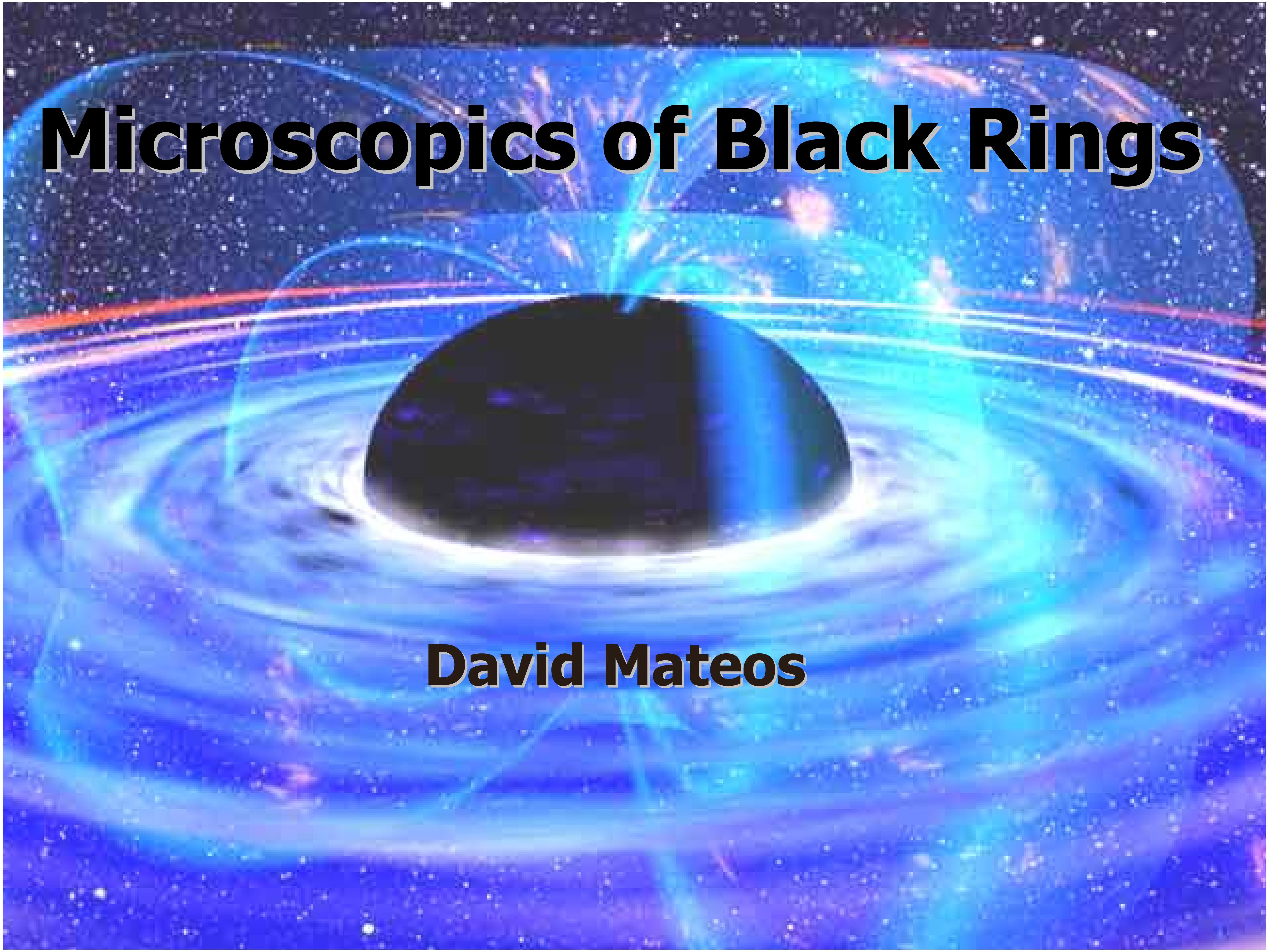


Microscopics of Black Rings

David Mateos

Why are Supersymmetric BRs interesting?

- Establish non-uniqueness in susy sector
- Establish stability of Black Rings
- Implications for microscopic entropy calculation

  ! Not only counting BPS states with same charges is not enough,

  it is also not right!

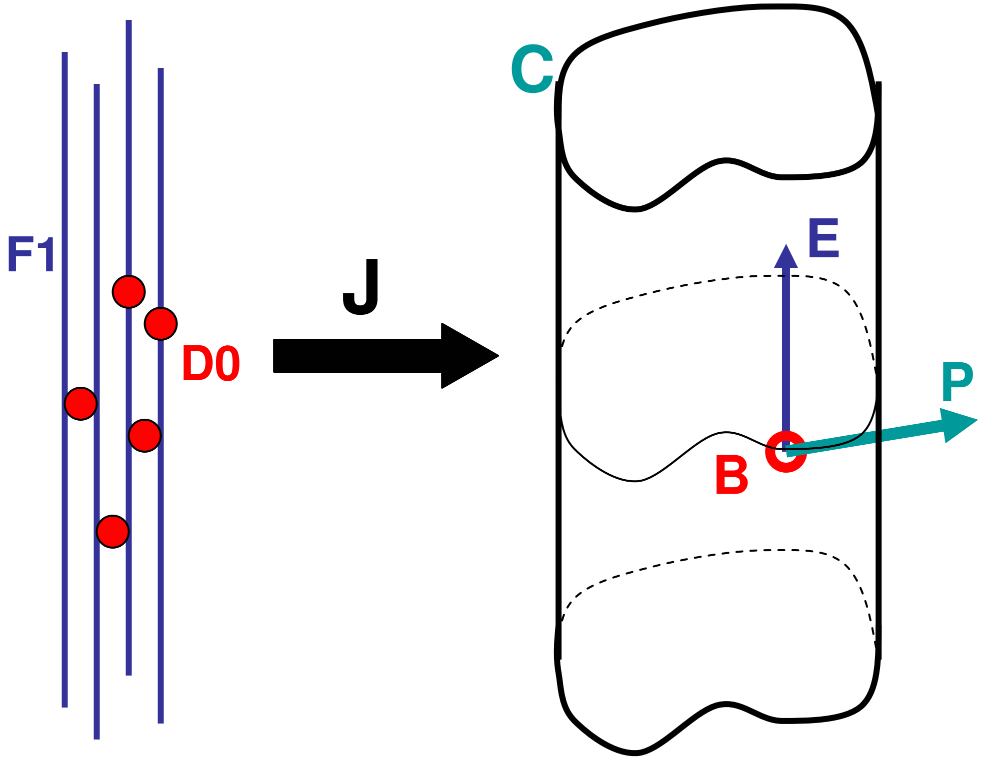
- Provide ideal arena to study these issues because:

  susy + know microscopic constituents + stability mechanism

Supertubes

DM & Townsend

Supersymmetric Brane Expansion in Flat Space by Angular Momentum



¼-SUSY

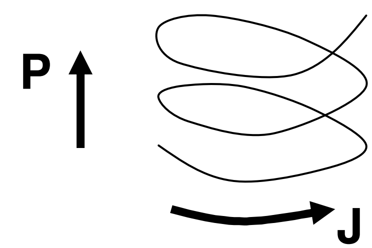
Tubular D2/F1/D0
Bound State

1/4-SUSY preserved

Q_{F1} and Q_{D0} dissolved as fluxes
J generated as integrated **Poynting**
$E = Q_{F1} + Q_{D0}$

Arbitrary Cross-section C in E^8

TS-Dualizing = \`Helical' String with wave on it



No net D2-brane charge
but dipole $q_{D2} \gg n_{D2}$

3-charge Supertubes and Black Rings

Elvang, Emparan, DM & Reall
Bena & Warner
Gauntlett & Gutowski

Ring solution with regular horizon ! 3 charges

Best microscopic description ! M-theory

First, lift 2-charge supertube to M-theory:

F1:	_	1
D0:	_	_
d2:	ψ	1

T34 →

F1:	_	1	_	_	_
D2:	_	_	_	3	4
d4:	ψ	1	_	3	4

Lift →

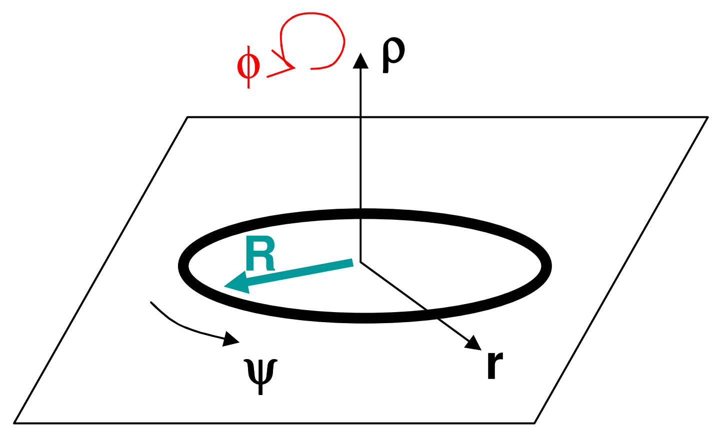
M2:	_	1	2	_	_
M2:	_	_	_	3	4
m5:	ψ	1	2	3	4

With 3 charges, each pair expands:

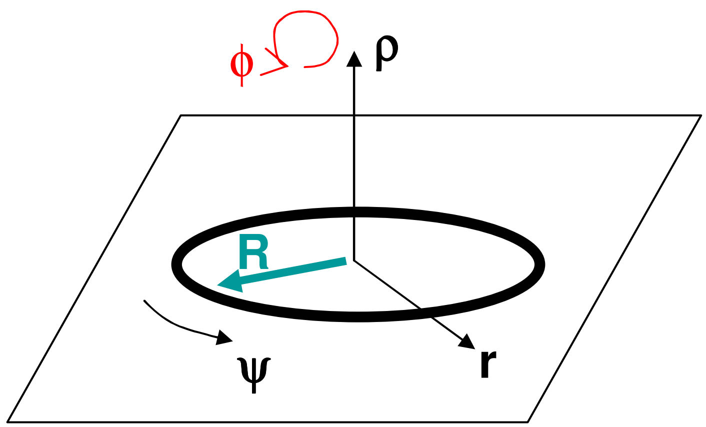
Q_1 M2:	1	2	_	_	_	_	_	_	_	_
Q_2 M2:	_	_	3	4	_	_	_	_	_	_
Q_3 M2:	_	_	_	_	5	6	_	_	_	_
q_1 m5:	_	_	3	4	5	6	ψ	_	_	_
q_2 m5:	1	2	_	_	5	6	ψ	_	_	_
q_3 m5:	1	2	3	4	_	_	ψ	_	_	_

$\underbrace{\qquad\qquad}_{T^6}$ $\underbrace{\qquad\qquad}_{E^4}$

$E^4 = E^2\,(r, \psi)$ £ $E^2\,(\rho, \phi)$ £ time = **5D black ring metric**



New feature: $J_\phi \neq 0$



7 parameters: R, Q_i , q_i

5 conserved charges: Q_i , J_ψ and J_ϕ

→ **Infinite violation of uniqueness by 2 continuous parameters**

Choosing Q_i, q_i and J_ψ as independent parameters:

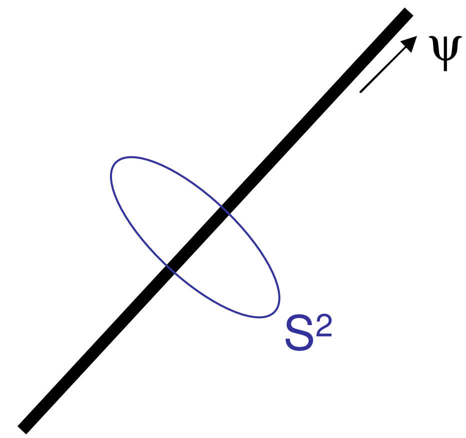
$$S = 2\pi\sqrt{\frac{D^2}{4} - DJ_\psi - \frac{1}{4}(q_1^2Q_1^2 + q_2^2Q_2^2 + q_3^2Q_3^2) + \frac{D}{2}\left(\frac{Q_1Q_2}{q_3} + \frac{Q_2Q_3}{q_1} + \frac{Q_1Q_3}{q_2}\right)}$$

$$D = q_1q_2q_3$$

Black String Limit

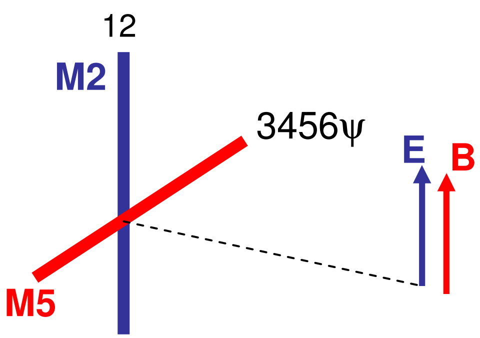
Send R ! 1 keeping Q_i / R and q_i fixed → Black string solution of Bena

Important: J_ψ ! $P_\psi \neq 0$ but J_ϕ ! 0 !

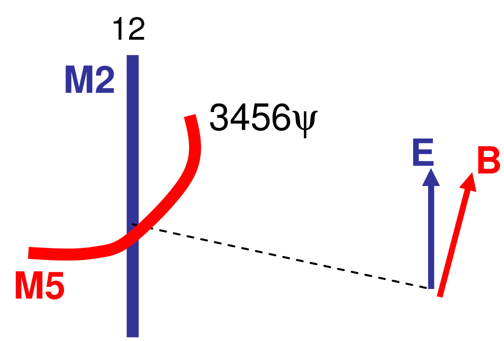


Suggests J_ϕ is entirely generated by SUGRA fields: J_ϕ » s $T_{0\phi}$ » s E £ B

Components of D=11 SUGRA F_4



E £ B = 0



E £ B / Q_1 q_1 + Q_2 q_2 + Q_3 q_3 – q_1 q_2 q_3

Worldvolume 3-charge Supertubes

First step: F1/D4/D0 bound state with D2/D6/NS5 dipoles

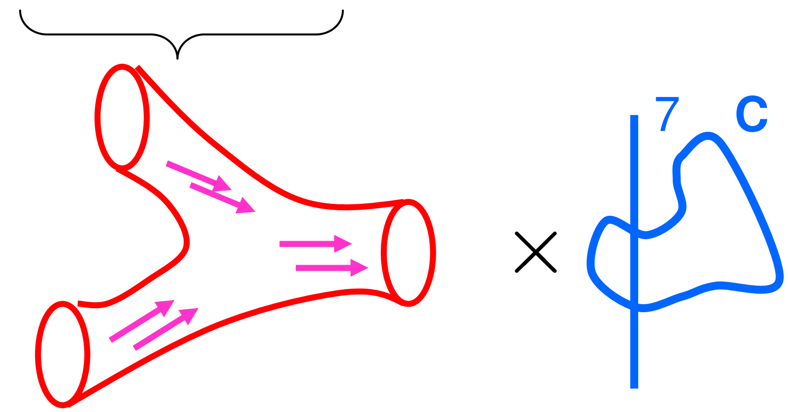
Bena & Kraus

Problematic in open string description

Circumvented in M-theory:

Q_1 M2:	1	2	_	_	_	_	_	_	_	_
Q_2 M2:	_	_	3	4	_	_	_	_	_	_
Q_3 M2:	_	_	_	_	5	6	_	_	_	_
q_1 m5:	_	_	3	4	5	6	$\mathcal{C}$	_	_	_
q_2 m5:	1	2	_	_	5	6	$\mathcal{C}$	_	_	_
q_3 m5:	1	2	3	4	_	_	$\mathcal{C}$	_	_	_

Single M5-brane =



Holomorphic 2-surface in T^6

Gibbons & Papadopoulos
Gauntlett, Lambert & West

Elvang, Emparan, DM & Reall

Turning on H induces M2 charge and allows arbitrary C

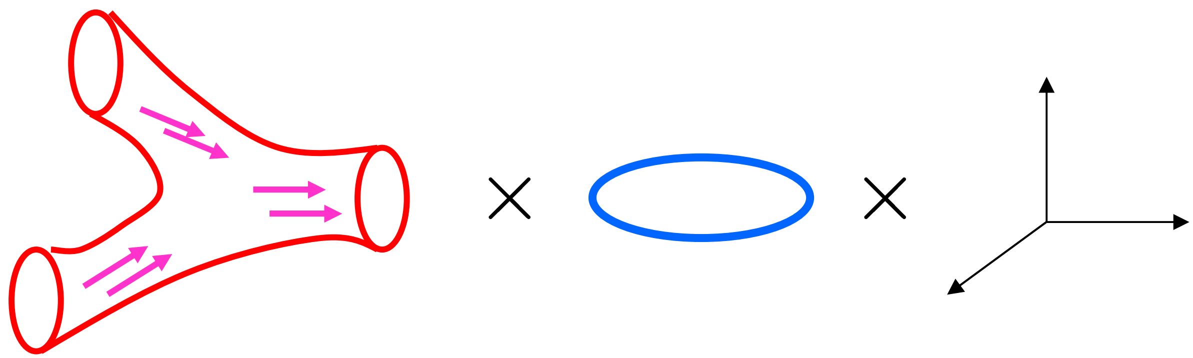
In summary: Captures 3 dipoles, $J_\phi = 0$

Microscopic Entropy Counting

Maldacena, Strominger & Witten; Vafa

M-theory on T^6 £ S^1 £ $R^{1,3}$

Single M5-brane =



Holomorphic 2-surface in T^6

S^1

$R^{1,3}$
4D black hole

(0,4) CFT with $c_{left} = 6q_1q_2q_3$ and left-moving momentum p

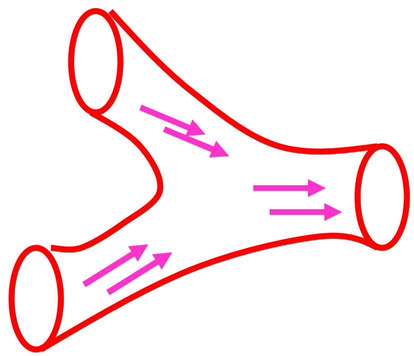
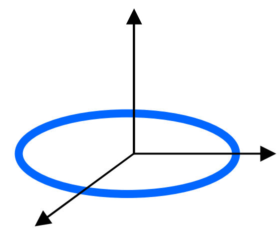
$$S = 2\pi\sqrt{p'\, c_L/6}$$

p' = p + M2-induced shift
+ zero-point shift

Microscopic Entropy Counting

Cyrier, Guica, DM & Strominger
(see also Bena & Kraus)

M-theory on T^6 £ $R^{1,4}$

Single M5-brane =  $\times$ 

Holomorphic 2-surface in T^6

S^1 in $R^{1,4}$
5D black ring

(0,4) CFT with $c_{left} = 6q_1q_2q_3$ and left-moving momentum $p = J_\psi$

$$S = 2\pi\sqrt{p'\,c_L/6}$$ ⟵ Counts states with $J_\phi=0$!!!

However, same spirit as Strominger & Vafa '96.

Distribution of Angular Momentum

Emparan & DM (to appear)

Komar Integral: $$J_\psi = \int_{\partial V} *dk_\psi$$

At infinity: $$\int_{S^3} *dk_\psi = J_\psi \;\; , \quad \int_{S^3} *dk_\phi = J_\phi$$

At the horizon: $$\int_{S^1\times S^2} *dk_\psi = p' \;\; , \quad \int_{S^1\times S^2} *dk_\phi = 0$$

Provides New Comparison of the Bek-Haw vs Mic Entropy:

$$S = 2\pi\sqrt{q_1 q_2 q_3 p'}$$

ONE MESSAGE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