

# GENERALISED GLOBAL SYMMETRY AND HOLOGRAPHY OF DYNAMICAL EXTENDED OBJECTS

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For **MANY-BODY QUANTUM CHAOS, BAD METALS AND HOLOGRAPHY** based on

- Grozdanov & NP, **Generalised Global symmetry and magnetohydrodynamic waves in a strongly interacting holographic plasma**, [1707.04182]
- Grozdanov & NP, **Effective theory of dissipative domain walls, propagating shear mode and holography** [to appear]

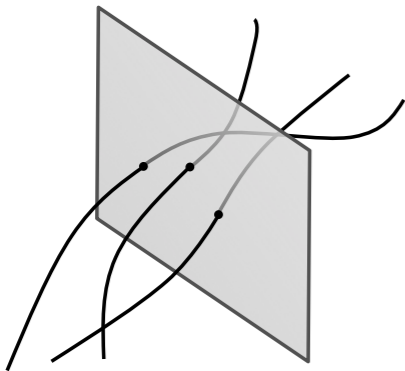
FOR BACKGROUND STORY

- Grozdanov, Hofman & Iqbal, *GGS and dissipative MHD*, [1610.07392]
- Hofman & Iqbal, *GGS and holography* [1707.08577]

# MAGNETOHYDRODYNAMICS AS A THEORY OF DISSIPATIVE STRINGS

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- \* Conservation of strings associated to the genuine global symmetry



Normal global U(1)

$$\partial_\mu j^\mu = 0$$

Generalised global U(1)

$$\partial_\mu J^{\mu\nu} = 0$$

Gaiotto, Kapustin, Seiberg & Willet '14

- \* GS can be: **gauged**, **anomalous**, **spontaneously broken**,  
**gradient expanded**,

Grozdanov, Hofman & Iqbal '16

**Simple to construct holographic dual** Grozdanov & NP '17; Hofman & Iqbal '17

- \* Hydrodynamics limit of plasma! + Consistently classify transport coef.  
Landau pole & Running of electromagnetic coupling

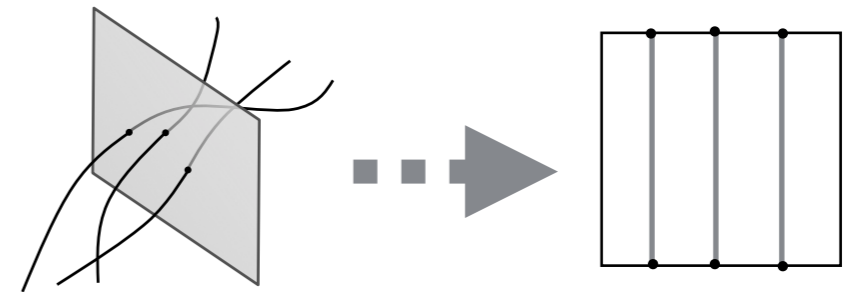
See Sašo's talk tomorrow!

# HYDRODYNAMICS FOR CONSERVED WALLS

- \* Conserved charge for extended objects

$$T^{\mu\nu} = (\varepsilon + p)u^\mu u^\nu + pg^{\mu\nu} - \mu\rho h^\mu h^\nu$$

$$J^{\mu\nu} = \rho(u^\mu h^\nu - h^\mu u^\nu)$$



- \* Same system of equations as in hydro + translational symmetry Goldstone

$$\partial_\mu T^{\mu\nu}(v, \partial_\mu \phi) = 0, \quad \partial_t \phi \sim v$$

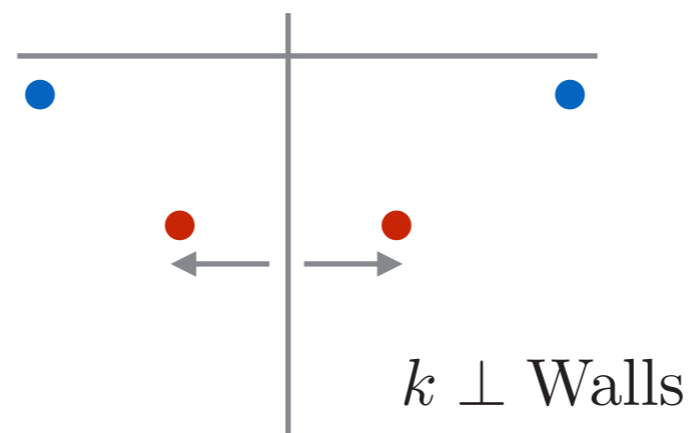
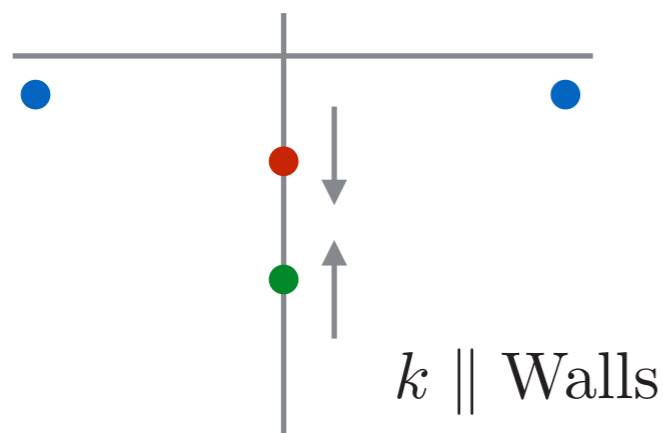
$$\partial_\mu J^{\mu\nu} = 0 \quad \Leftrightarrow \quad \partial_t(\partial\phi) \sim \partial \cdot v$$

Martin, Parodi & Pershan '72

Zippelius, Nelson & Halperin '80

Delacretaz, Gouteraux, Hartnoll & Karlsson '17

- \* Same excitations but perhaps more systematic way to classify transport



- Longitudinal sound
- Transverse mode
- "Lattice" diffusion

# HOLOGRAPHY FOR CONSERVED WALLS

- \* Conserved charge for extended objects

$$S_{\text{bulk}} = \int d^4 X \sqrt{-G} \left( R + 2\Lambda - \frac{1}{3} H_{abc} H^{abc} \right)$$

Analytic solution for two domain walls

Bardoux, Caldarelli & Charmousis '12

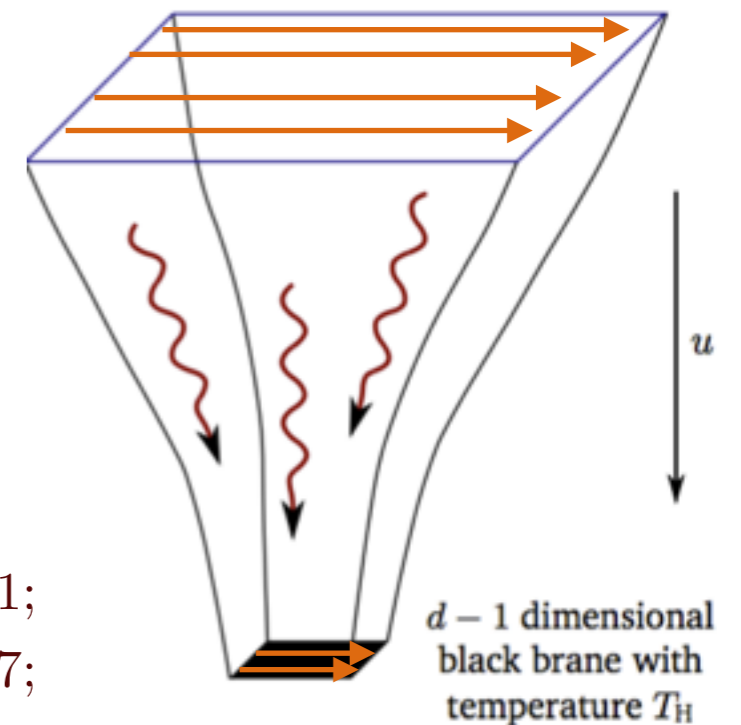
Andrade & Withers '13

- \* Holographic renormalisation demand mixed boundary condition

$$S_{\text{and}} = \int_{u=1/\Lambda} d^4 x \sqrt{-\gamma} \left( \frac{1}{\kappa(\Lambda)} J_{\mu\nu} J^{\mu\nu} \right)$$

Witten '01;

Papadimitriou '07;



- \* Found “lattice” diffusion mode at and propagating modes in the shear channel

See also Esposito, Nicolis & Penco '17

- \* Effective action:  $S_{\text{eff}} \sim S_{\text{matter}} + c_r (\partial\phi)^2$ , upon taking  $\star_{3d} H = d\phi$

# SUMMARY

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- \* All these results only demand the conservation of extended objects!
  - \* “Josephson relation” = Conservation of walls ?
  - \* Simple and straightforward holography for propagating shear mode
  - \* **Gauged, anomalous, spontaneously broken** symmetry
    - Goldstone of generalised global symmetry (Photon? Phonon? Graviton? )  
Hofman & Iqbal '17
  - \* Relation to massive gravity?  
Blake, Vegh & Tong '13; Alberte, Baggioli, Knnelitsky Pujolas '15; **SEE ALSO MATTEO TALK**
  - \* Application in plasma and other area?  
Delacretaz, Gouteraux, Hartnell & Karlsson '16 -'17
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THANK YOU FOR YOUR ATTENTION