STABLE NON-BPS STATES IN STRING THEORY

3
hep-th/980~~[illegible]~~194, 9805019, 9805170

+ WORK IN PROGRESS

$\boxed{\text{SET } \alpha' = 1}$ $\hbar = 1$ $c = 1$

Strings 98

ASHOKE SEN

DURING THE LAST FEW YEARS WE HAVE LEARNED A LOT ABOUT THE SPECTRUM OF BPS STATES IN STRING THEORY

MANY STRING THEORIES ALSO CONTAIN ELEMENTARY STRING STATES WHICH ARE STABLE DUE TO CHARGE CONSERVATION BUT NOT BPS.

SPECTRUM OF THESE STATES AT WEAK COUPLING CAN BE FOUND BY PERTURBATIVE ANALYSIS

IN THIS TALK WE SHALL ANALYZE THE SPECTRUM OF THESE STATES AT STRONG COUPLING

EXAMPLE I: SO(32) HETEROTIC STRING THEORY

→ CONTAINS STATES IN THE SPINOR REPRESENTATION OF SO(32) AT WEAK COUPLING

(NON-BPS STATES)

THE LIGHTEST STATE IN THE SPINOR REPRESENTATION OF SO(32) MUST BE STABLE AT ALL VALUES OF THE COUPLING

Q. WHAT IS THE MASS OF THIS STATE AT STRONG COUPLING?

$\boxed{\text{ANSWER : } K\, g^{1/2}}$ → STRING COUPLING CONST.

KNOWN NUMERICAL COEFFICIENT

EXAMPLE 2: A DIRICHLET p-BRANE ON TOP OF AN ORIENTIFOLD p-PLANE

(SO(2) TYPE)

CLASSICAL MASS OF AN OPEN STRING STRETCHED BETWEEN THE D-BRANE AND ITS IMAGE VANISHES IN THIS LIMIT

BUT THE SUPERSYMMETRIC GROUND STATE IS PROJECTED OUT.

THE GROUND STATE SURVIVING THE PROJECTION IS MASSIVE AND NON-BPS

THIS STATE CARRIES <u>CHARGE</u> UNDER THE SO(2) GAUGE FIELD LIVING ON THE WORLD-VOLUME OF THE SYSTEM.

THE <u>LIGHTEST</u> STATE CARRYING SO(2) CHARGE MUST BE <u>STABLE</u> FOR ALL VALUES OF THE COUPLING

Q. WHAT IS THE MASS OF THIS STATE IN THE <u>STRONG</u> COUPLING LIMIT?

$19\frac{1}{2}$

SUMMARY OF THE RESULTS FOR THE Dp-BRANE + Op-PLANE SYSTEM

p	MASS (IN STRING METRIC) FOR $g \gg 1$	OVERALL COEFFICIENT
6	$\propto g$	KNOWN
5	$\propto g^{1/2}$	KNOWN
4	$\propto g^{1/3}$	UNKNOWN
3	?	

$p \geq 7$: ASYMPTOTIC g NOT FINITE CONSTANT

$p \leq 2$: CHARGED STATE HAS ∞ SELF-ENERGY FROM $\int^{\infty} d^p x \, F_{\mu\nu} F^{\mu\nu}$

NOW WE TURN TO EXAMPLE I

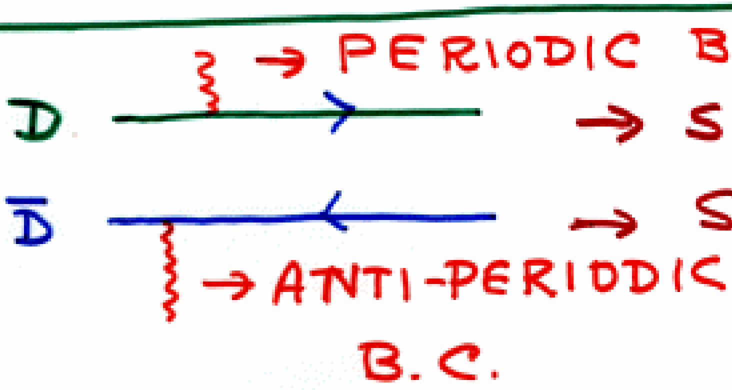
SO(32) SPINORS IN HETEROTIC THEORY IN STRONG COUPLING LIMIT

$\downarrow$ DUAL THEORY

WEAKLY COUPLED TYPE I

CONSIDER TYPE I COMPACTIFIED ON S^1 OF LARGE RADIUS R

TAKE A D-STRING - ANTI-D-STRING PAIR WRAPPED ON S^1 (COINCIDENT)



Polchinski & Witten

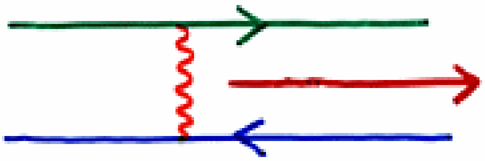
$\Rightarrow$ A SPINOR OF SO(32)

MASS = 2 . 2πR . T_D $\rightarrow \infty$ AS R $\rightarrow \infty$

↓

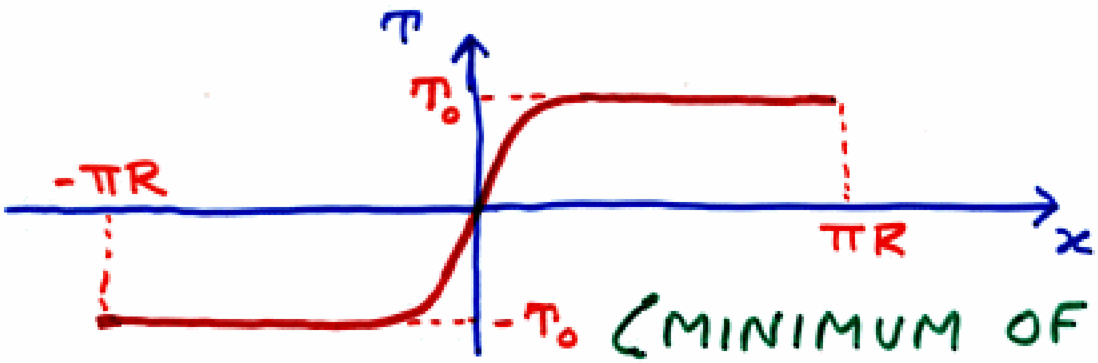
D-STRING TENSION

WE NEED TO TAKE INTO ACCOUNT THE FACT THAT THIS SYSTEM HAS A <u>TACHYONIC MODE</u>.



ANTI-PERIODIC B.C. ALONG S^1

THIS GIVES THE FOLLOWING MINIMUM ENERGY CONFIG. FOR R>>1:



(MINIMUM OF V(T))

→ HAS FINITE MASS FOR R→∞ IF $V(T_0)+2T_D=0$


ENERGY
DENSITY

$$\boxed{V(T_0) + 2\,T_D = 0}$$ → CAN BE "PROVED"

ASSUMING THIS RELATION TO BE TRUE, WE GET

$$\boxed{\text{MASS} = c / \tilde{g}}$$ → IN TYPE I METRIC

c → NUMERICAL CONSTANT

$\tilde{g}$ → TYPE I COUPLING

INDIRECT ARGUMENT

$$\Rightarrow \quad \boxed{c = \frac{[\text{illegible}]}{\sqrt{2}}}$$

MEASURED IN <u>HETEROTIC</u> METRIC:

$$\boxed{m = k\, g^{1/2}}$$

k → A NUMERICAL CONST. RELATED TO c

g → HETEROTIC COUPLING

DETERMINATION OF C:

$$\boxed{\text{COMPACTIFY TYPE I ON A CIRCLE OF RADIUS } R \text{ \& TAKE A D-STRING ANTI-D-STRING PAIR WRAPPED ON } S^1}$$

BOUNDARY CONDITION ON T:

$$\boxed{T(x+2\pi R) = -T(x)}$$

$\Rightarrow$ SPINOR OF $SO(32)$.

$$\boxed{T(x) = \sum_{n\in\mathbb{Z}} T_{n+1/2}\, e^{i(n+\frac{1}{2})\frac{x}{R}}}$$

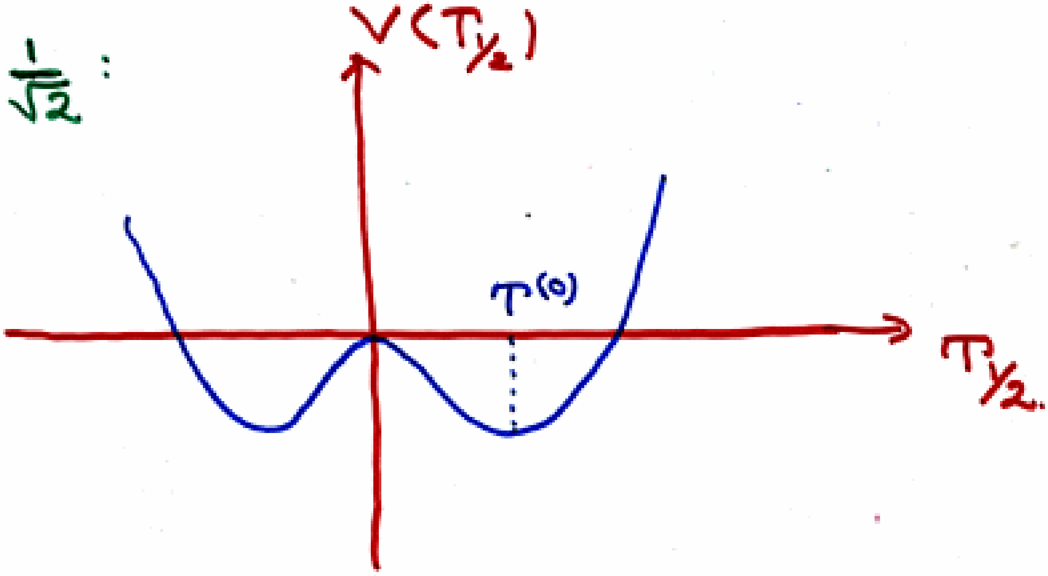
$\Rightarrow$ EFFECTIVE MASS^2 OF $T_{n+1/2}$:

$$\boxed{(n+\tfrac{1}{2})^2/R^2 - m_T^2{}_{=1/2}}$$

$\Rightarrow$ NO TACHYONIC MODE FOR $\boxed{R \leq \frac{1}{\sqrt{2}}}$

INTERPRETATION

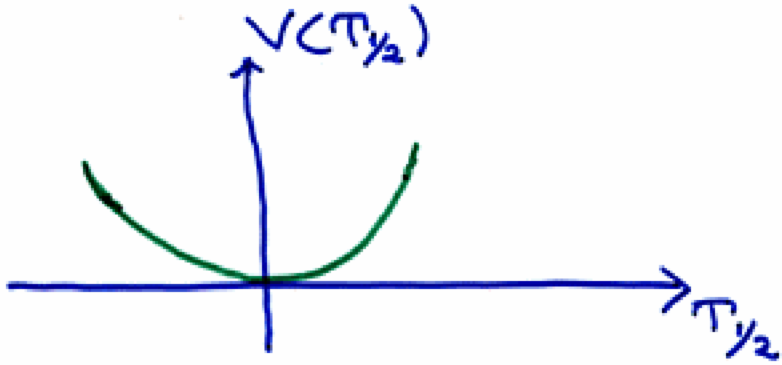
$R > \frac{1}{\sqrt{2}}$:



$$\underbrace{2 \cdot 2\pi R \cdot T_D}_{\text{TOTAL MASS OF } D1 + \overline{D1}} > m_{SPINOR}$$

T_D = D-STRING TENSION

$R < \frac{1}{\sqrt{2}}$:



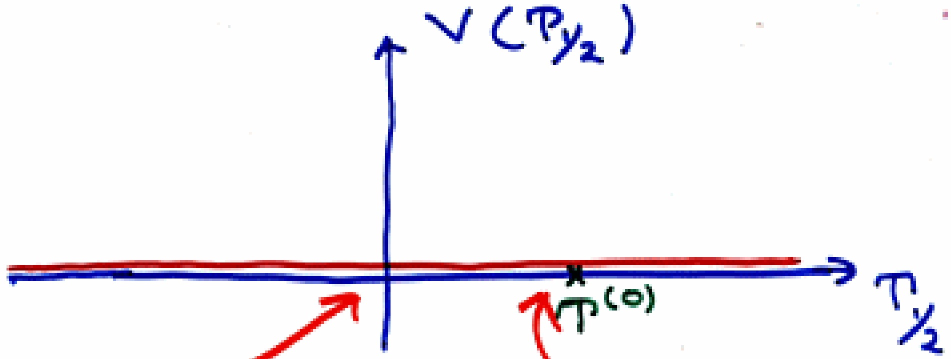
$$2 \cdot 2\pi R \cdot T_D < m_{SPINOR}$$

$D1 + \overline{D1}$ SYSTEM IS STABLE

AT $R = \frac{1}{\sqrt{2}}$, $T_{1/2}$ IS MASSLESS MODE

IN FACT IT REPRESENTS AN EXACTLY MARGINAL DEFORMATION

$$\Rightarrow V(T_{1/2}) = 0$$



$$\Rightarrow 2 \cdot 2\pi \underset{\substack{\parallel \\ 1/\sqrt{2}}}{R} \cdot \underset{\substack{\parallel \\ \frac{1}{2\pi\tilde{g}}}}{T_D} = m_{SPINOR}$$

$$\Rightarrow m_{SPINOR} = 2 \cdot 2\pi \cdot \frac{1}{\sqrt{2}} \cdot \frac{1}{2\pi\tilde{g}} = \frac{\sqrt{2}}{\tilde{g}}$$

$$\Rightarrow c = \sqrt{2}$$

CAVEAT:

THIS DERIVATION ASSUMES THAT:

$$\boxed{m_{SPINOR}(R=\infty) = m_{SPINOR}\left(R=\tfrac{1}{\sqrt{2}}\right)}$$

CAN WE IGNORE THE INTERACTION BETWEEN THE SPINOR STATE AND ITS IMAGES AT DISTANCE $\sim 2\pi n \cdot \frac{1}{\sqrt{2}}$?

WE DO NOT HAVE A COMPLETE ANSWER BUT NOTE THAT:

$$\boxed{\text{GRAVITATIONAL INT.} \sim \underbrace{\frac{1}{\tilde{g}} \cdot \frac{1}{\tilde{g}}}_{\text{MASSES}} \cdot \underbrace{\tilde{g}^2}_{G_N} \sim 1 \ll \frac{1}{\tilde{g}}}$$

CONCLUSION:

WE HAVE IDENTIFIED THE SO(32) SPINOR STATE IN TYPE I AND CALCULATED ITS MASS

PERHAPS THERE IS A SIMPLER DESCRIPTION OF THIS STATE AS SOME KIND OF "D-PARTICLE" IN TYPE I

Bergman & Gaberdiel

WE SHALL NOW TURN TO THE Dϕ-BRANE + Oϕ-PLANE SYSTEM