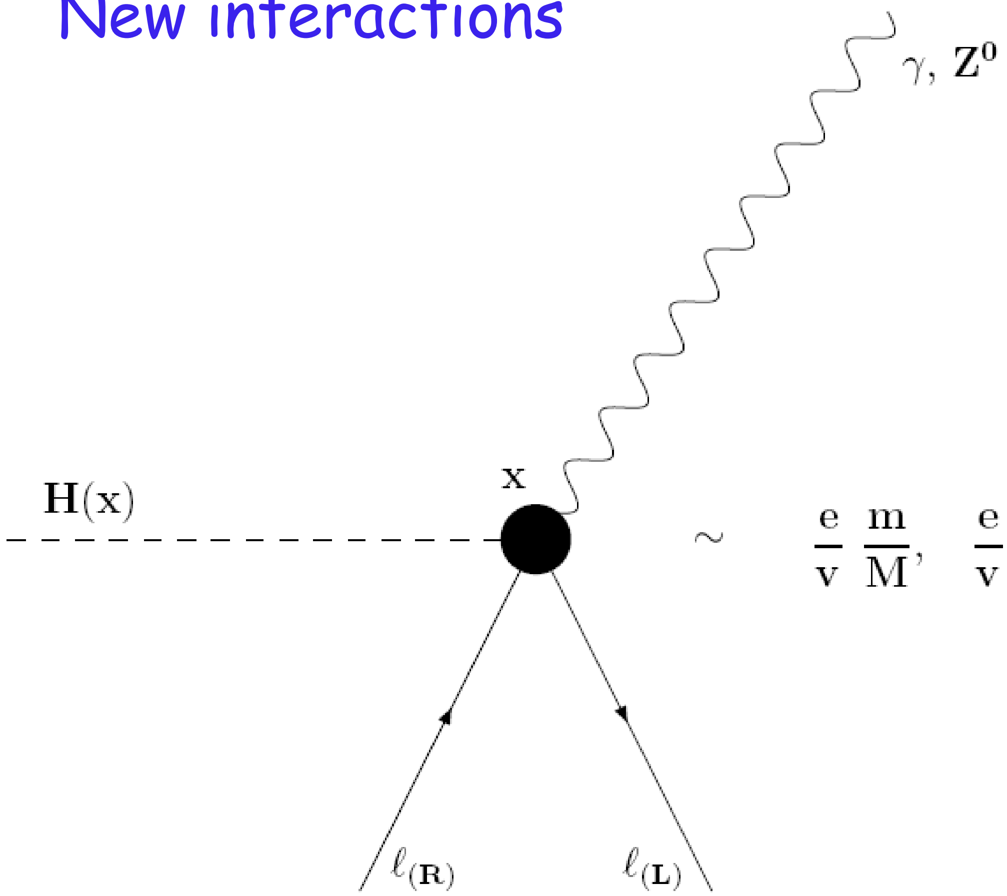
New P-odd effects

The new free chirality fields may be represented as:

$$\Psi_{(R,L)}(x) \approx \Psi_{r,l}(x) \pm \frac{i\partial_n \gamma^n}{2M} \Psi(x)$$

and one predicts corrections to all weak interaction processes. A global fit of all SM LEP data gives M ~ 1 TeV

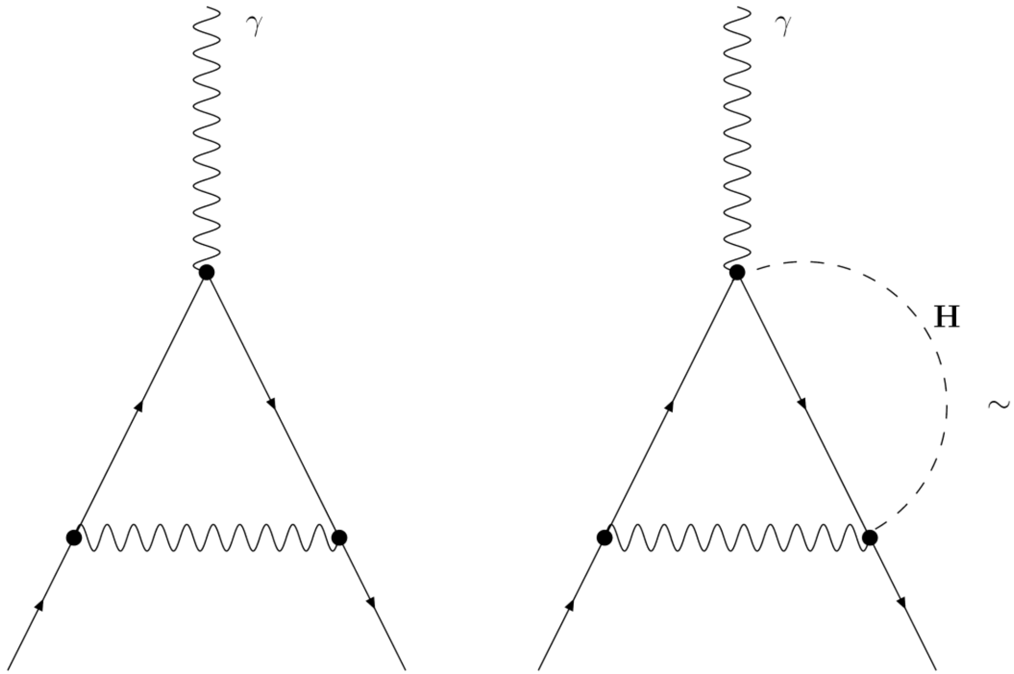
New interactions



$$\sim \quad \frac{e}{v}\,\frac{m}{M}, \quad \frac{e}{v}\,\frac{m}{M}\,\gamma^5, \quad \frac{e}{v}\,\frac{m^2}{M^2}$$

New Higgs decay mode $$H \rightarrow 2l^{(\pm)} + \gamma$$

Contribution to anomalous magnetic moment



$$\alpha_{\mu}^{MMM} \approx \frac{1}{M^{2}}$$

$$\Delta a_{\mu} = a_{\mu}^{\exp} - a_{\mu}^{SM} = 292(63)(58) \times 10^{-11} \rightarrow M \geq 300\ GeV$$

- Specific relations between the Youkawa coupling constants and M:

$$M^2 = \frac{\lambda_{f_1}^4 v^4}{8(\lambda_{f_1}^2 v^2 - m_{f_1}^2)} = \frac{\lambda_{f_2}^4 v^4}{8(\lambda_{f_2}^2 v^2 - m_{f_2}^2)} = ...$$

Exotic fields

$$2M(p^5 - M\cos\mu) =$$

$$= (p_n\gamma^n - \gamma^5(p^5 + M) + 2M\cos\tfrac{\mu}{2})(p_n\gamma^n - \gamma^5(p^5 + M) - 2M\cos\tfrac{\mu}{2})$$

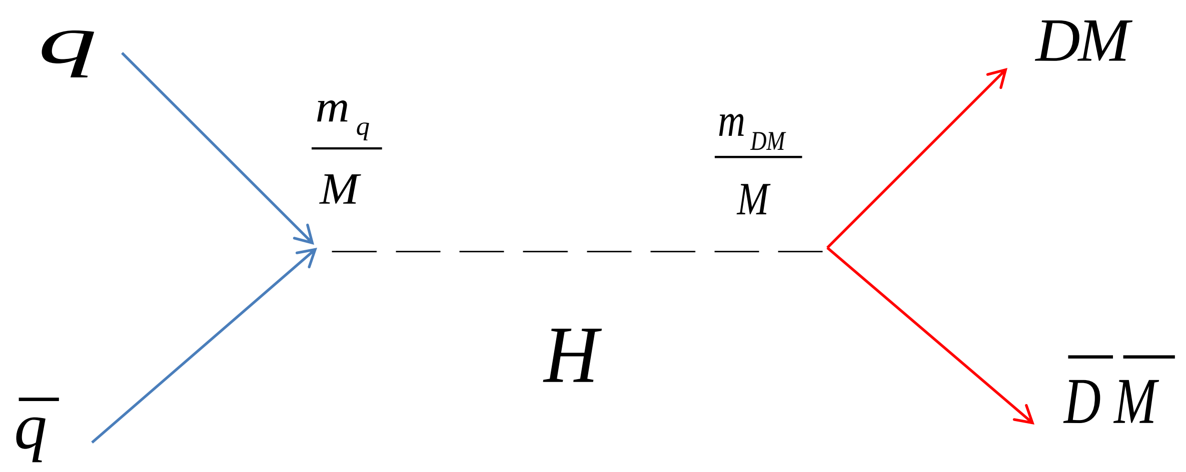
$$S_0^{(exotic)}(M) = 2\pi M \int \varepsilon(p_5)\delta(p_L p^L - M^2)d^5p \times$$

$$\times \left\{ \ \overline{\xi}_{exotic}(p, p_5) \left[p_n\gamma^n - (p_5 + M)\gamma^5 + 2M\cos\tfrac{\mu}{2}\right] \psi_{exotic}(p, p_5) \ \right\}$$

Exotic fields are good candidates for dark matter:

- they are completely different from ordinary fermions.
- in the flat limit they do not have an ordinary analogue.

Dark matter production



Exotic matter is connected to ordinary matter through the same mass generation Higgs mechanism.

The new “dark matter” world may happen to be connected with us only through gravitation and Higgs exchange!

Conclusions:

1. On the basis of a new physical principle - the existence of a maximal mass M and purely geometrical considerations - a local QFT MMM is constructed.

2. Chirality (parity violation) has clear geometrical origin.

New P-odd effects are predicted.

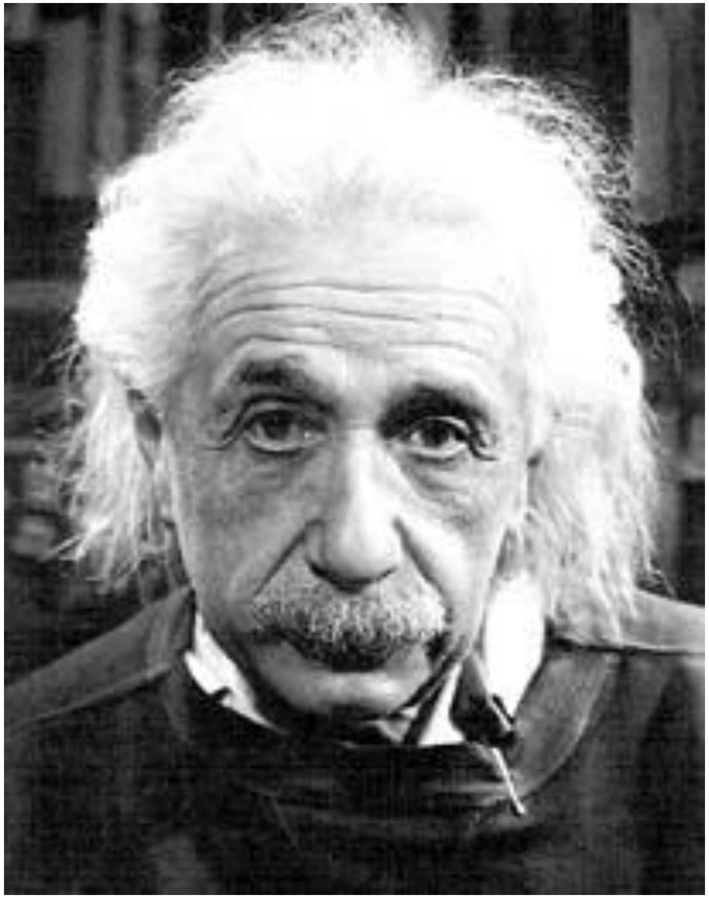
3. New interactions are appearing in the Higgs sector.

4. M is predicted to be in the TeV region.

5. We predict "exotic" fermions (candidates for dark matter) coupled to the ordinary matter through the Higgs field.

Yuri Manin

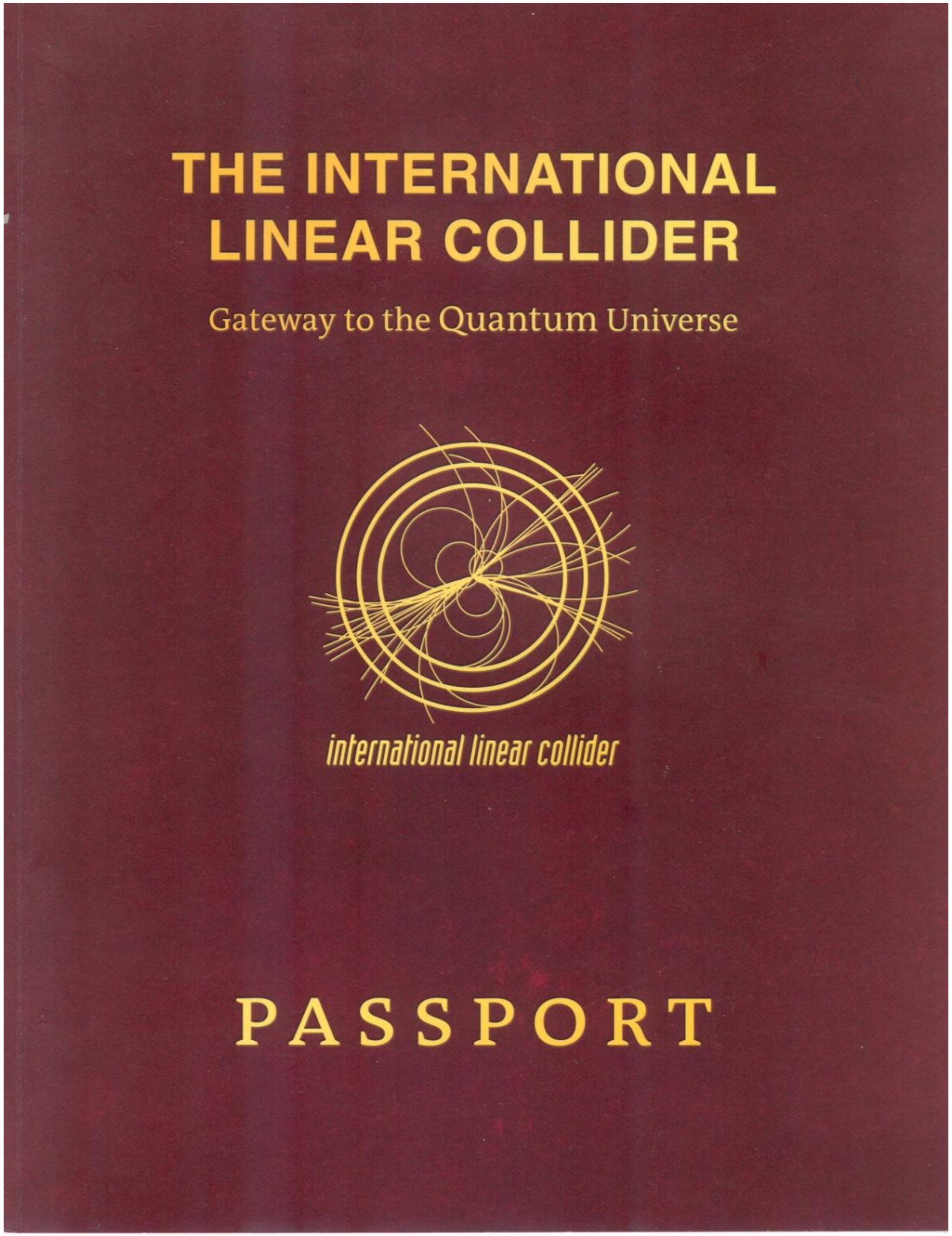
«GEOMETRY IS A SPECIFIC PRESERVATIVE FOR QUICKLY ROTTENING PHYSICS»

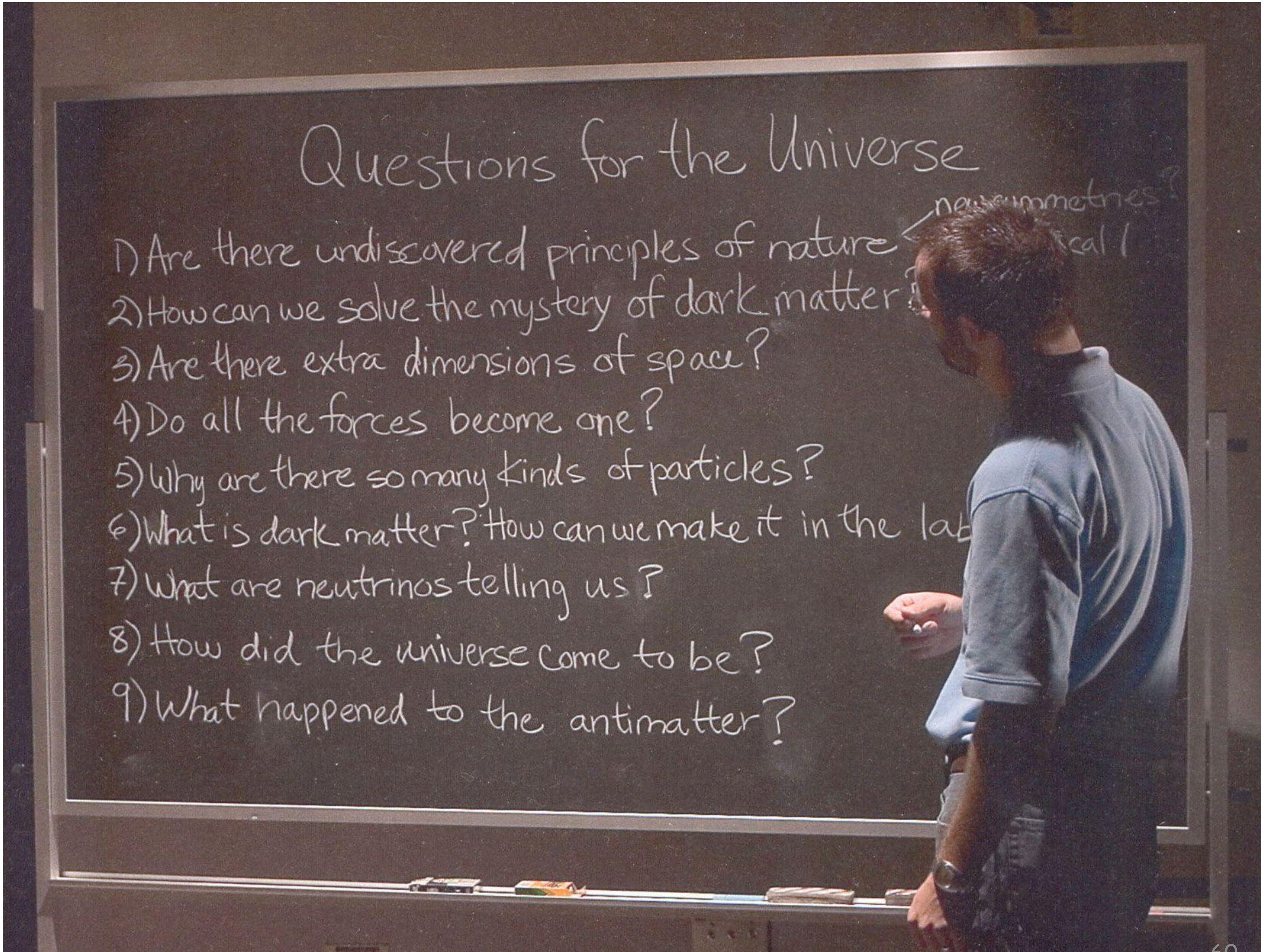


«EXPERIMENT =
= GEOMETRY +
PHYSICS»

A. EINSTEIN

LHC = Geometry + Physics


THE INTERNATIONAL
LINEAR COLLIDER
Gateway to the Quantum Universe
international linear collider
PASSPORT


Questions for the Universe
1) Are there undiscovered principles of nature
2) How can we solve the mystery of dark matter
3) Are there extra dimensions of space?
4) Do all the forces become one?
5) Why are there so many kinds of particles?
6) What is dark matter? How can we make it in the la
7) What are neutrinos telling us?
8) How did the universe come to be?
9) What happened to the antimatter?

THANK YOU!