Electric field quench and turbulent meson condensation in AdS/CFT

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with K.Hashimoto, S.Kinoshita, T.Oka

- K,Hashimoto,S.Kinoshita,KM,T.Oka, ”Electric Field Quench in AdS/CFT”, arXiv:1407.0798, accepted in JHEP.
- K,Hashimoto,S.Kinoshita,KM,T.Oka, ”Turbulent meson condensation in quark deconfinement”, arXiv:1408.6293
- K,Hashimoto,S.Kinoshita,KM,T.Oka, "Meson turbulence at quark deconfinement from AdS/CFT”, arXiv:1412.4964

Non-equilibrium process in AdS/CFT

- N=4 SYM
- QCD
- Condensed matter physics
- etc…

AdS/CFT ⟺

Gravity theories

↓ **Non-equilibrium** ↓

First-principles calculation is not tractable.

Tractable.
At least, there is no problem in the formulation(Cauchy problem).

The AdS/CFT gives one of the hopeful approaches to study the non-equilibrium process in strongly coupled systems.

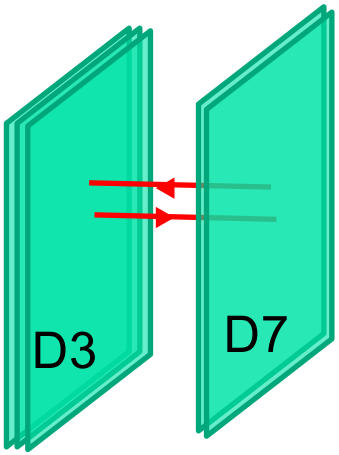
We study the non-equilibrium process in holographic QCD induced by time dependant electric field.

D3/D7 model

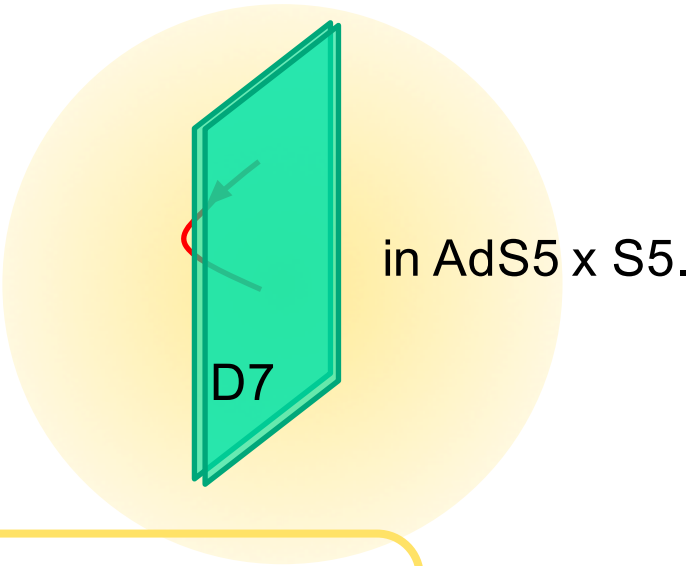
Karch&Katz, 02

	0	1	2	3	4	5	6	7	8	9
Nc D3	✓	✓	✓	✓						
Nf D7	✓	✓	✓	✓	✓	✓	✓	✓		

Nc>>Nf



Near horizon lmit of D3-branes



in AdS5 x S5.

D7 action

$$S = \int d^8\sigma \sqrt{\det(h_{ab} + 2\pi\alpha' F_{ab})}$$

induced metric

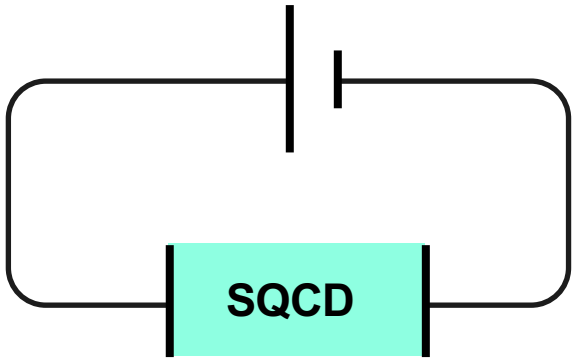
Electromagnetic field

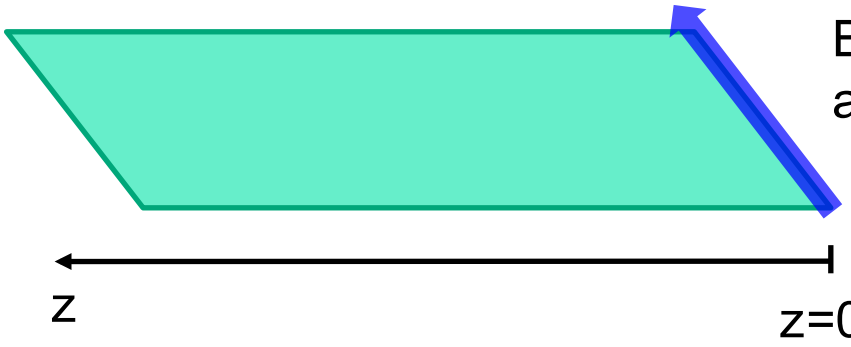
This model is dual to N=2 Super symmetric QCD.

Fluctuation of the D7-brane = meson excitation

Static electric field

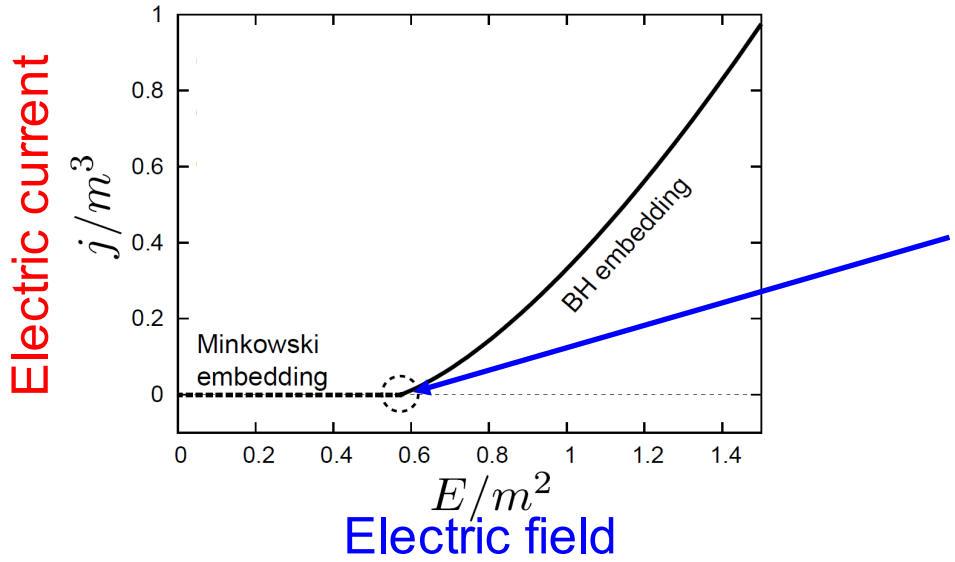
Karch&O'Bannon,07





Boundary condition
at AdS boundary

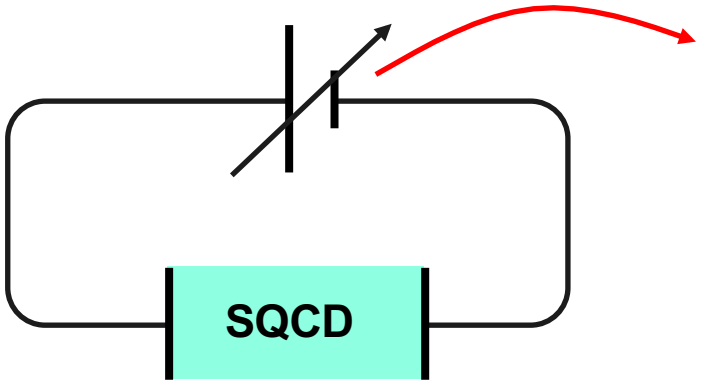
$$F_{tx} = -E$$

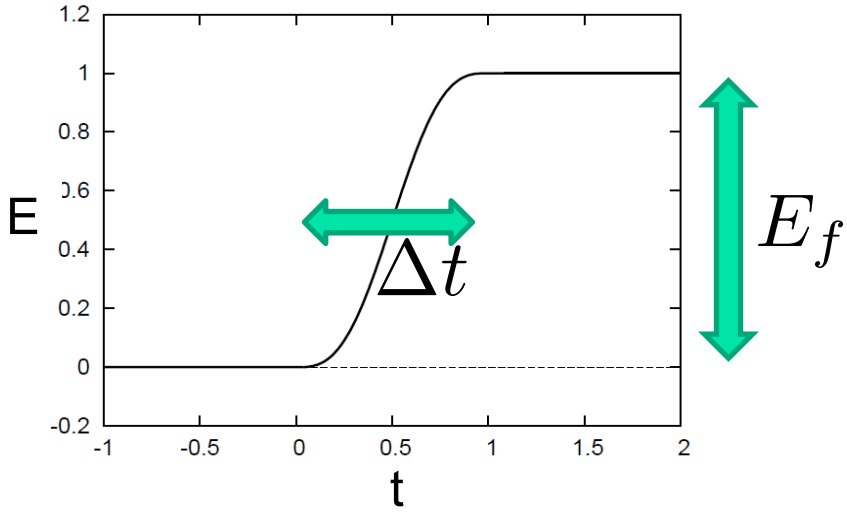


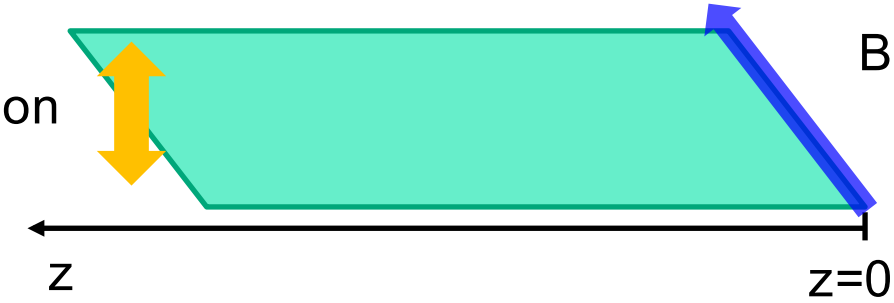
Schwinger limit $E = E_{Sch}$
above which non-zero
electric current is generated.

Albash,Filew,Johnson&Kundu,07
Erdmenger,Meyer&Shock,07
Nakamura,12
Hashimoto,Kinoshita,KM,Oka, 14

Time dependant electric field







Boundary condition:

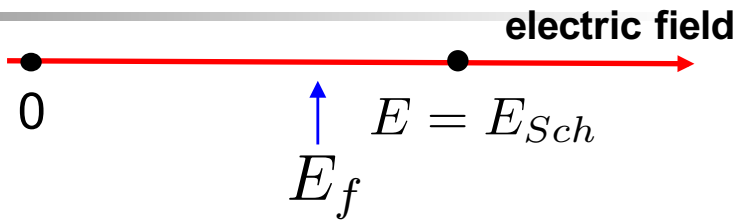
$$F_{tx}|_{z=0} = -E(t)$$

Time-dependant electric field induces the brane motion.

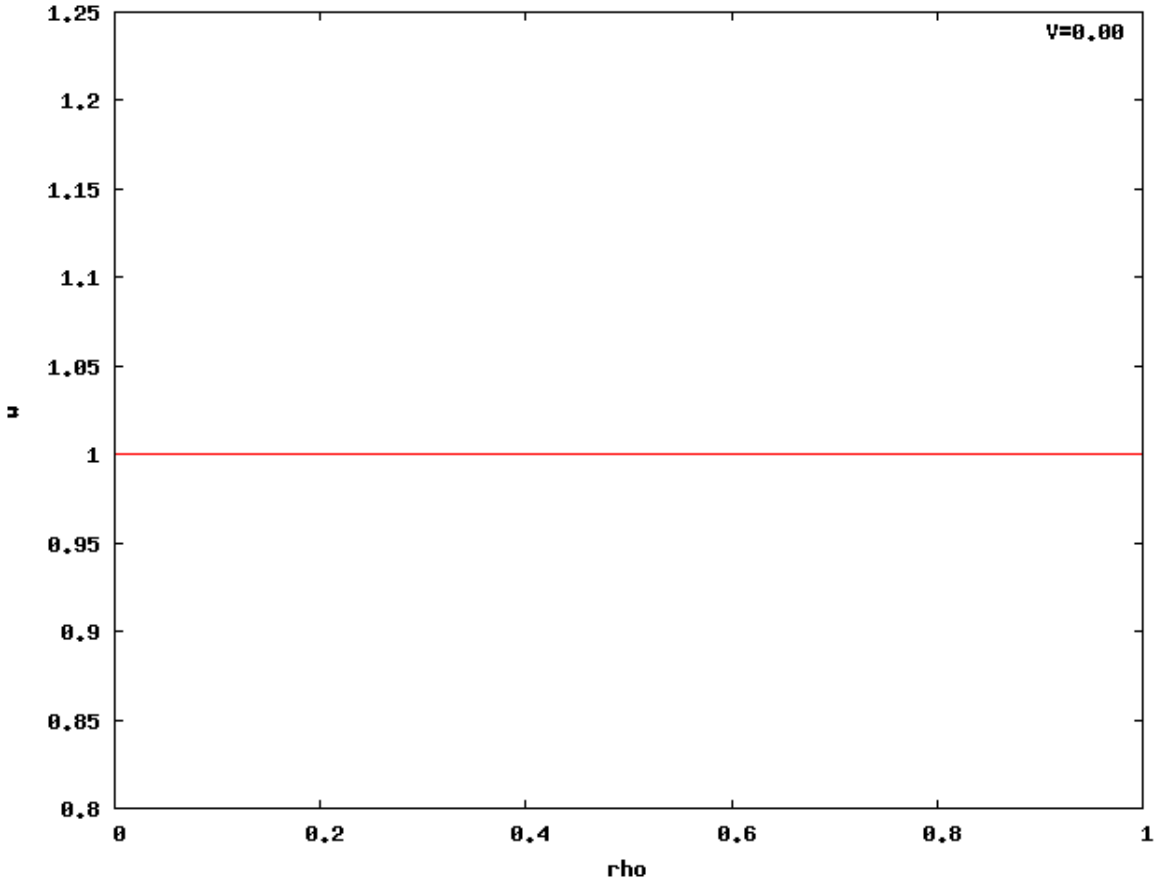
Numerical calculation

Ishii, Kinoshista, KM, Tanahashi, 14

Subcritical case



$$E_f/m^2 = 0.19, \quad m\Delta t = 2$$

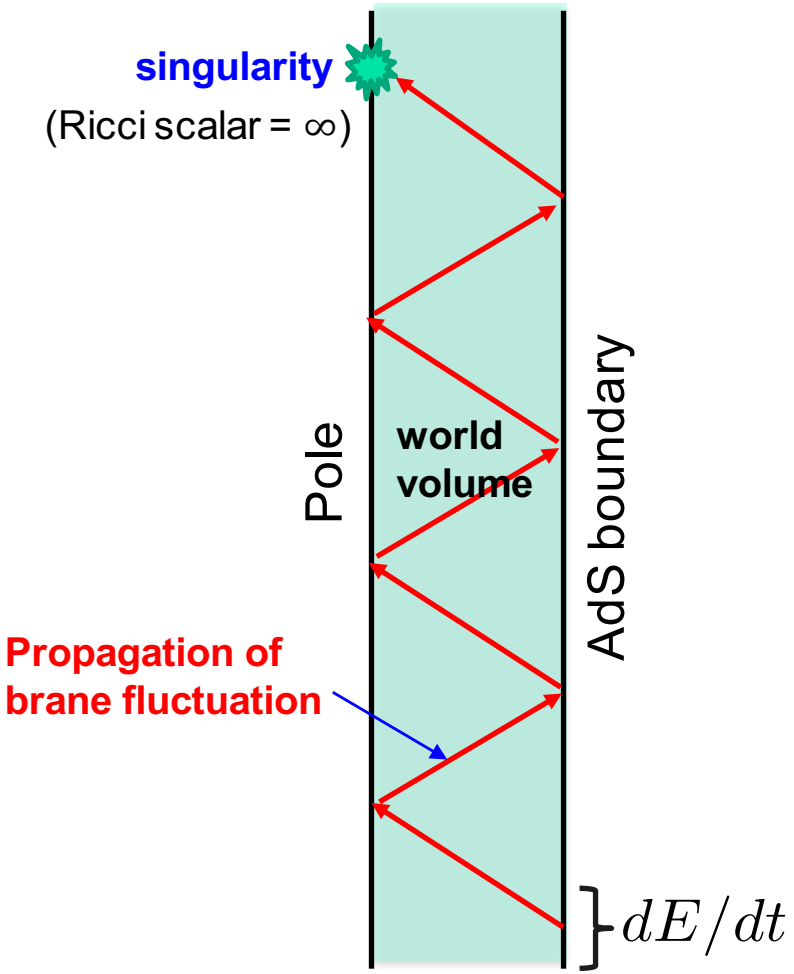


At t~12, the brane moves very quickly.

Our numerical calculation has crushed there.

What's happened?

Naked singularity formation

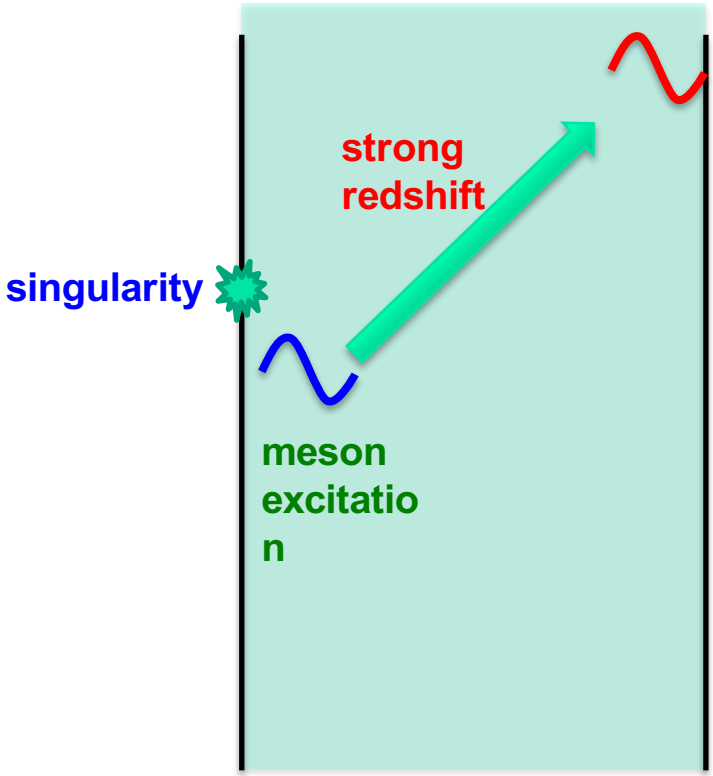


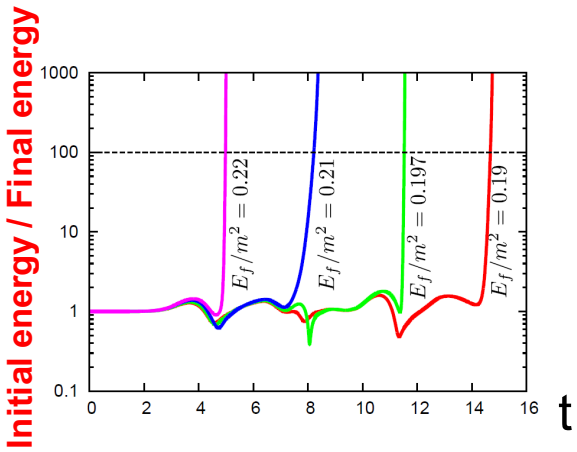
D-brane version of the weakly turbulent instability in AdS.
Bizon&Rostworowski, 11

The final fate is not a BH, but a naked singularity.

Singularity formation implies quark deconfinement

A meson excitation going through near the singularity is strongly redshifted.

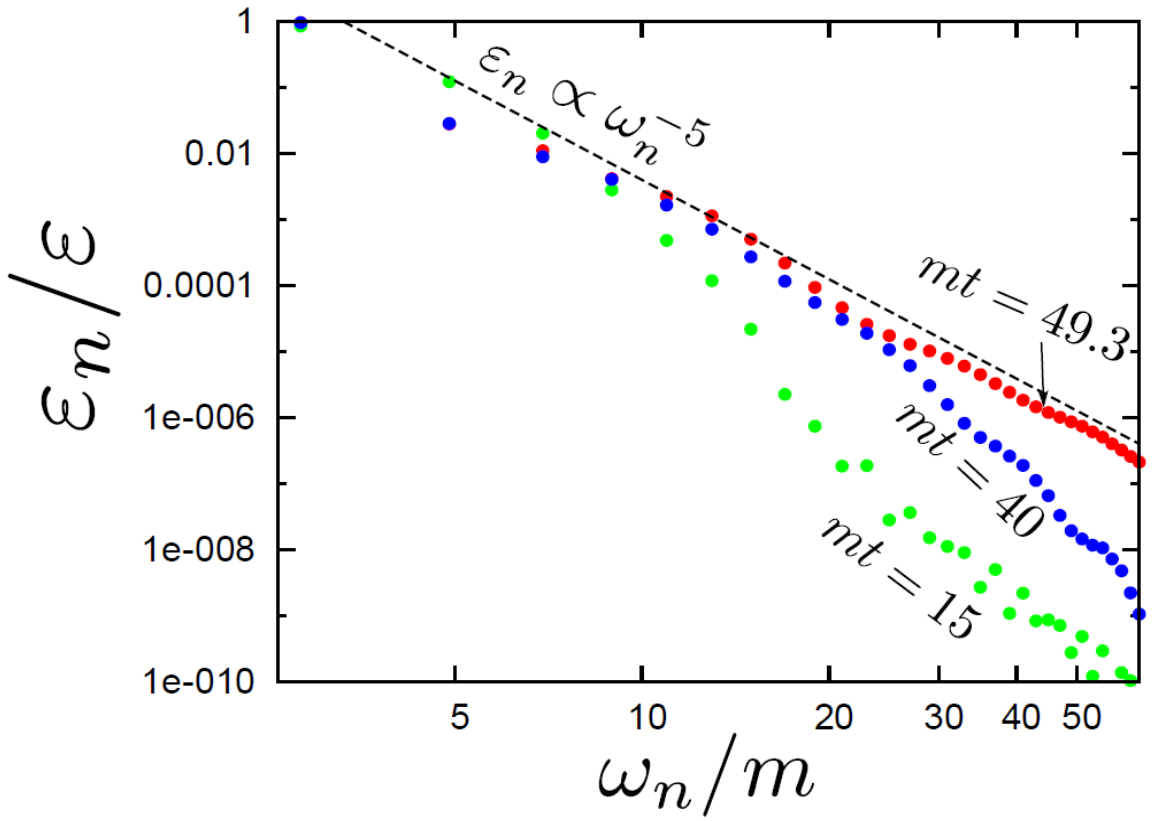




Energy of mesons dissipates into the background.

“Deconfinement” of quarks.

Energy transfer from large to small scale



Energy flow from large scale to small scale.

Weak turbulence

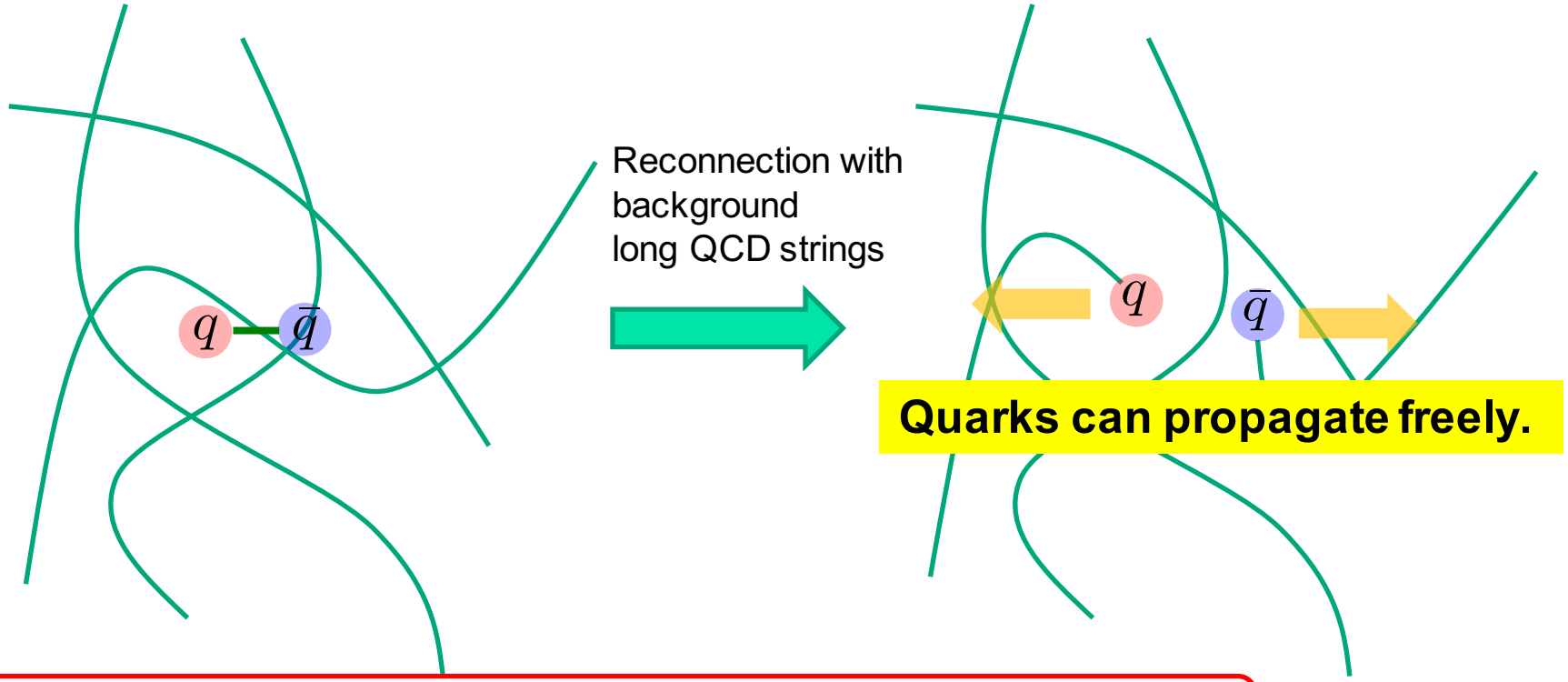
Production of many heavy mesons just before the deconfinement.

Why are many heavy mesons produced before the deconfinement?

Deconfinement occurs due to heavy quark condensate

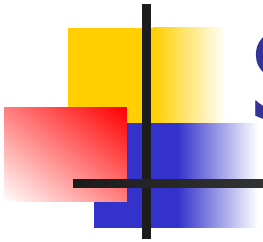
Polyakov, 78
Pisarski&Alvaretz, 82
Patel, 84
Lucini et al, 05
Hanada et al, 14

Heavy mesons = long QCD strings



Heavy meson condensation ⇒ Quark deconfinement

Our AdS/CFT calculation supports this idea.



Summary

We studied non-equilibrium process in holographic QCD,
which is induced by time-dependant electric field.

We found a weak turbulence in the D3/D7 system.

There is a energy flow from large to small scale.

This can be regarded as production of many heavy mesons in SQCD.

Heavy meson production can cause deconfinement transition.