Universal turbulence on branes in holography

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[arXiv:1504.XXXX(hep-th)]

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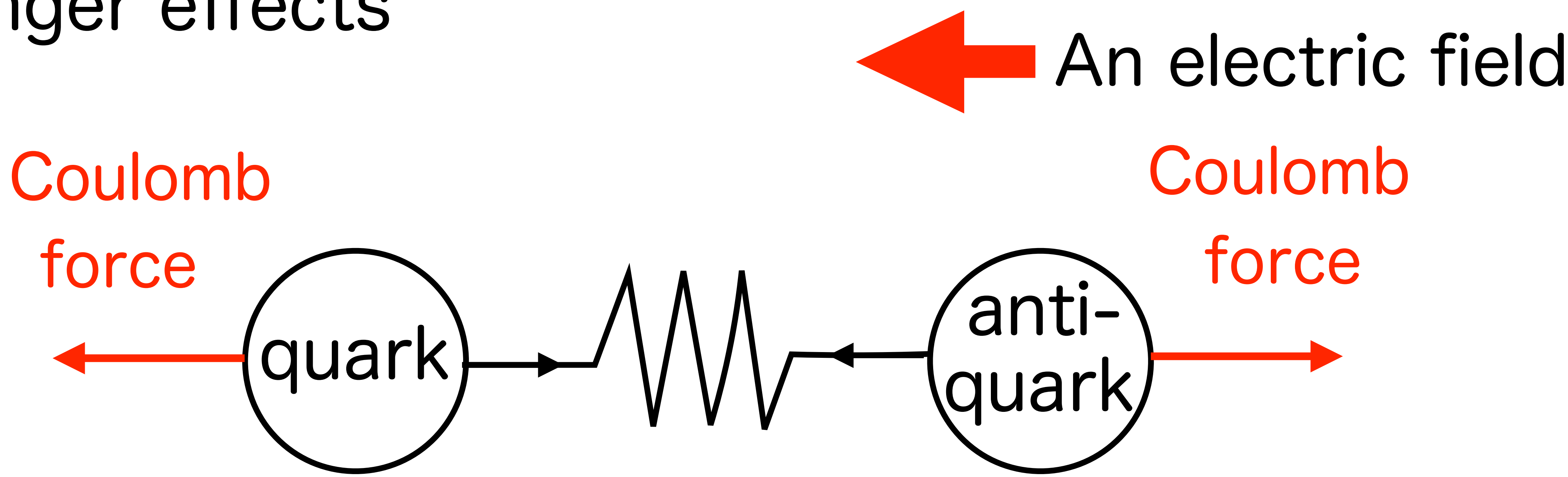
Introduction

Power law scaling, universal phenomena

Schwinger effects



[K.Hashimoto, T.Oka (1307.7423)]
[K.Hashimoto, T.Oka, A.S (1403.6336)]
[K.Hashimoto, T.Oka, A.S (1412.4254)]

We evaluated vacuum instability induced by an electric field and a magnetic field.

➡ Meson condensation at the phase boundary ?

Introduction

Power law scaling, universal phenomena

Power law scaling at the phase transition

ex1) Hagedorn transition in string theory

$$\rho(E_n)\exp\left(-\frac{E_n}{T}\right) \simeq E_n^\alpha \exp\left(\frac{E_n}{T_c}\right)\exp\left(-\frac{E_n}{T}\right)$$ Power law

ex2) Turbulent meson condensation

[Hashimoto, Kinoshita, Murata, Oka (1408.6293)]

➡ Universality of turbulent meson ?

[Weak turbulence in AdS space-time

[P.Bizon, A.Rostworowski(1104.3702 [gr-qc])]

Power law scaling: $E_n \simeq n^\alpha$]

Problem

Universality of a power law on turbulent mesons condensation ?

Methods

Gravity dual to D3-D5 brane(N=2 SQCD)

The fluctuation of the D5-brane by an electric field or a temperature

↓

The spectrum of the scalar mesons

Results

- The D5-branes have a cusp by the electric field or a temperature.
- (The energy of the n-th meson) $\propto$ (mass) $^{-4}$

Problem

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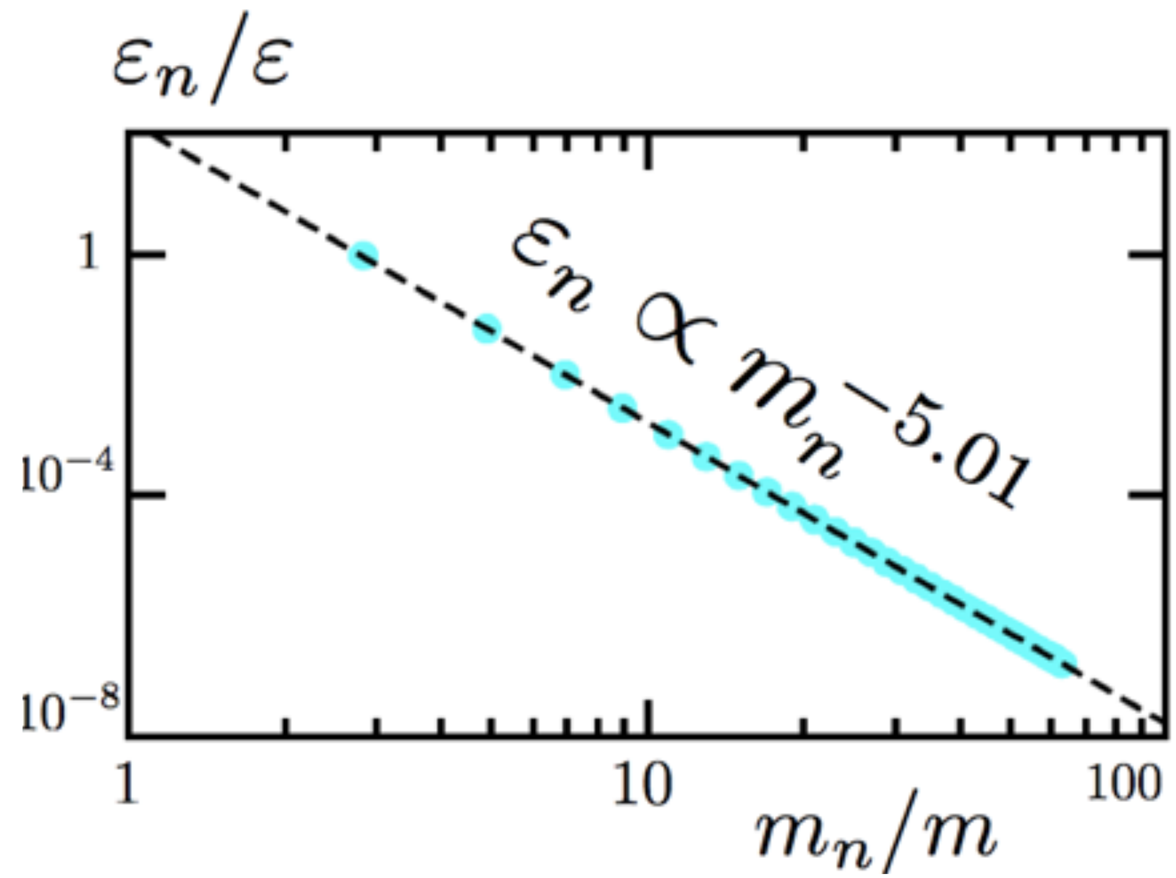
[Hashimoto, Kinoshita, Murata, Oka (1408.6293)]

In D3-D7 brane system(N=2 SQCD)



The power law of the n-th meson in the other brane systems ?

Methods

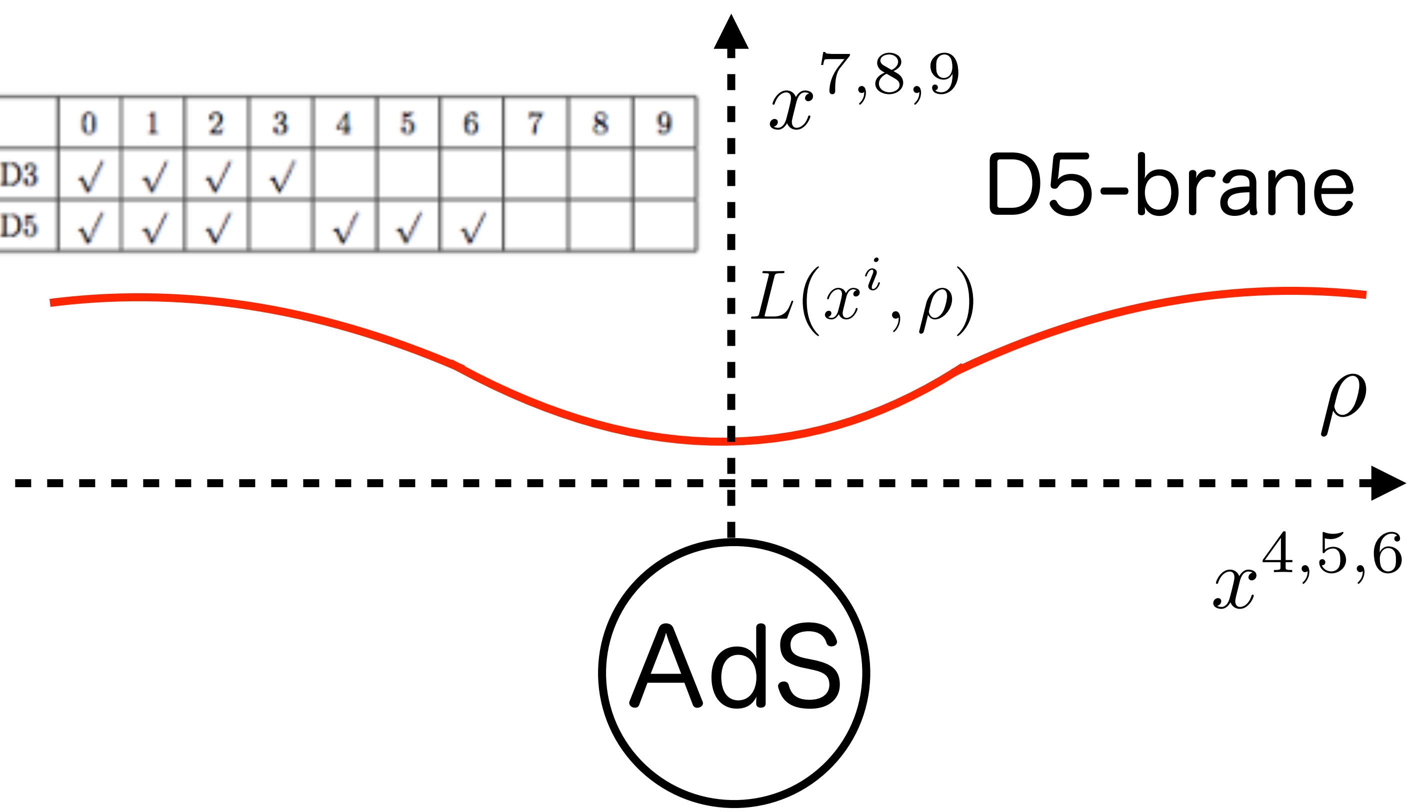
Gravity dual to D3-D5 brane(N=2 SQCD)

The fluctuation of the D5-brane by an electric field or a temperature

The spectrum of the scalar mesons

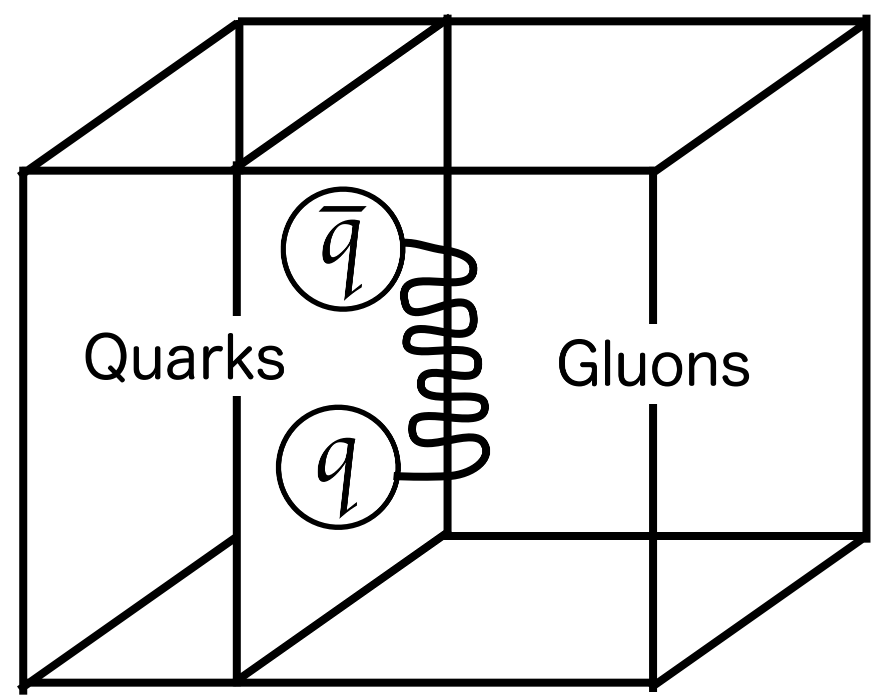
D3-D5 brane(an electric field)

	0	1	2	3	4	5	6	7	8	9
D3	√	√	√	√						
D5	√	√	√		√	√	√			



[J.Erdmenger, R.Meyer, J.P.Shock (0709.1551)]

N=2 SQCD



The quarks on the domain wall

Methods

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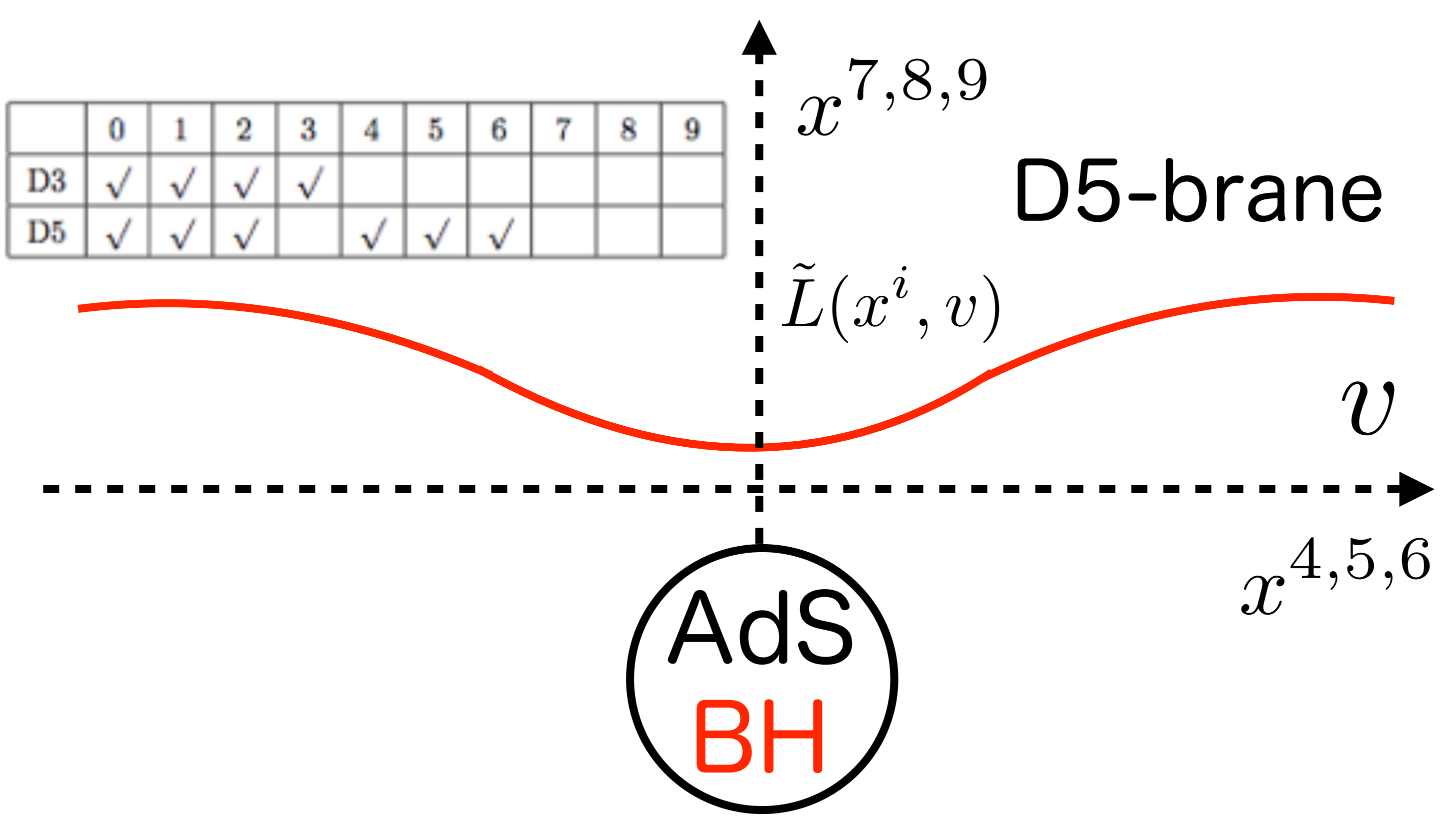
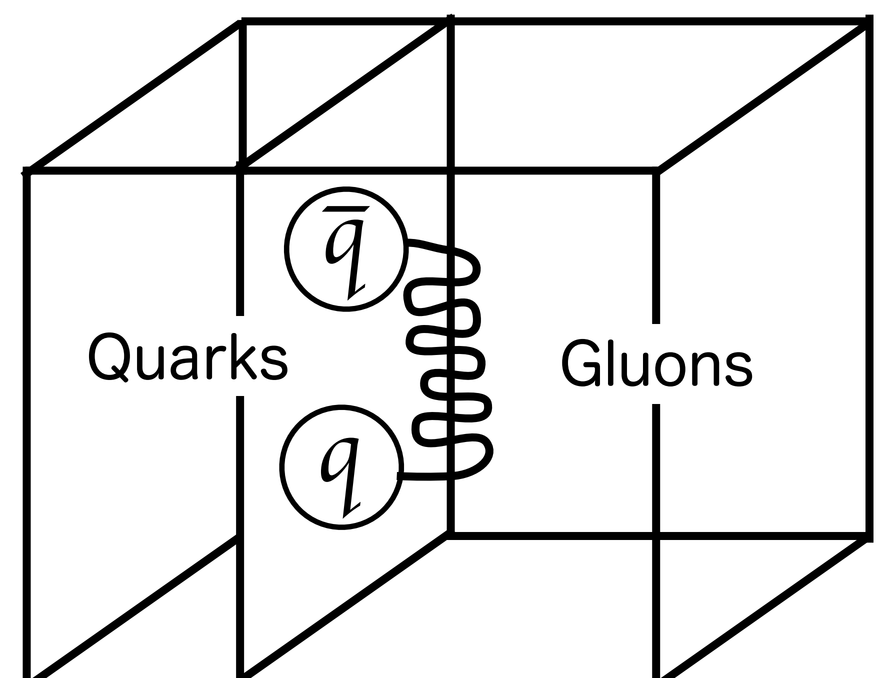
D3-D5 brane(a temperature)



	0	1	2	3	4	5	6	7	8	9
D3	√	√	√	√						
D5	√	√	√		√	√	√			

[D.Mateos, R.C.Myers, R.M.Thomson(0605046)]

N=2 SQCD



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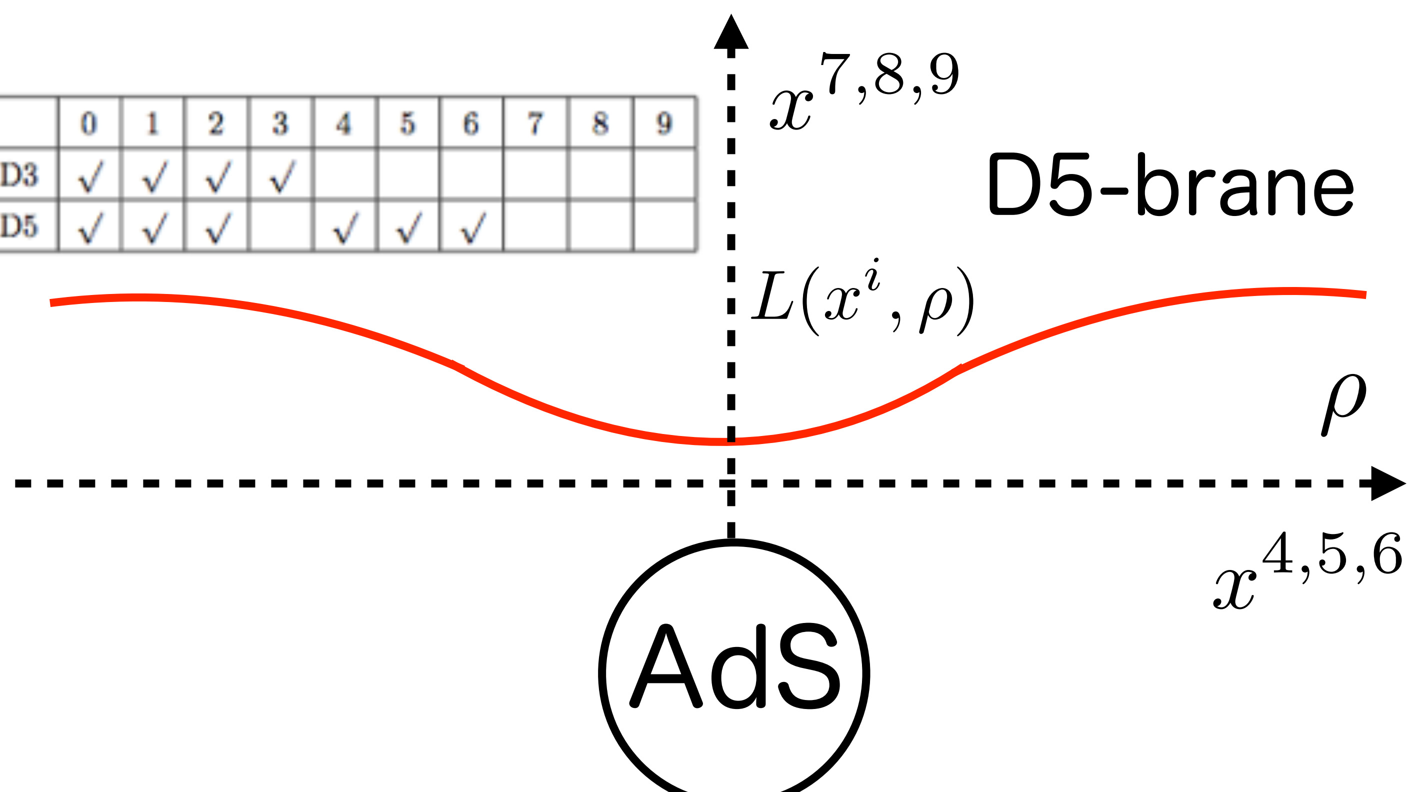
The spectrum of the scalar mesons

D3-D5 brane

	0	1	2	3	4	5	6	7	8	9
D3	√	√	√	√						
D5	√	√	√		√	√	√			



D5-brane action

$$S = -\tau_5 \int d^6\xi \sqrt{-\det\left(P\left[L(x^i,\rho)\right]_{ab} + 2\pi l_s^2 F_{ab}\right)}$$

Scalar field: $L(x^i, \rho)$ $(i = 0, 1, 2)$

↓

The energy and mass of the scalar meson

$$\varepsilon_n, \ m_n \ (n = 0, 1, 2, \cdots)$$

[M.Kruczenski, D.Mateos, R.C.Myers, D.J.Winters(0304032)]

Methods

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Meson effective action [R.C.Myers, R.M.Thomson (0605017)]

$$S = \int d^3x \int_0^\infty d\rho \frac{\rho^2 R^2 m}{2(\rho^2+R^4m^2)^2}\left[(\partial_t\chi)^2 - \frac{(\rho^2+R^4m^2)^2}{R^4}(\partial_\rho\chi)^2\right] + \mathcal{O}(\chi^3)$$

$$\left[\frac{\partial^2}{\partial t^2} - \frac{(\rho^2+R^4m^2)^2}{\rho^2R^2m}\frac{\partial}{\partial\rho}\frac{\rho^2 m}{R^2}\frac{\partial}{\partial\rho}\right]\chi = 0$$ E.O.M. $\chi = \sum_{n=0}^{\infty} c(t) e_n(\rho)$ Meson modes

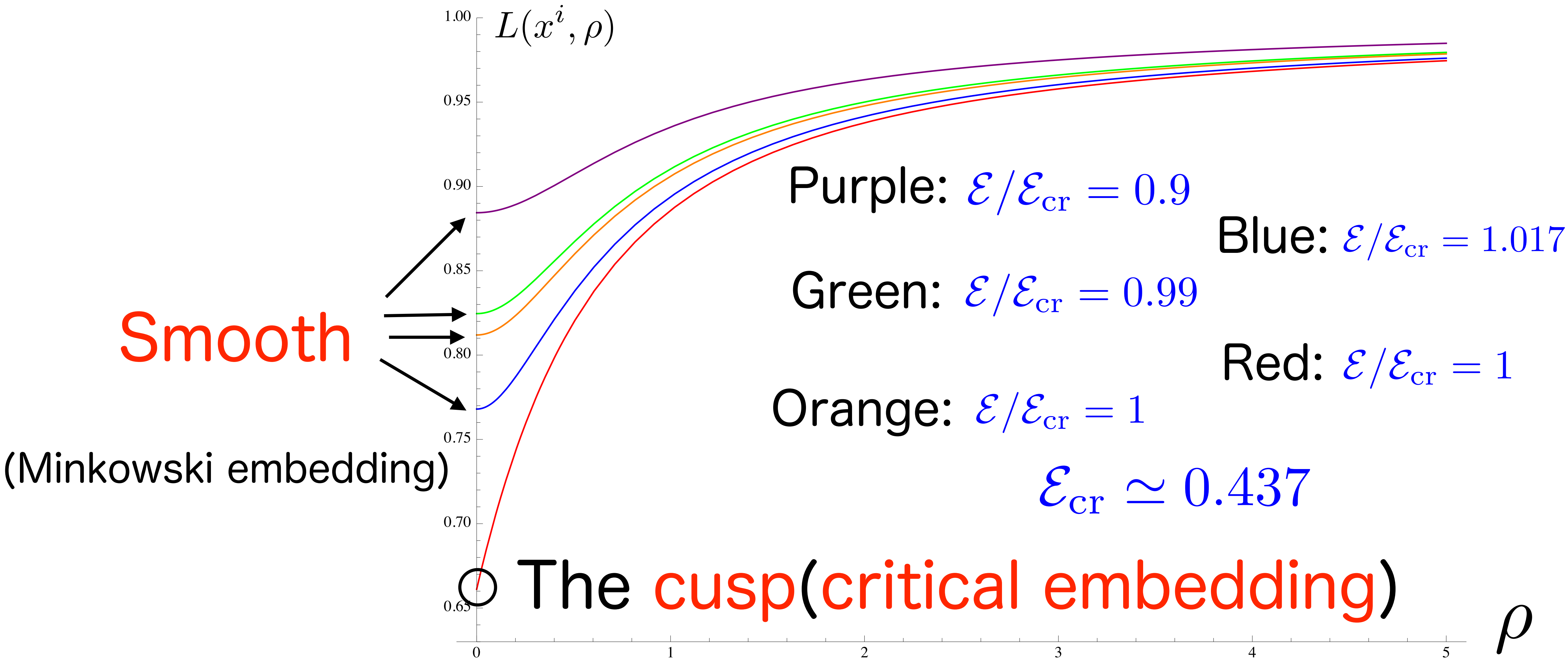
$$e_n(\rho) \equiv N_n F\left(-n, -1/2-n, 3/2; -\frac{\rho^2}{R^4m^2}\right) \qquad \Omega_n \equiv 2\sqrt{(1/2+n)(3/2+n)}m$$

$$S = \int d^3x \sum_{n=0}^{\infty}\left[\frac{1}{2}\dot{c}_n^2 - \frac{1}{2}\Omega_n^2 c_n^2\right] + \mathcal{O}(\chi^3)$$ Meson energy $\varepsilon_n \equiv \frac{1}{2}(\dot{c}_n^2 + \Omega_n^2 c_n^2)$

Results

- The D5-branes have a **cusp** by the **electric field** or a **temperature**.
- (The energy of the n-th meson) $\propto$ (mass)$^{-4}$

The shape of the D5-brane(the electric field)



Results

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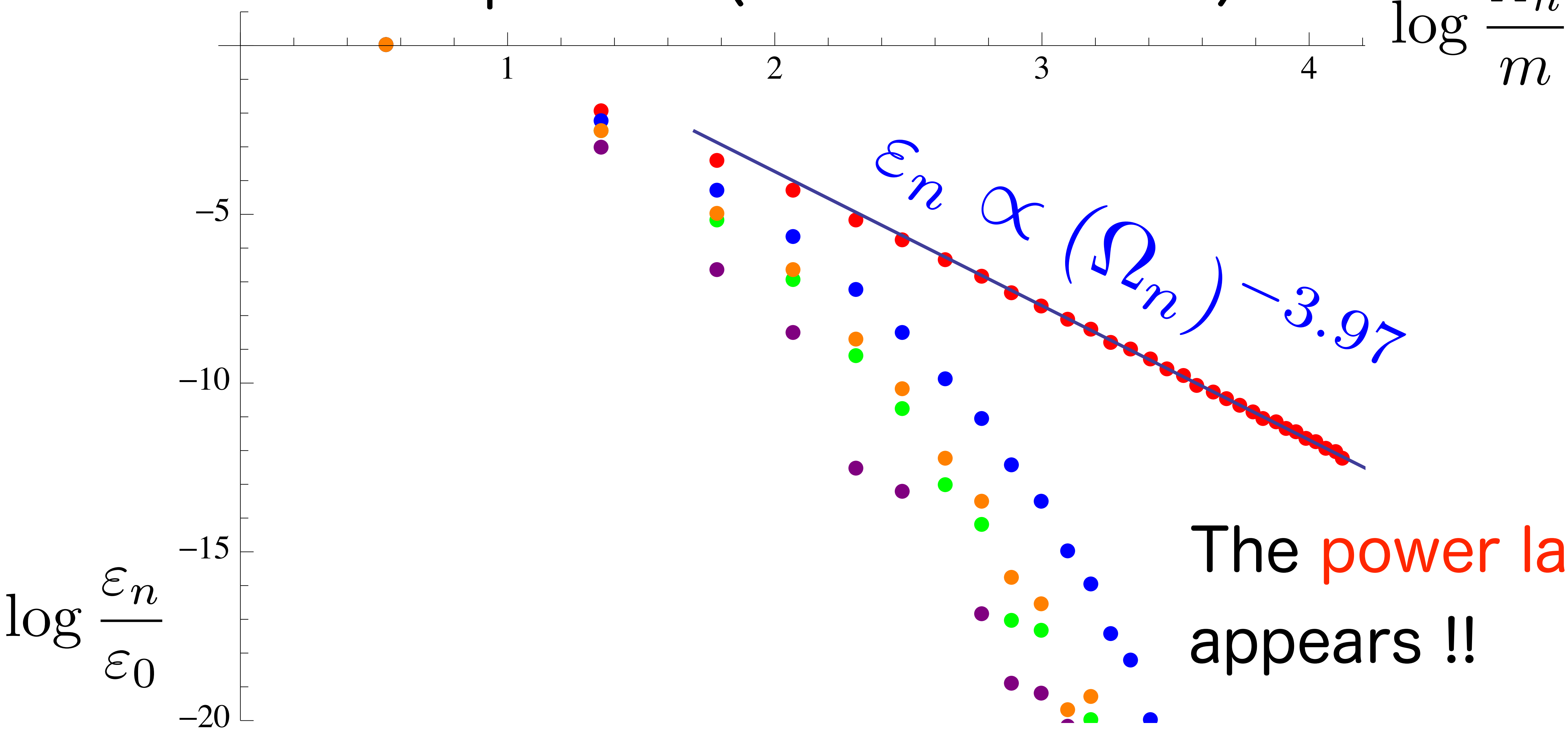
The n-th meson spectrum(the electric field)

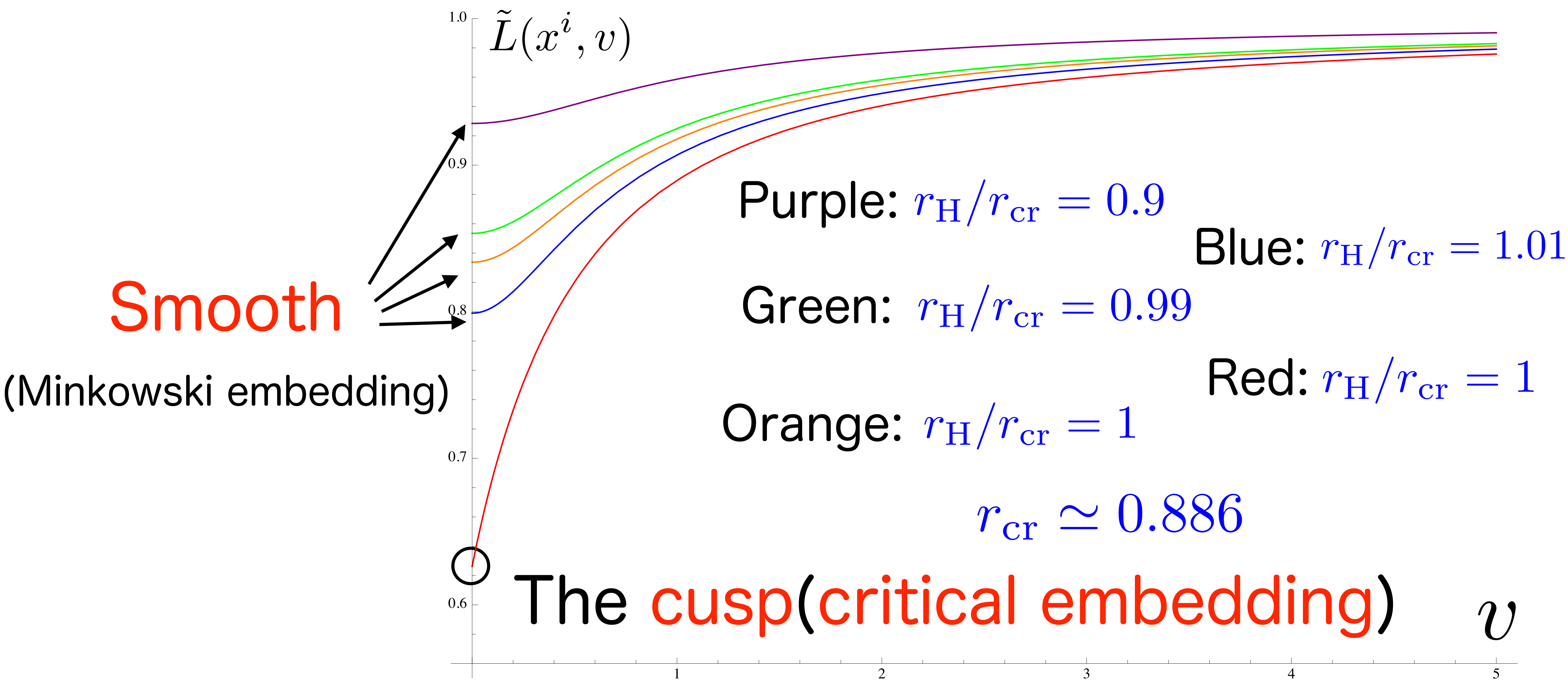


The **power law** appears !!

Results

- The D5-branes have a cusp by the electric field or a temperature.
- (The energy of the n-th meson) $\propto$ (mass)$^{-4}$

The shape of the D5-brane(a temperature)



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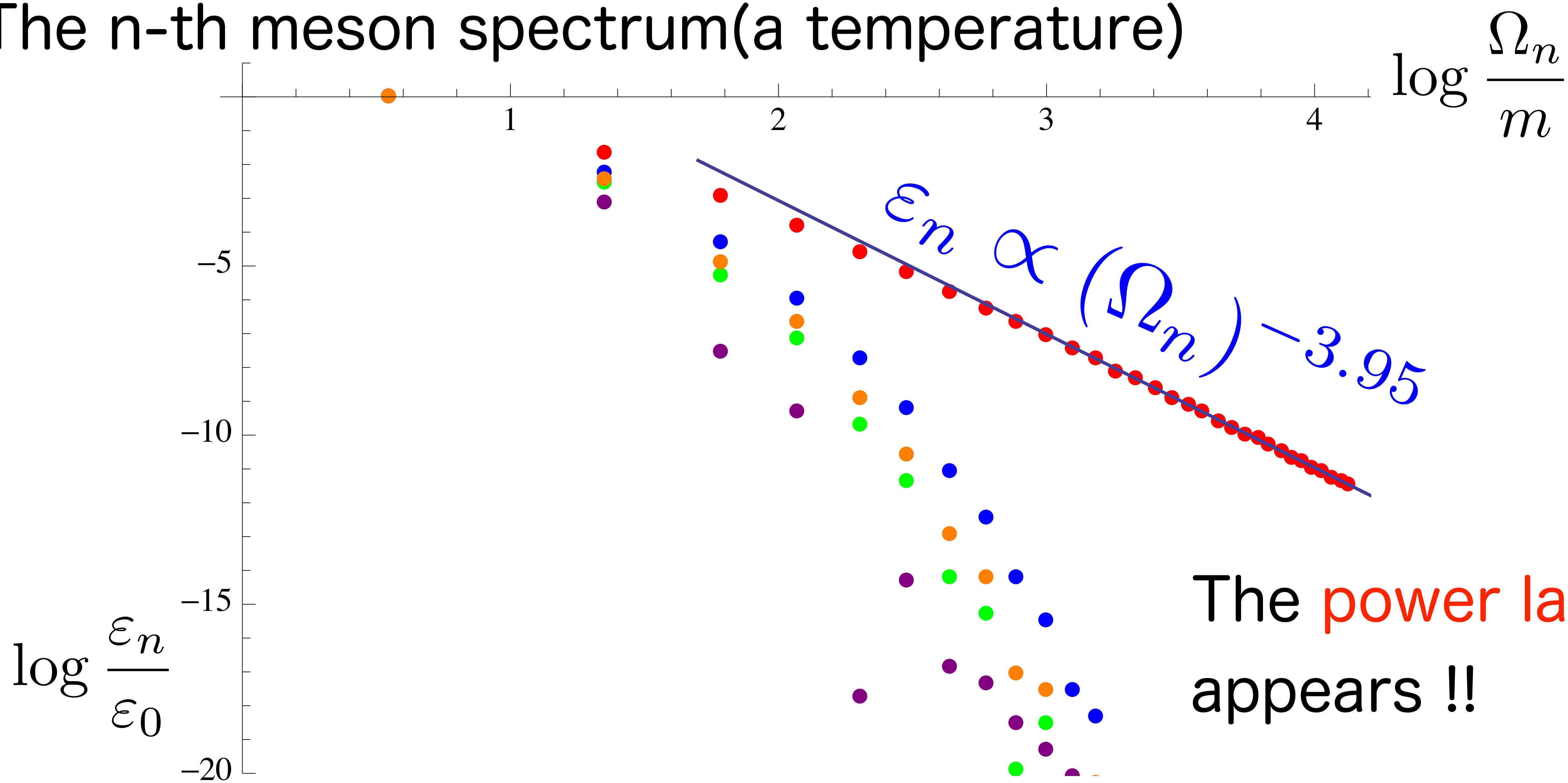
The n-th meson spectrum(a temperature)



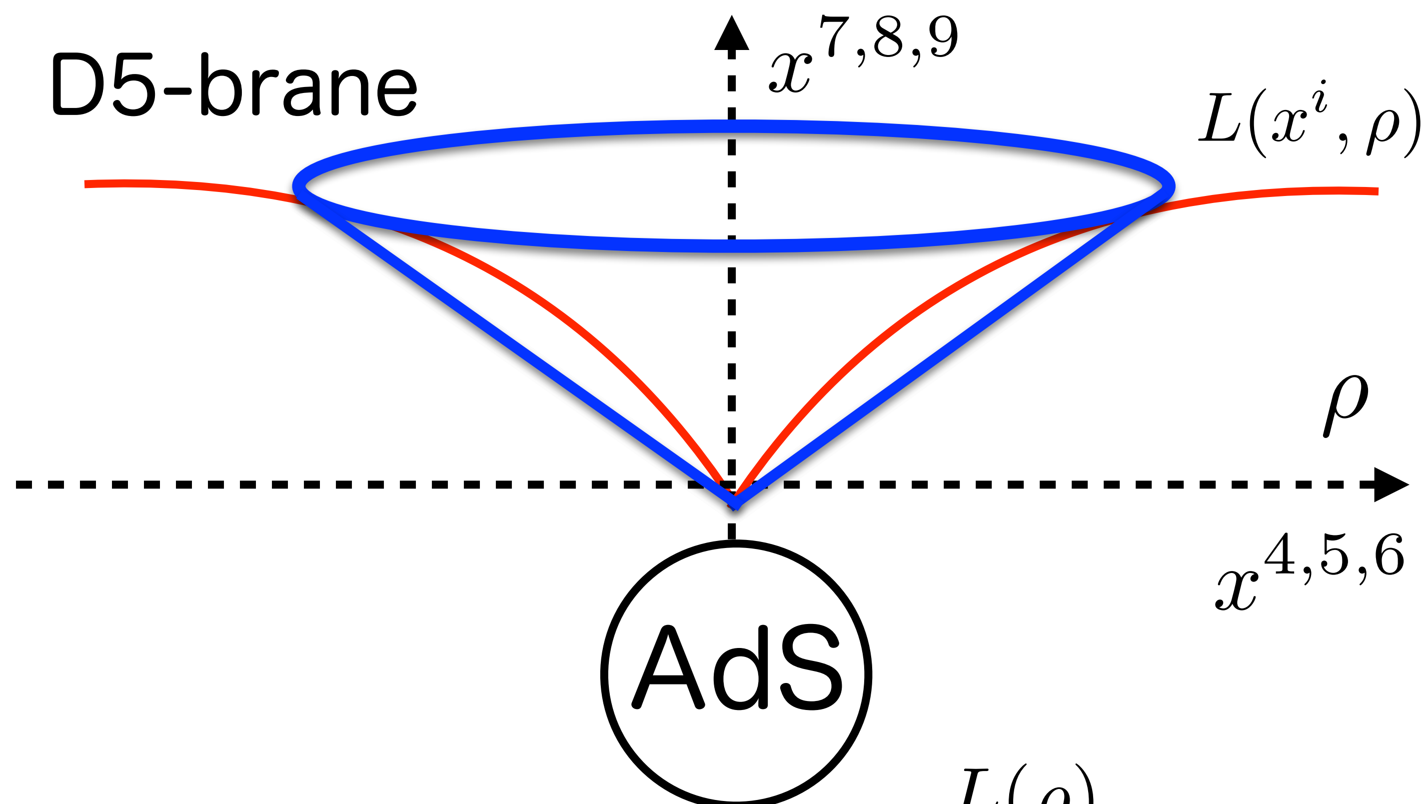
The power law appears !!

Conjectures

The power law α depends on only the **dimensionality of the brane cone**: $-(d_{\mathrm{cone}}+1)$

	0	1	2	3	4	5	6	7	8	9
D3	√	√	√	√						
D5	√	√	√		√	√	√			

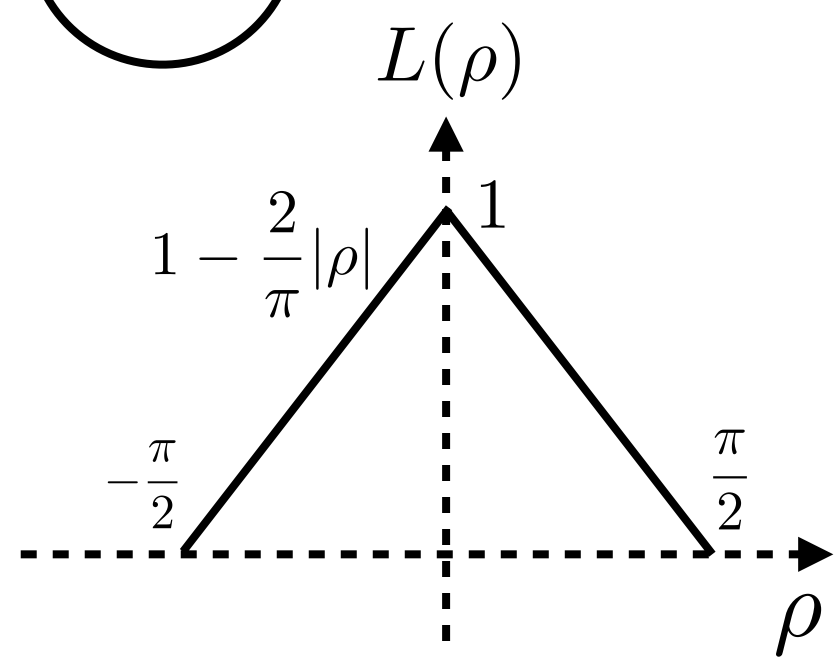
3-dimensional cone!!



Ex. 1-dimensional cone

$$L(\rho) = \sum_{n=0}^{\infty} c_n e_n(\rho)$$

$$\varepsilon_n \equiv \frac{1}{2} m_n^2 c_n^2 = \frac{2^4}{\pi^3} \frac{1}{(2n+1)^2} \quad \Rightarrow \quad \varepsilon_n \sim n^{-2}$$



(Ex. 2-dimensional cone $\varepsilon_n \sim n^{-3}$)

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