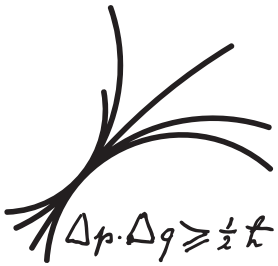
Spontaneous Holographic Lattices from a Magnetic Field



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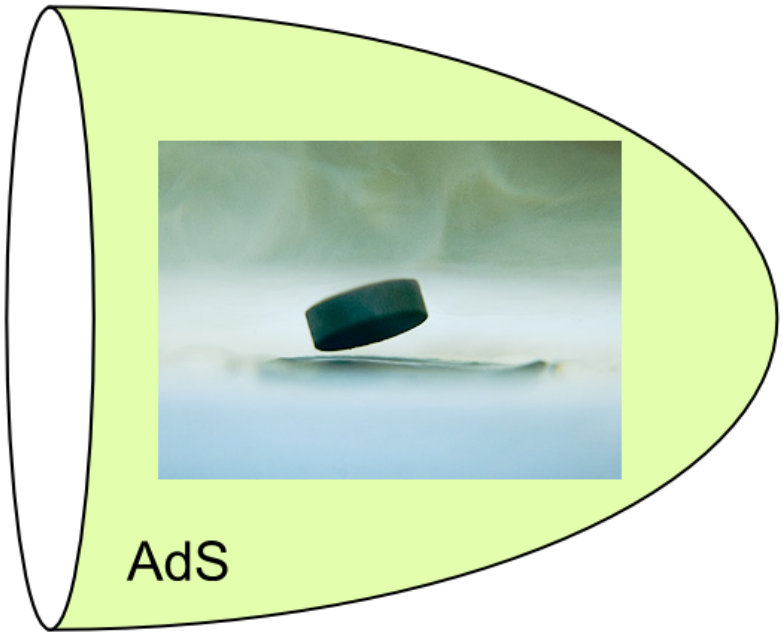
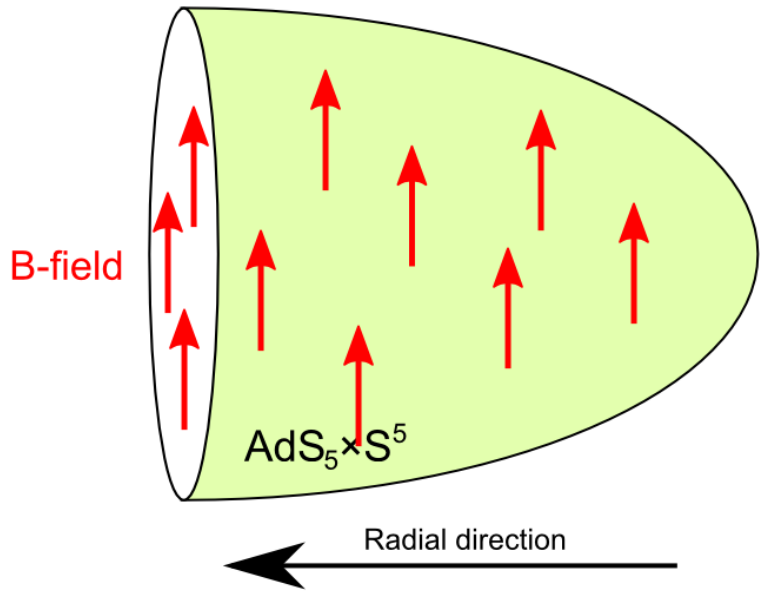
How do we build an interesting holographic superconductor using only an $SU(2)$ gauge field and a black hole?



Magnetic field $\Leftrightarrow$ Magnetic field

$SU(2)$ **flavour field**

Choose $F^3_{xy} = B$, $F^a_{\mu\nu} = 0$ otherwise.
Also fix $\mathcal{A}^3_y = xB$ and other components so that only $U(1)$ gauge symmetry remains.

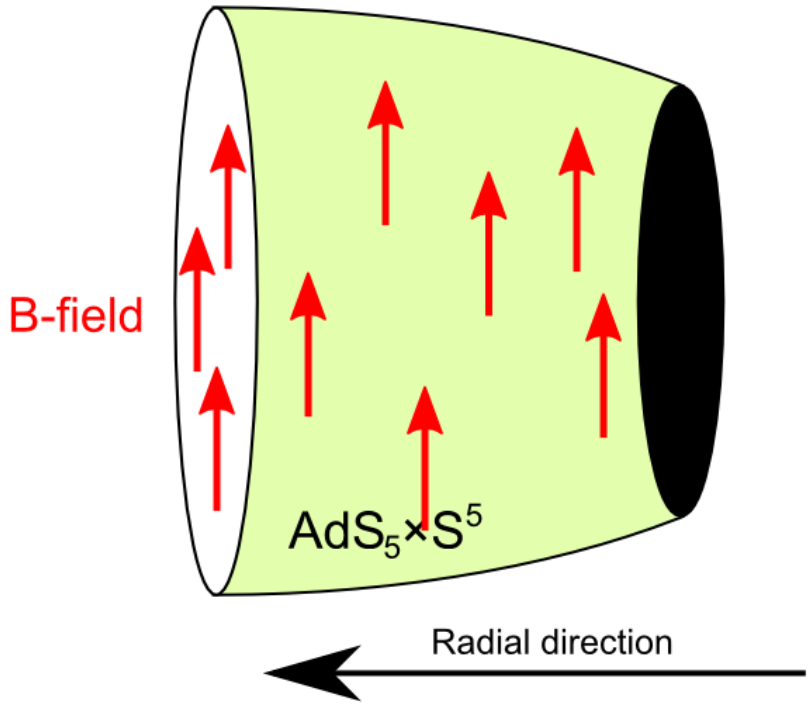


Finite temperature $\Leftrightarrow$ Black hole

Planar black hole

This puts the theory at finite temperature and is needed to fix a scale.

E. Witten (1998)



The Holographic Model

$$S = \int d^5x\sqrt{-g}\ \left\{\frac{1}{16\pi G_N}\left(R + \frac{12}{L^2}\right) - \frac{1}{4\hat{g}^2}\mathrm{tr}\left(F_{\mu\nu}F^{\mu\nu}\right)\right\} + S_{\mathrm{bdy}}$$

Assume the probe limit. The metric in 5 dimensions, working in Poincaré coordinates with the boundary at $u = 0$:

$$ds^2 = \frac{L^2}{u^2}\left(-f(u)dt^2 + dx^2 + dy^2 + dz^2 + \frac{du^2}{f(u)}\right)$$

AdS-Schwarzschild: $f(u) = 1 - u^4/u_H^4$.

Order parameter

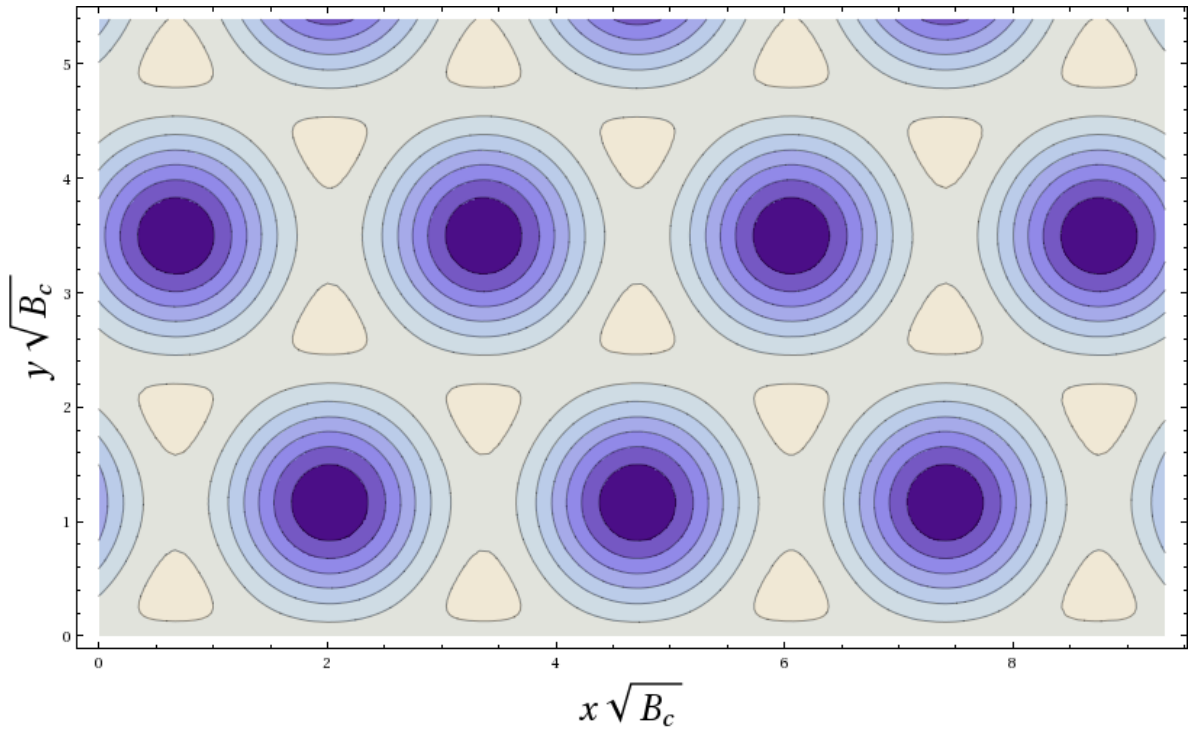
- The components $\mathcal{A}^{1,2}_{x,y}(x, y, u)$ act as an order parameter. Boundary expansion:

$$\mathcal{A}^a_\mu \approx 0 + u^2 \langle J^a_\mu \rangle + \mathcal{O}(u^4)$$

- When $B < B_c$, these components are zero.
- When $B > B_c$, some of these components become nonzero.

Ground state lattice

Calculating $|J_\mu|^2$, we find a triangular lattice ground state dynamically appearing in the superconducting phase.



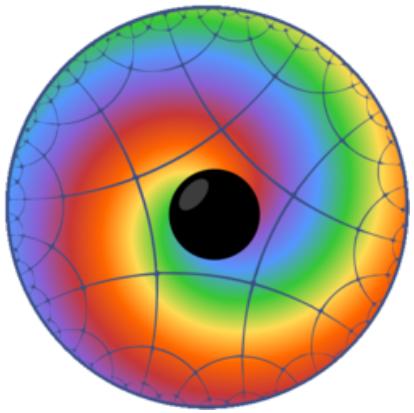
This agrees with the field theory calculations in a DSGS model, and Abrikosov lattices in type II superconductors.

A. Abrikosov, M. Chernodub

Context of our work

- Superconductors: Gubser (2008), Hartnoll, Herzog, Horowitz (2008)
- Theories on a lattice: Horowitz, Santos, Tong (2012)
- Spontaneously broken translational symmetry: Domokos, Harvey (2007)
- Spontaneous breaking with magnetic field: Donos, Gauntlett, Pantelidou (2011)

Thank you!



For further information

M. Ammon, J. Erdmenger, P. Kerner, MS arXiv:1106.4551

Y. Bu, J. Erdmenger, J. Shock, MS arXiv:1210.6669