Black holes in a periodic chemical potential as probes of strange metallic physics

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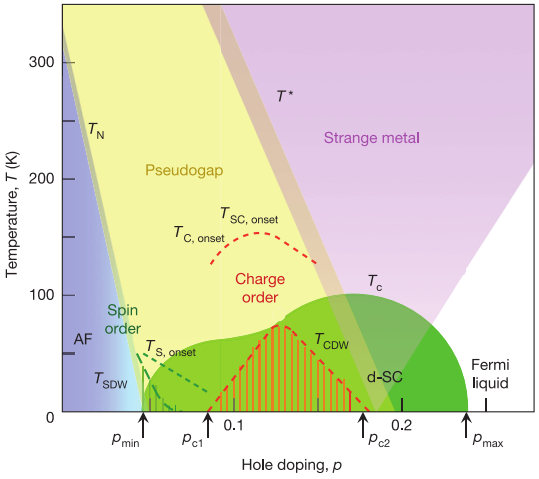
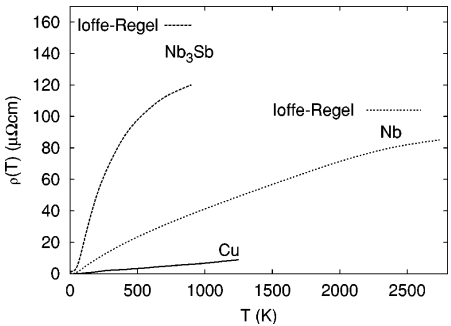
Cuprates

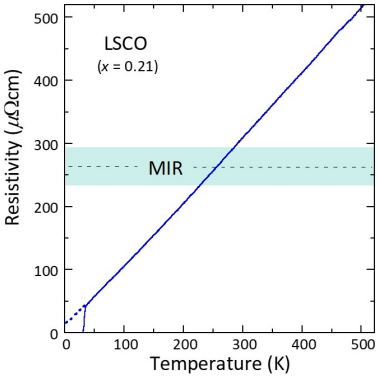


B. Keimer, S. Kivelson et al., Nature 518, 179–186 (2015)

Resistivity

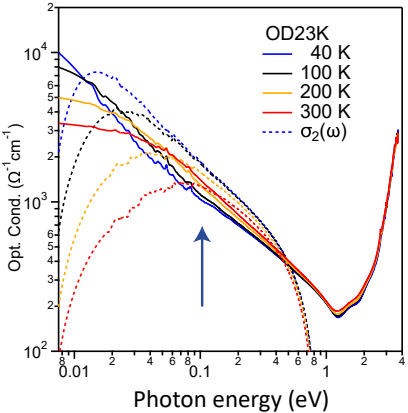


Ordinary metals: O. Gunnarsson, M. Calandra, and J. Han, Rev. Mod. Phys. 75, 1085 (2003)

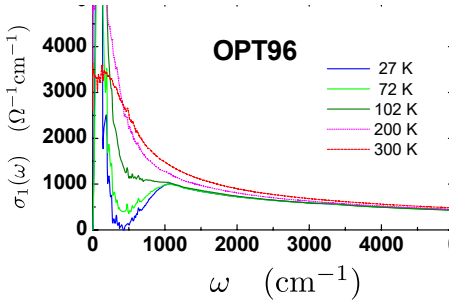


Strange metal: P. Philipps, N. Hussey, P. Abbamonte, Science 377, eabh4273 (2022)

Optical conductivity of strange metals



Bi-2201: E. van Heumen, X. Feng et al., PRB 106, 054515 (2022)



Bi-2212: J. Hwang, T. Timusk et al. 2007 J. Phys.: Condens. Matter 19 125208

For more: L. Delacrétaz, B. Goutéraux, S. Hartnoll, A. Karlsson SciPost Phys. 3, 025 (2017)

Gubser-Rocha model

We depart from the AdS_4 black hole Gubser-Rocha solution of the following EMD action

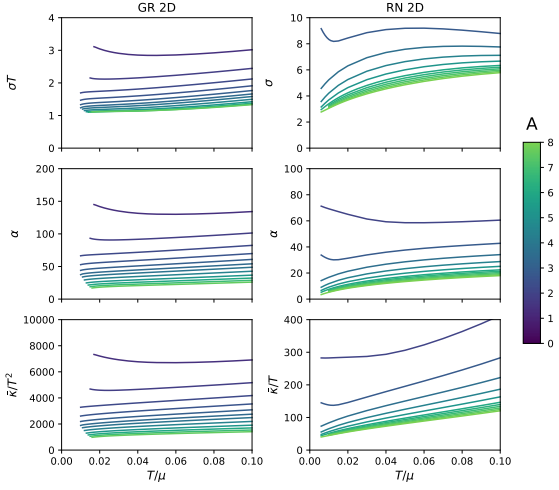
S. Gubser, F. Rocha, PRD 81, 046001 (2010)

$$S = \int \mathrm{d}^4x\sqrt{-g}\left[\underbrace{\frac{R}{2\kappa^2}}_{\text{Gravity}} \underbrace{-\frac{e^{\phi}}{4e^2}F^2}_{\text{Maxwell}} \underbrace{-\frac{3(\partial\phi)^2}{2}+6\cosh(\phi)}_{\text{Scalar}}\right]$$

- The black hole solutions form a family parametrized by (T, μ)
- $\phi = 0$ is the typical RN solution
- The translational symmetry is broken by imposing

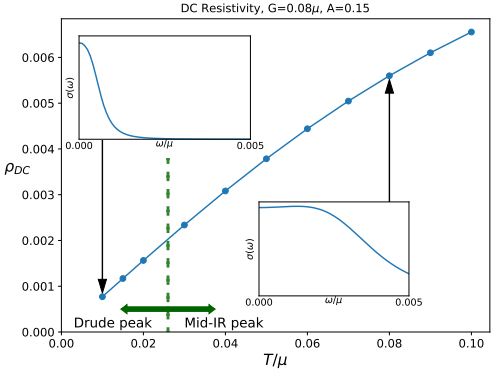
$$A_t(z=0,x,y) = \mu\left[1+\frac{A}{2}\left(\cos(Gx)+\cos(Gy)\right)\right]$$

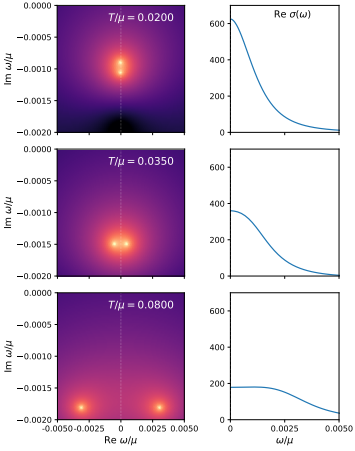
Resistivity



$$G/\mu = 0.14$$

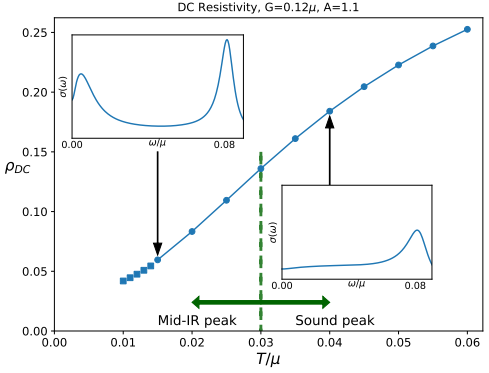
Results

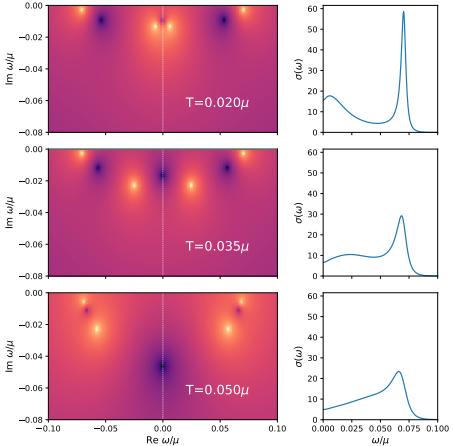




$A = 0.15, G/\mu = 0.08$

Results – Three regimes





$A = 1, G/\mu = 0.1$

For more details, see:

- N.C. and K. Schalm [arXiv: 2303.17685]
- F. Balm, N. C et al., Phys.Rev.B 108 (2023) 12 [arXiv:2211.05492]

Thank you for your attention