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COSMIC STRINGS

from

HIGHER DIMENSIONS

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based on:

Nucl. Phys. B339 (1990) 533.

Mod. Phys. Lett. A5 (1990) 1109.

Prog. Theor. Phys. 84 (1990) 1100.

Phys. Lett. B259 (1991) 58.

In multi dimensional unification schemes,
(including 'fundamental' gauge fields)

Topologically Non-trivial Objects may arise.

I. YM theory in 6 dims.

in $M^4 \otimes S^2$ geometry,

radius = b

$$\frac{1}{4} \text{tr } F_{\mu\nu}^2$$

$SU(2) \rightarrow$



$$\langle A_0 \rangle = \frac{1}{2} \begin{pmatrix} 0 & -i\Phi e^{-i\theta} \\ i\Phi e^{i\theta} & 0 \end{pmatrix}$$

$$\langle A_\phi \rangle = \frac{1}{2} \begin{pmatrix} 1 - \cos\theta & -\Phi e^{i\theta} \\ -\Phi e^{-i\theta} & -(1 + \cos\theta) \end{pmatrix}$$

$$\langle A_\mu \rangle = \tilde{A}_\mu \frac{1}{2} \begin{pmatrix} 1 & 0 \\ 0 & -1 \end{pmatrix}$$

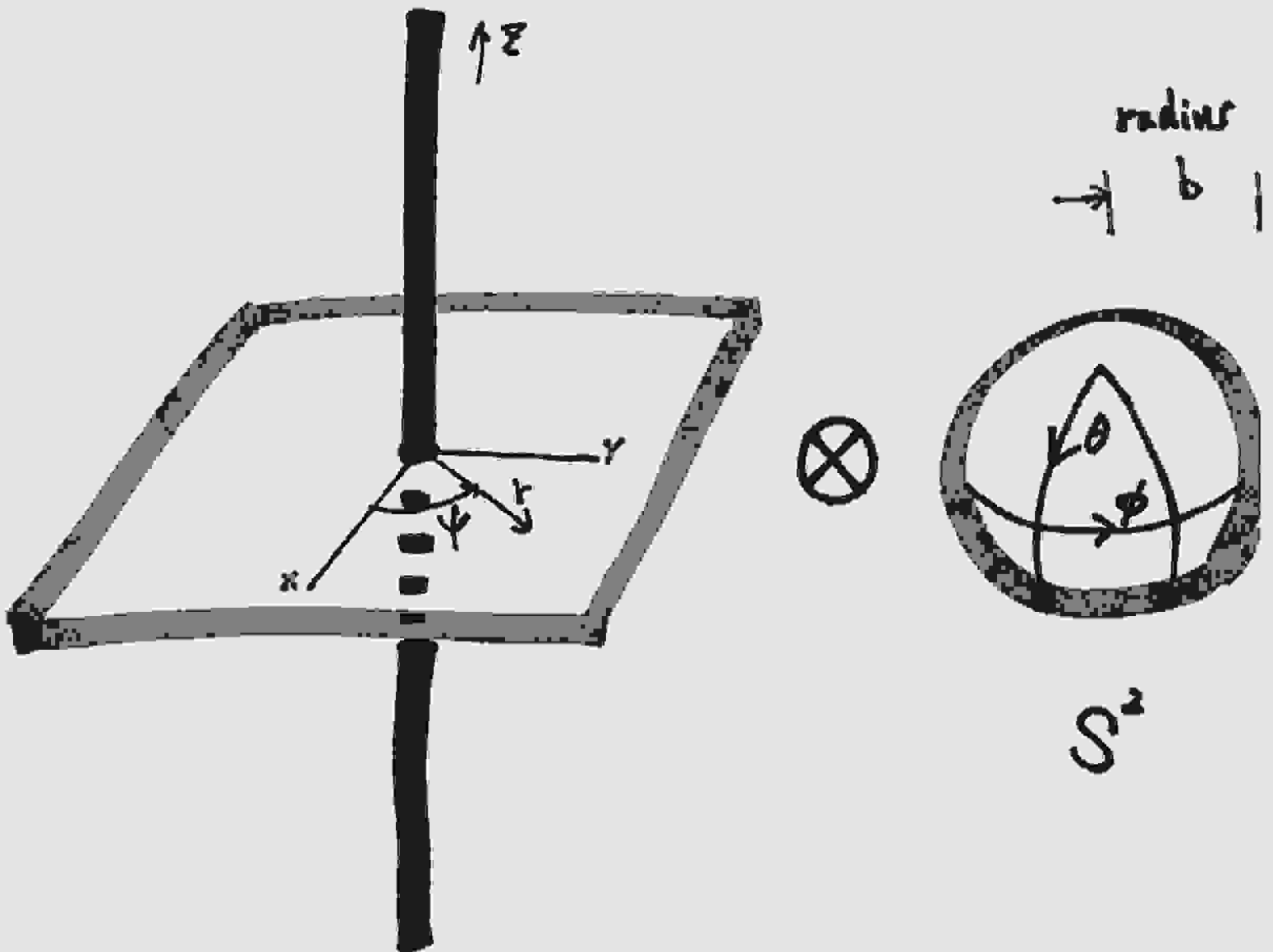
$$\frac{1}{b^2} |D_\mu \Phi|^2 + \frac{1}{2b^4} (1 - |\Phi|^2)^2 + \frac{1}{2} \tilde{F}_{\mu\nu}^2$$

$$D_\mu = \nabla_\mu + i\tilde{A}_\mu, \quad \tilde{F}_{\mu\nu} = \partial_\mu \tilde{A}_\nu - \partial_\nu \tilde{A}_\mu$$

\Downarrow
 \approx Abelian-Higgs model

\Downarrow
Nielsen-Olesen Vortex

\parallel
Cosmic String



- characteristics

① The thickness of string

\approx compactification scale (b)

② $SU(2)$ symmetry is unbroken outside the core of the string!

$\langle A_\theta \rangle, \langle A_\phi \rangle |_{|\Phi|=1} \approx$ locally equivalent to \bigcirc

③

$$I = \frac{1}{32\pi^2} \int_{\mathcal{M}} \text{tr} F \wedge F = -n$$

for n -vorticity sol.



→ # of fermion zero-modes around the string.

Our Cosmic String is

a "deformed" Instanton in .

Couple to Gravity:

$$\mathcal{L}_{16} = \frac{1}{4e^2} \text{tr} F_{\mu\nu}^2 - \frac{1}{2n^2} R + \Lambda + \frac{1}{4g^2} G_{\mu\nu}^2$$

$U(1)$ gauge strength \longleftarrow
Monopole-like config. on S^2

$$\langle G_{\theta\phi} \rangle = -\frac{1}{2} \sin\theta$$

physical quantities are determined by $\boxed{q^2 \equiv \frac{e^2}{2g^2}}$

$$q \rightarrow \infty : b = \text{const.}$$

① $b^2 > b^2(\infty) = \underline{1}$ in our unit.
 $b^2(0) \simeq \exp(1/q^2)$

② deficit angle

$$\Delta\varphi \simeq \frac{2\pi}{q^2}$$

the mass density per unit length

$$\mu \sim \frac{8\pi}{q^2}$$

③ Two strings in the same kind attract each other
(because of an effective scalar from the scale of the extra space.)

II. Einstein - Maxwell in 5 dims. in $M^4 \otimes S^1$

$$L_{(5)} = -\frac{1}{4}R + \frac{1}{4}F_{\mu\nu}^2$$



$$ds^2 = \frac{1}{b} \tilde{g}_{\mu\nu} dx^\mu dx^\nu + b^2 (dx^5)^2$$

$$\langle b \rangle = \frac{\sqrt{3}}{2} \tau_2(x, y), \quad \langle A_5 \rangle = \tau_1(x, y)$$

$$L_{(4)} \sim -\frac{1}{4}R + \frac{3}{8} \frac{(\tilde{\nabla} \tau_1)^2 + (\tilde{\nabla} \tau_2)^2}{\tau_2^2}$$

In the (Gravity + NLO model) system,
a string-like solution is known
(Greene et al.)

• We apply the model to **$N=2$ SG in 5-dim.**
which contains a graviton, a gauge field, and a
gravitino.

• For the solution which can be lead from

$$\partial_z \tau = 0 \quad (z = x + iy),$$

the SUSY in this Background is shown to be
reduced to **$N=1$** .

Conclusion

- We have shown that multi dimensional unification has a fatal flaw (of a new-type).
super-massive strings.
 $\mu \sim M_{pl}^2$
- In a general models, defects of other types (domain walls, etc.) can arise.
depends on gauge group & manifold
- Further study of production & decaying mechanisms is needed.

$|\Phi|$

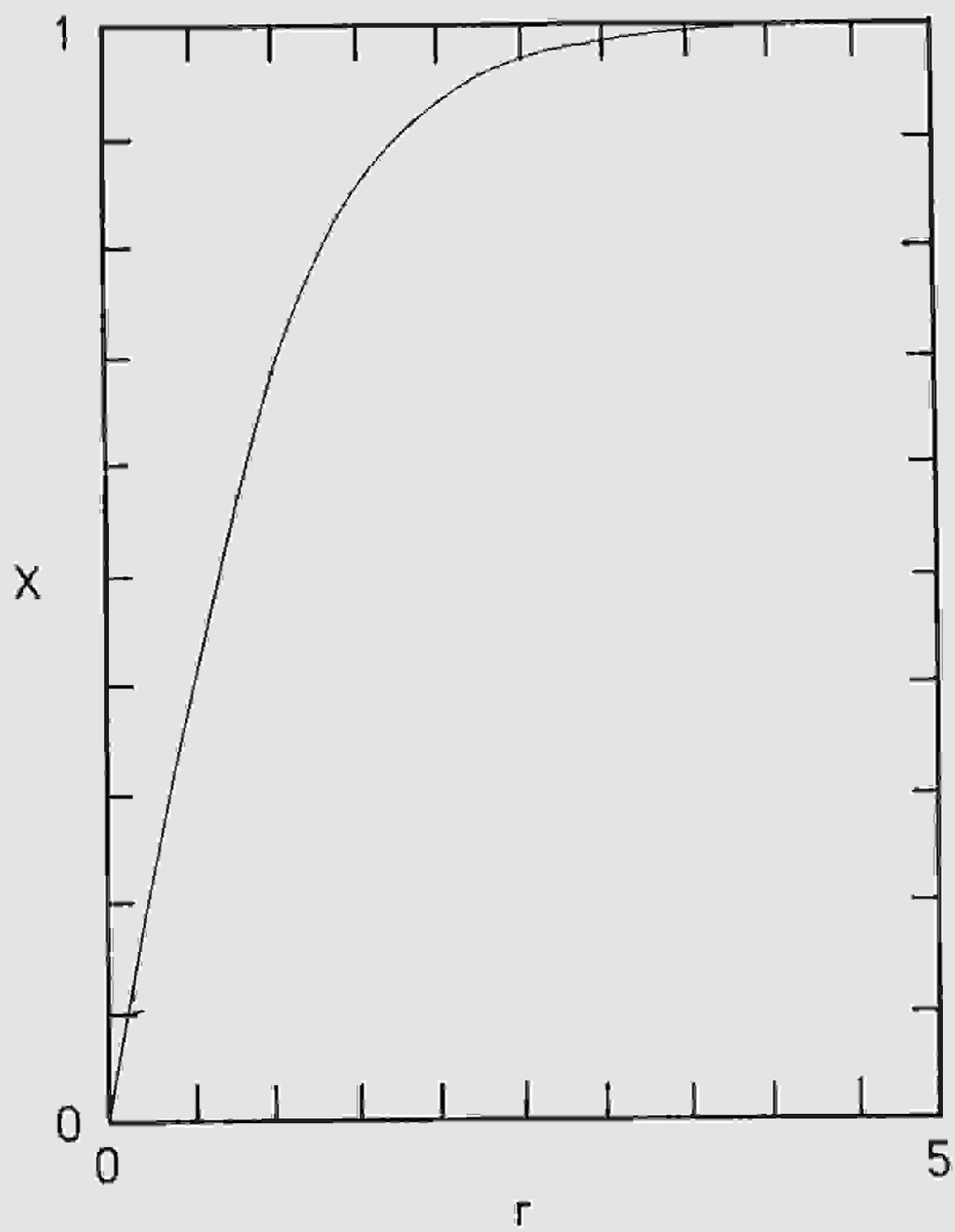


FIG. 1

radius of $S^2 \equiv b$

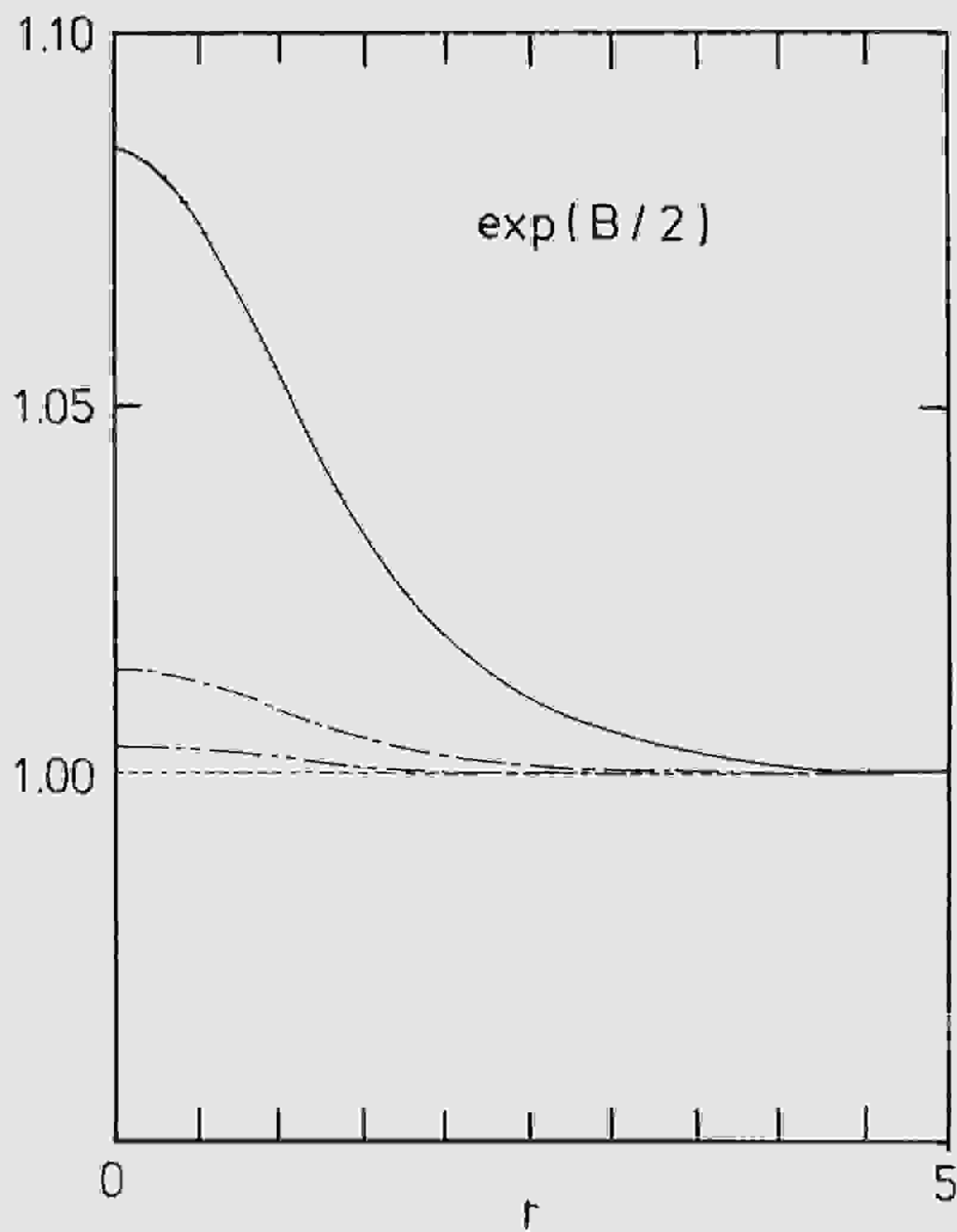
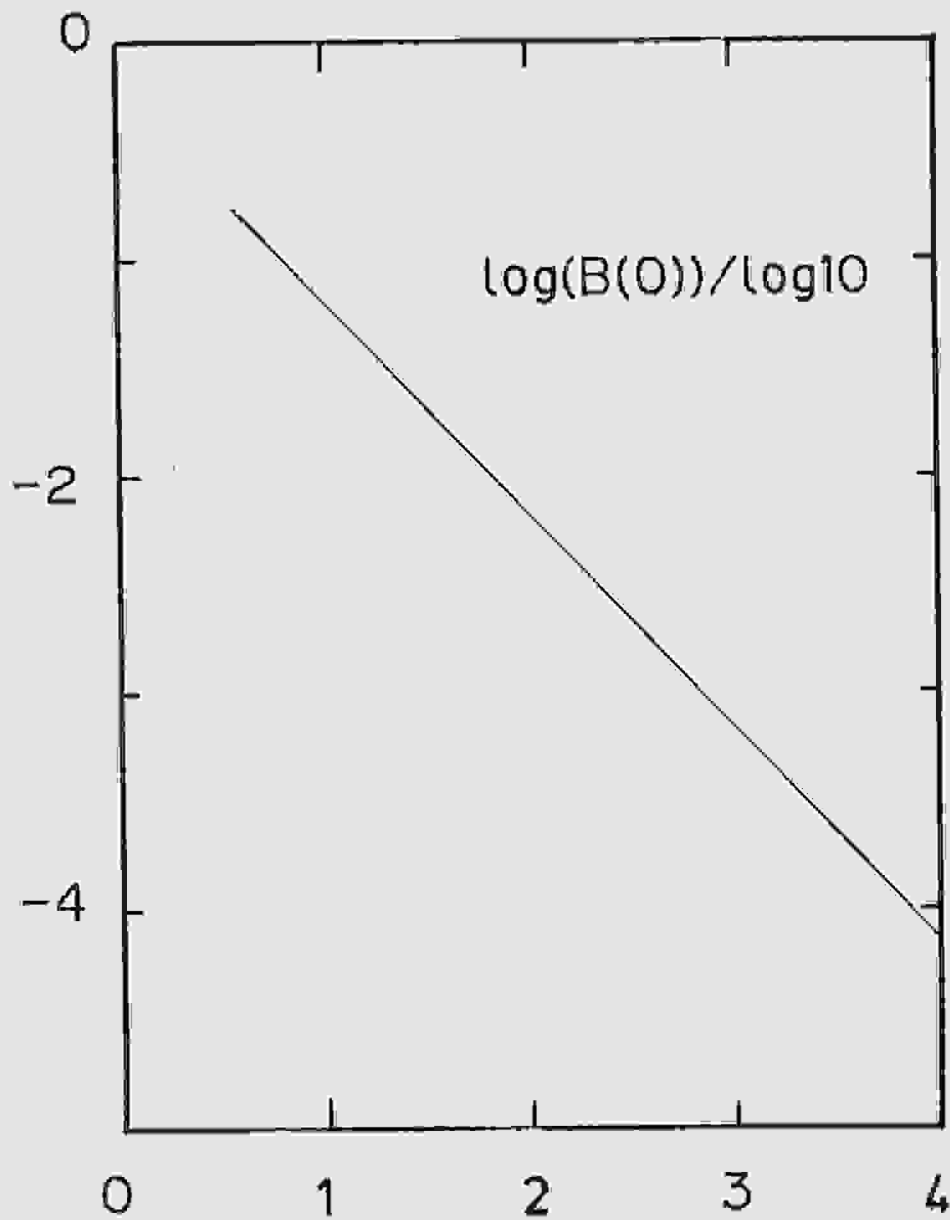


FIG. 4

distance from the origin



radius of S^2 $\log(q^2)/\log 10$

$$b = \exp(B/2)$$

FIG.6