Gravity and Gauge Fields in Infinite Volume Extra Dimensions

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SOME MOTIVATION

BEST MEASURED QUANTITY:

$$\Lambda \lessapprox 10^{-29}\ \mathrm{g/cm^3}$$

$$\left.\begin{array}{l}\text{GLOBAL SUSY}\\ \text{SUPERGRAVITY + R SYMMETRY}\end{array}\right\} \Rightarrow \Lambda = 0$$

CAN SUPERSYMMETRY BE UNBROKEN?

ALL WE NEED $m_F \neq m_B$

I. 4D

II. INFINITE-VOLUME EXTRA DIMENSIONS

UNBROKEN SUSY

$$Q|0\rangle = 0 \rightarrow \Lambda = 0$$

$$\downarrow$$

$$Q|B,F\rangle = |F,B\rangle$$

EXEPTIONS FROM THE RULE:

I.

Q IS <u>ILL-DEFINED</u>

IN THE BACKGROUND OF $|B,F\rangle$

II CASE WHEN WE SEE NO $m_B = m_F$

EVEN IF Q IS UNBROKEN:

(G.D., M. Shifman)

IF WE LIVE ON A BRANE IN

INFINITE-VOLUME EXTRA D.

SUCH THAT ANY Q SHIFTS THE BRANE

THEN: $Q|F\rangle = |B\rangle$

BUT,

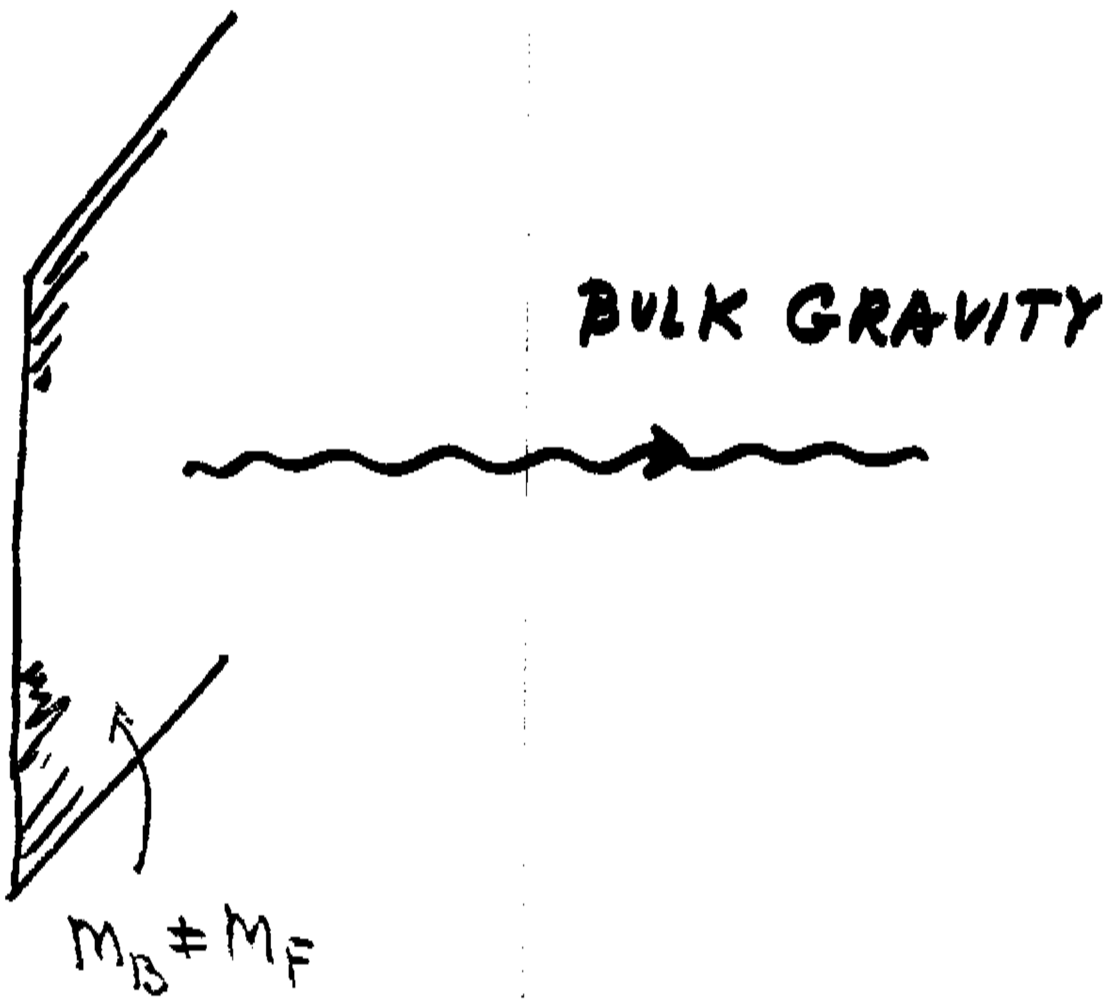
$|F\rangle \in$ OUR BRANE

and

$|B\rangle \in$ SHIFTED BRANE

$\Rightarrow$ BRANE IS NON-BPS STATE

NON-BPS BRANE WORLD

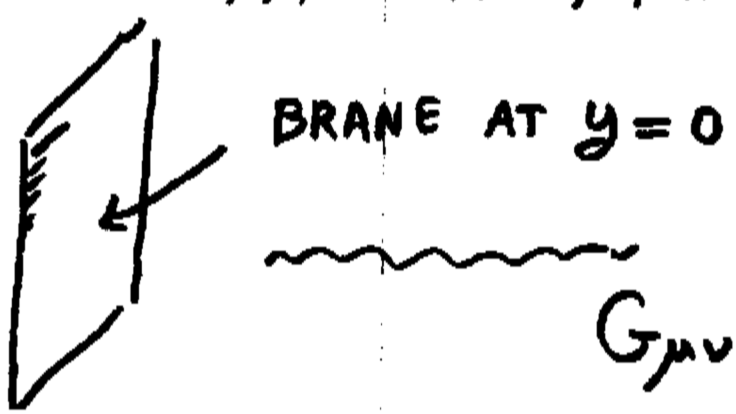


A model of infinite-volume extra dimensions:

BRANE-INDUCED 4D GRAVITY

G.D., G. Gabadadze, M. Porrati ($N=1$);
G.D., G. Gabadadze ($N>1$).

$D=4+N \qquad x_{\mu=0,1,2,3}\,;\; y_{m=1,2,\dots N}$



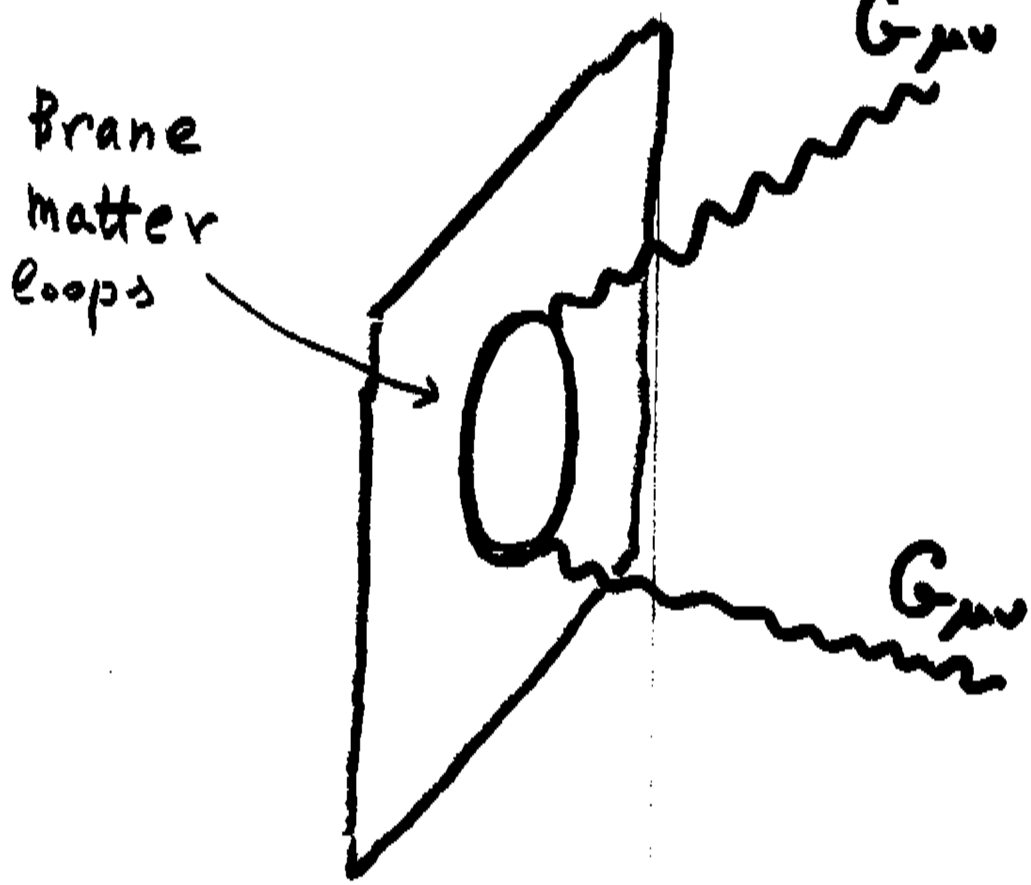
$$G_{\mu\nu}(x_\mu, y=0) = g_{\mu\nu}(x_\mu)$$

$$S = \int d^{4+N}x\,\sqrt{-G}\,M^{2+N}R^{(4+N)} +$$

$$+ \int d^4x\,\sqrt{-g}\,\{M_P^2 R^{(4)} + \dots T\}$$

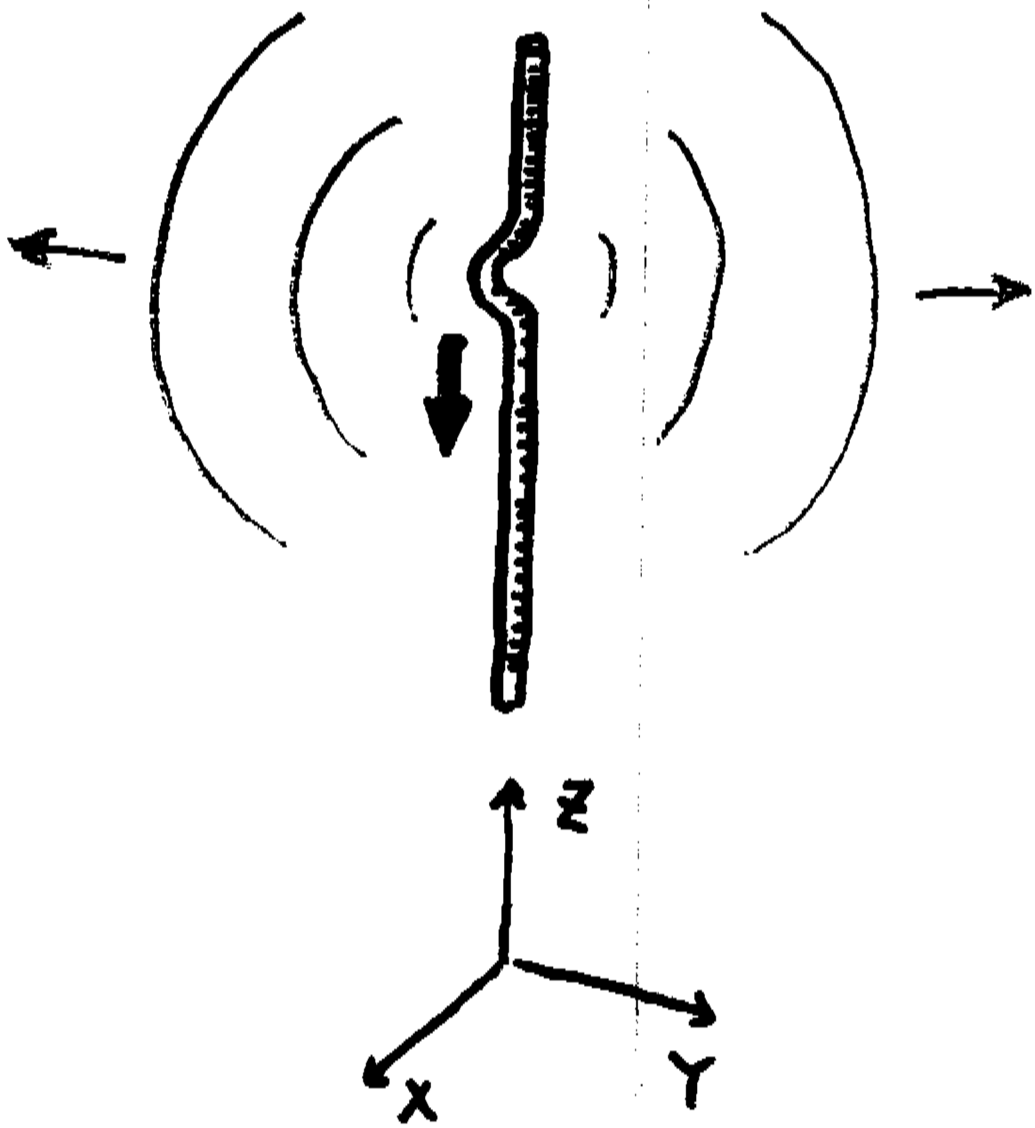
(4D Einstein term)

ORIGIN OF $\int d^4x \sqrt{-g}\, R^{(4)}$ – TERM



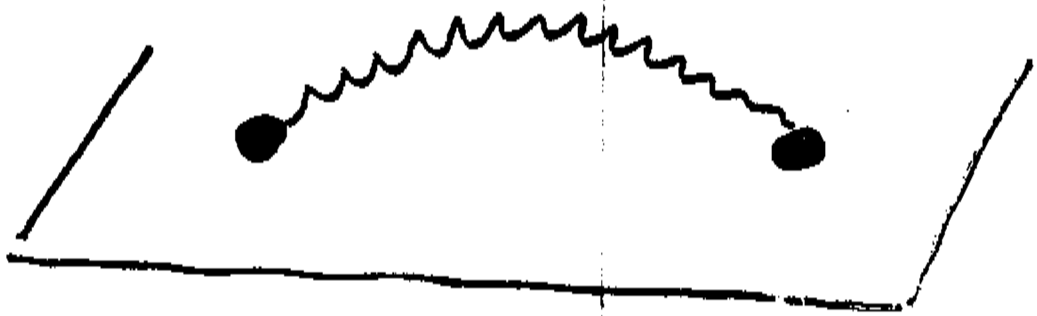
Induced Gravity on the Brane

SOUND WAVE



$$\left[\partial_t^2 - \vec{\nabla}^2 + \delta(x)\,\delta(y)\left(\partial_t^2 - \partial_z^2\right)\right]\varphi_{(t,\vec{r})} = \delta^3(\vec{r})$$

GRAVITON PROPAGATION ON THE BRANE



N=1 EXTRA DIMENSION:

$$G(p) = \frac{1}{p^2 + p/r_c}$$

$$\Downarrow$$

NEWTONIAN GRAVITY ON THE BRANE:

$$V(r) = G_N \frac{m_1 m_2}{r} \quad \text{FOR} \quad r \ll r_c$$

$$V(r) = (G_N r_c) \frac{m_1 m_2}{r^2} \quad \text{FOR} \quad r \gg r_c \; !$$

FOR $N > 1$ EXTRA DIMENSIONS GRAVITY ON THE BRANE IS AN EINSTEIN GRAVITY:

$$G(p) = \frac{1}{p^2}$$

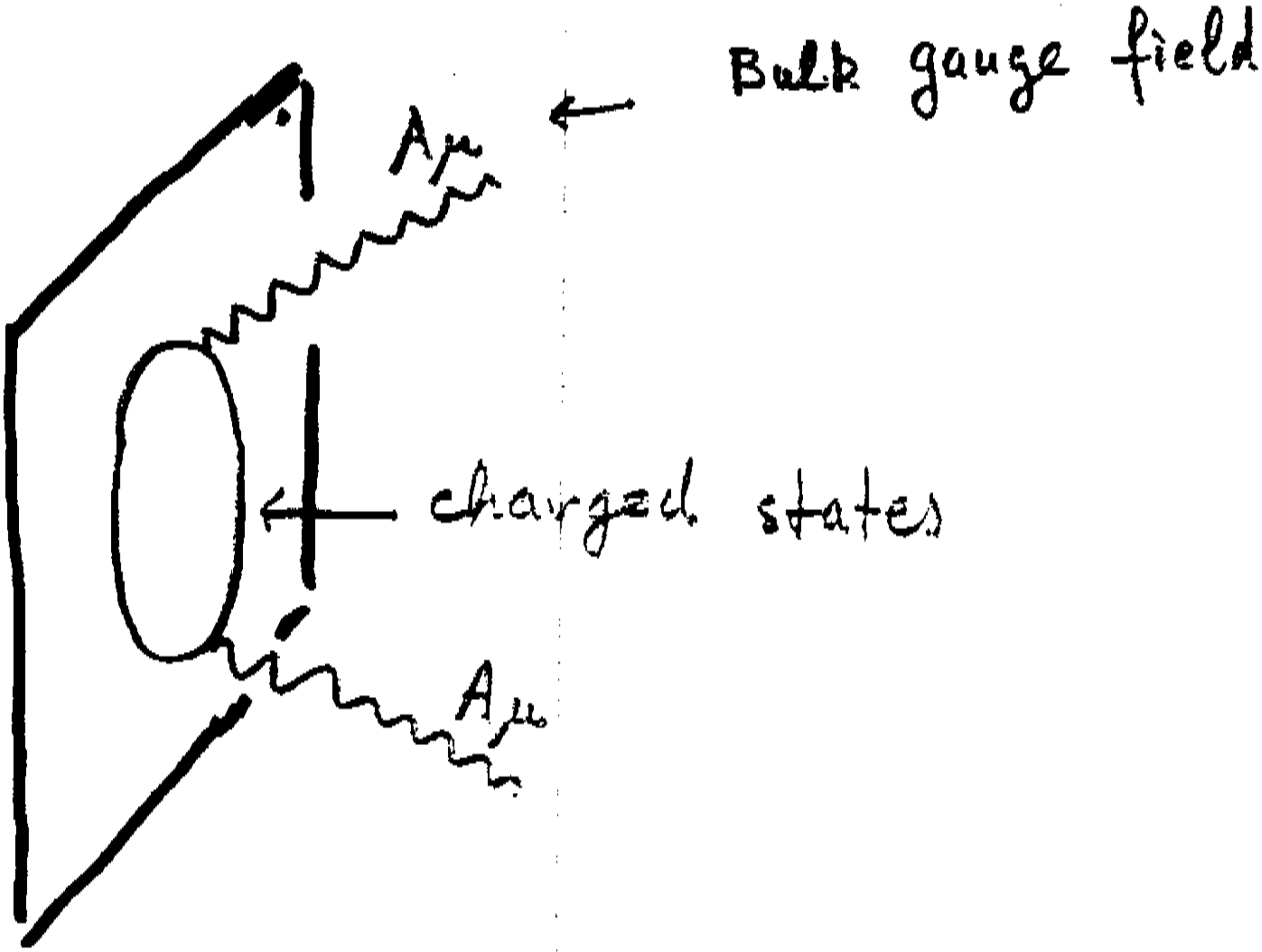
$$\Downarrow$$

NEWTONIAN LIMIT

$$V(r) = G_N \frac{m_1 m_2}{r^2}$$

FOR AN ARBITRARILY LARGE r !

(Quasi)Localized Gauge Fields



$$\mathcal{L} = -\frac{1}{4g^2}F_{AB}^2 - \frac{1}{4e^2}F_{\mu\nu}^2\,\delta(y)$$

$$e^{-2} = \frac{2N_f}{3\pi}\ln\frac{\Lambda}{\mu}$$

Gauge field propagator on the brane

$$D_{\mu\nu}(p) = \frac{\eta_{\mu\nu}}{p^2 + \underline{p}\,\frac{2e^2}{g^2}} \left[1 + \mathcal{O}(p)\right]$$

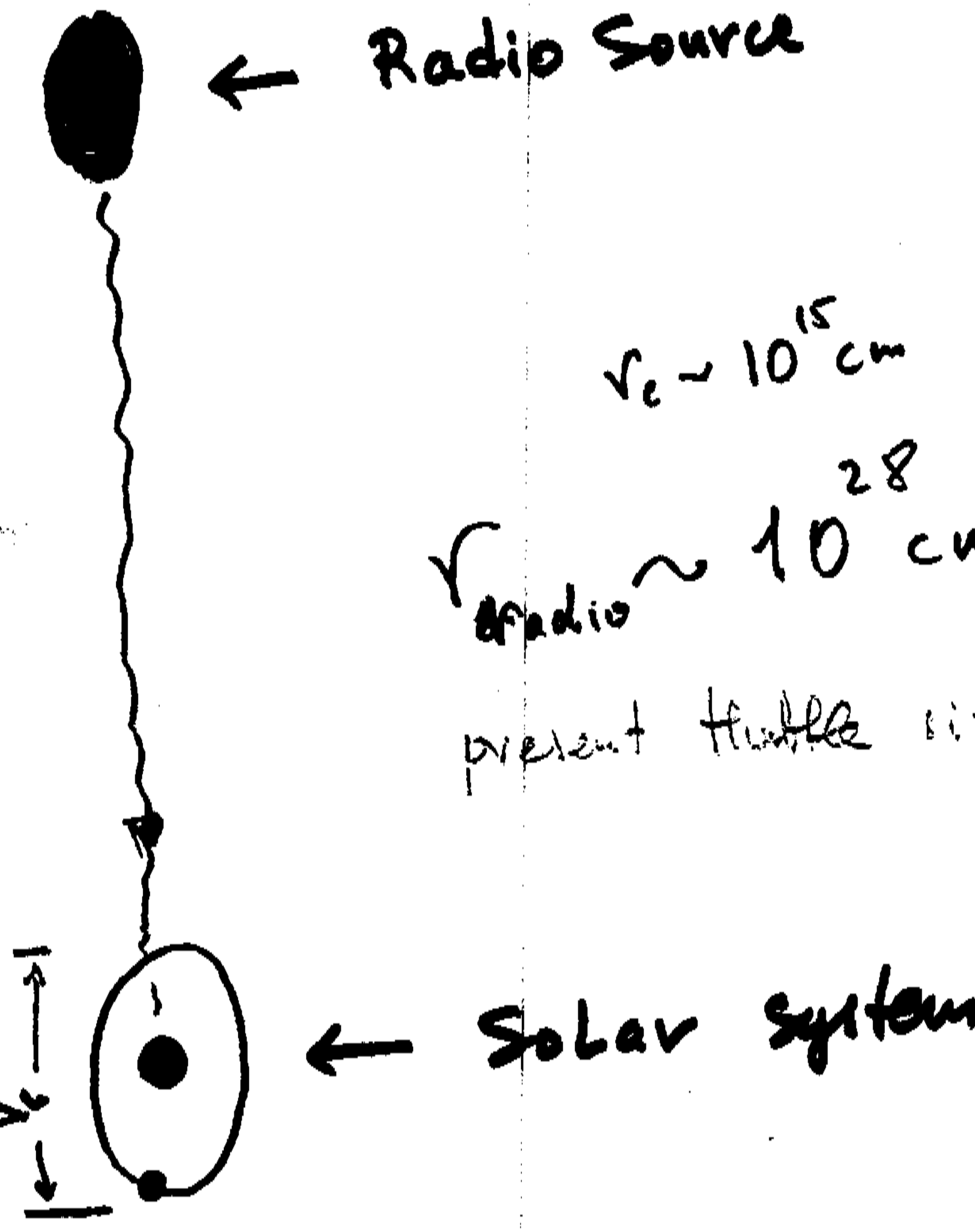
Coulomb law breakes down

at $\quad r > r_c \sim \frac{g^2}{2e^2}$

Waves propagate as <u>4-dimensional</u>

over the distances

$$r \leq \omega r_c^2$$

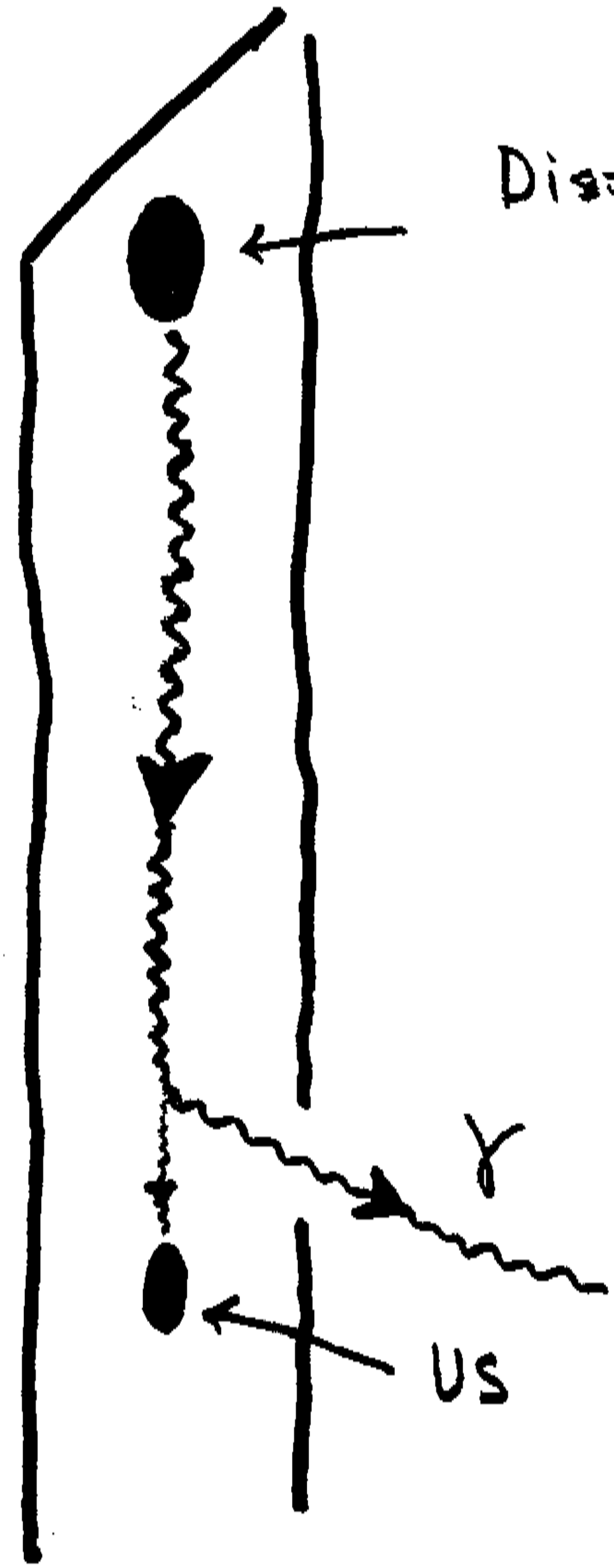


$r_c \sim 10^{15}$ cm

$r_{radio} \sim 10^{28}$ cm!

present Hubble size!

Dissipating Cosmic Radiation to Extra Dimensions ???



$r_c \sim 10^{11} - 10^{12}$ cm