Holographic helical supeconductors

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work in progress with A.Donos and J.P.Gauntlett.

Introduction to AdS/CMT

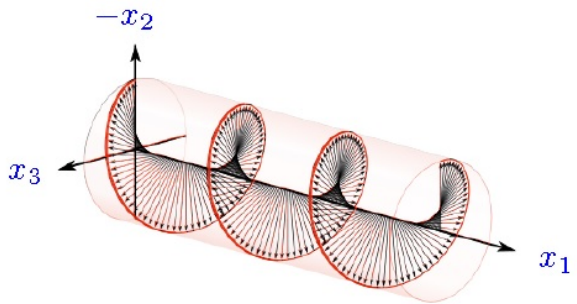
- Idea: use the Gauge/Gravity correspondence to study strongly coupled theories of interest in CM.
- Holographic Superconductors

s-wave	$l = 0$	scalar in the bulk
p-wave	$l = 1$	vector or 2-form in the bulk
d-wave	$l = 2$	charged, spin-2 interacting particle in the bulk

- Spatial modulation: phases with spontaneously broken translational invariance (e.g. charge density wave). The modulation is fixed by an order parameter with a non-zero momentum.
- Spatially modulated superconductors?

Helical superconductors

Helical superconductors conjectured to exist in the '60s (FFLO phase), but still awaiting for experimental veryfication; possible candidates include heavy fermions (e.g. CeCoIn5) and organic superconductors.



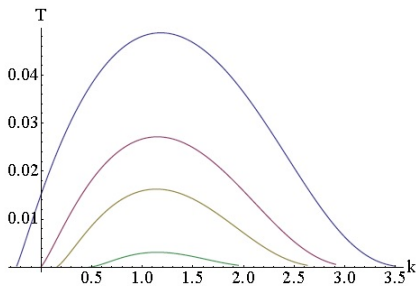
Consider a charged two-form in D=5

$$\mathcal{L} = (R + 12) * 1 - \frac{1}{2} * F \wedge F - \frac{1}{2} * C \wedge \bar{C} - \frac{i}{2m} * C \wedge \bar{H}$$

where $F = dA$ and $H = dC + ieA \wedge C$.

Step 1: Linearised perturbations

- Consider linearised perturbations of the two-form (it decouples) around the AdS-RN black hole [Donos, Gauntlett]
- Two possible ansatz that capture helical stucture: p-wave and p+ip-wave.
- Contruct the zero modes for various values of (e, m).



- At $T = T_c$, there is (2nd order) phase transition from the ordinary metalic phase to the helical one. Same T_c for both p- and p+ip-wave.

Step 2: Back-reacted helical black holes

Construct numerically the 2-parameter families of p-wave [Donos, Gauntlett] and p+ip-wave helical black holes for fixed m and e- parametrised by (k,T)

- Preferred locus within each family? Can it be obtained from variation of the action with respect to k?
- Is there competition between p- and p+ip-wave phase? Does it depend on (e,m)?
- T=0, near horizon limit?
- Reversal of helix?

Thank you!

Additional material I

The ansatz cosidered at linear level:

- p_{x2} helical structure (for $k = 0$, dx_2 direction)

$$\delta C = \cdots + c_3(r)[sin(kx_1)dx_1 \wedge dx_2 + cos(kx_1)dx_1 \wedge dx_3]$$

- $p_{x2} + ip_{x3}$ helical structure (for $k = 0$, $dx_2 + idx_3$ direction)

$$\delta C = \cdots + c_3(r)e^{ikx_1}[idx_1 \wedge dx_2 + dx_1 \wedge dx_3]$$

Same T_c for both p- and p+ip-wave. Differences?

p+ip-wave	p-wave
isotropic $T_{22} = T_{33}$	anisotropic $T_{22} \neq T_{33}$
$T_{23} = 0$ for all k	$T_{23} \neq 0$ for $k \neq 0$

Additional material II