On the role of the z^5-term in the metric strain coefficient for the holographic description of magnetic catalysis in QGP

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MSU

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References

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- Aref'eva, Hajilou, K.R., Slepov *"Magnetic Catalysis in Holographic Model with two Types of Anisotropy for Heavy Quarks"* (2023)
  arXiv:2305.06345 [hep-th]
- K.R. *"Holographic Model with two Types of Anisotropy for Heavy Quarks: Magnetic Catalysis via z^5-term"* in progress

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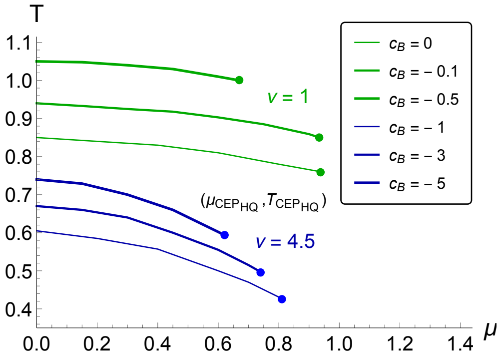
Magnetic Catalysis

$$\mathfrak{b}(z) = e^{-cz^2/2 - 2(p - c_B\, q_3) z^4}$$



arXiv:2305.06345 [hep-th]

Twice Anisotropic Background

$$\mathcal{L} = R - \frac{f_0(\phi)}{4} F_0^2 - \frac{f_1(\phi)}{4} F_1^2 - \frac{f_3(\phi)}{4} F_3^2 - \frac{1}{2}\,\partial_\mu\phi\partial^\mu\phi - V(\phi)$$

$A_\mu^0 = A_t(z)\delta_\mu^0$ $\quad$ $F_1 = q_1\ dx^2 \wedge dx^3$ $\quad$ $F_3 = q_3\ dx^1 \wedge dx^2$

$A_t(0) = \mu$ $\quad$ $g(0) = 1$ $\quad$ *Dudal et al., (2019)*

$A_t(z_h) = 0$ $\quad$ $g(z_h) = 0$ $\quad$ $\phi(z_0) = 0 \ \rightarrow\ \sigma_{\text{string}}$

$$ds^2 = \frac{L^2}{z^2}\,\mathfrak{b}(z)\left[-\,g(z)\,dt^2 + dx_1^2 + \left(\frac{z}{L}\right)^{2-\frac{2}{\nu}} dx_2^2 + e^{c_B z^2}\left(\frac{z}{L}\right)^{2-\frac{2}{\nu}} dx_3^2 + \frac{dz^2}{g(z)}\right]$$

I.A., A.G. (2014), Giataganas (2013) $\quad$ *Gürsoy, Järvinen et al., (2019)*

$\mathfrak{b}(z) = e^{2\mathcal{A}(z)}\ \rightarrow$ quarks mass $\quad$ "Bottom-up approach"

$\mathcal{A}(z) = -\ cz^2/4\ \rightarrow$ heavy quarks background (b, t) $\quad$ *Andreev, Zakharov (2006)*

$\mathcal{A}(z) = -\,a\ln(bz^2+1)\ \rightarrow$ light quarks background (d, u) $\quad$ *Li, Yang, Yuan (2020)*

“Heavy” Quarks Warp Factor

$$\mathcal{A}(z) = -\,cz^2/4$$

Aref'eva, K.R., Slepov
*JHEP **07** 161 (2021)*
arXiv:2011.07023 [hep-th]

$$\Downarrow$$

$$\mathcal{A}(z) = -\,cz^2/4\,-(p - c_B\,q_3)z^4$$

Aref'eva, Hajilou, K.R., Slepov
arXiv:2305.06345 [hep-th]

$$\mathcal{A}(z) = -\,az^2 - dB^2z^5$$

Bohra, Dudal, Hajilou, Mahapatra
*PRD **103** 086021 (2021)*
arXiv:2010.04578 [hep-th]

$$f_0 = e^{-(c+q_3^2)z^2}\,\frac{z^{-2+\frac{2}{\nu}}}{\sqrt{\mathfrak{b}}}$$

$a = 0.15$ GeV^2, $c = 1.16$ GeV^2

$d > 0.05$

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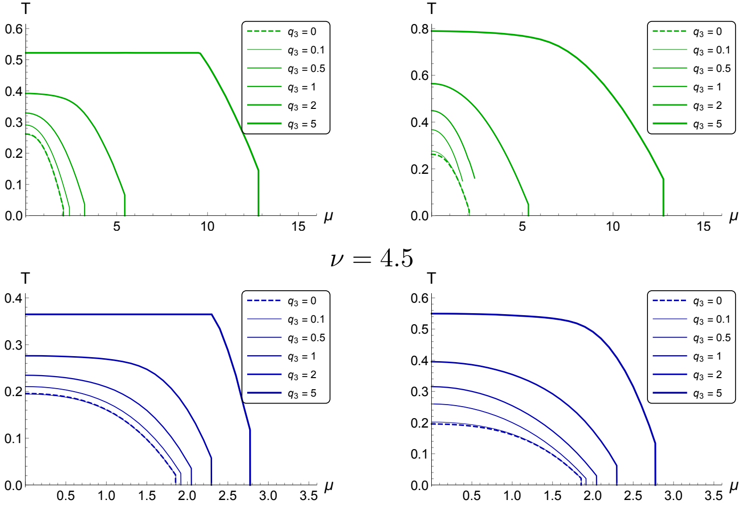
Magnetic Catalysis: $T(z_h, q_3)$ for fixed $c_B < 0$, $\forall d$

Phase Diagram $T(\mu)$, $c_B = -0.01$

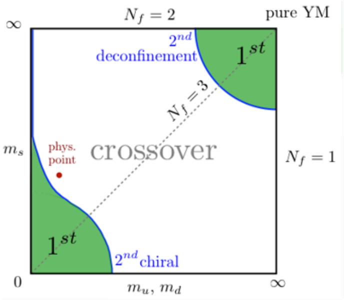
$\nu = 1$



$d = 0.01$ $d = 0.1$

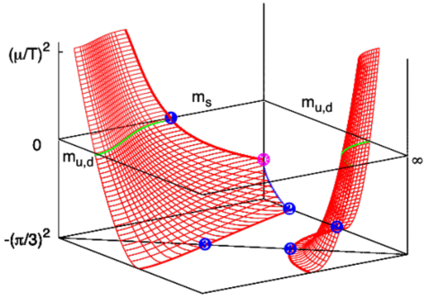
QCD Phase Diagram: Lattice

Phase diagram
on quark mass



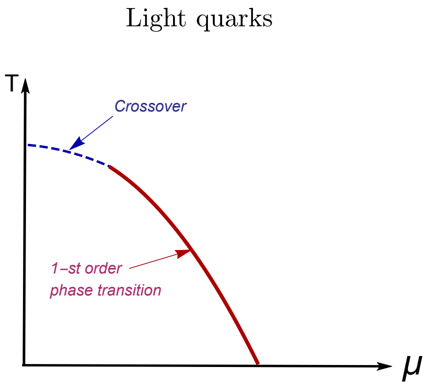
Columbia plot
Brown et al., PRL (1990)

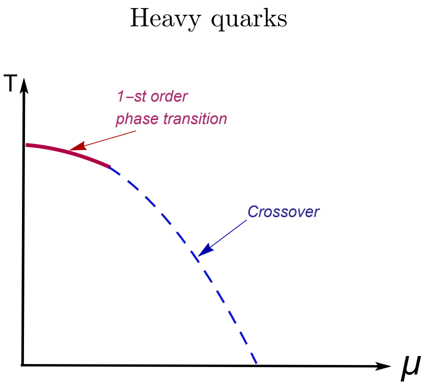
Main problem with $\mu \neq 0$
Imaginary chemical potential method



Philipsen, Pinke, PRD (2016)

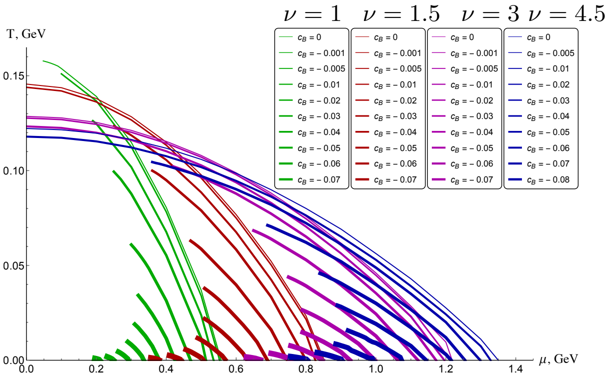
“Light” and “Heavy” Quarks from Columbia Plot





"Light" Quarks: Inverse Magnetic Catalysis

$$\mathfrak{b}(z) = e^{-a\ln(bz^2+1)}$$



Eur.Phys.J.C **83** *79 (2023)*

Conclusions

Terms z^4 and z^5 in the warp-factor give a wide opportunity to fit Lattice results and experimental data for large chemical potential

- The coefficient value in z^5-term doesn't seems to determine MC/IMC behavior (no $d > 0.05$ limit found)
- Stable solution with MC effect needs fixed $c_B < 0$
- Increasing d value rises PT temperature
- Increasing d value has weak influence on μ_{max}: $T(\mu_{max}) = 0$
- Primary anisotropy lowers PT temperature and stabilises μ_{max} value

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What to do next

- Temporal Wilson loops
- Cornell potential and string tension
- Drag forces and energy losses
- Other characteristics (susceptibility, transport coefficients, eta/s, direct-photon spectra, jet quenching, thermalization time, etc)

Thank you
for your attention

BACKUP. Relations between 5-dim backgrounds and 4-dim models

- Relations between parameters of the 5-dim background (black hole) and thermodynamical parameters are the following:
  - $T_{BH} = T_{QCD}$, where T_{BH} is the temperature of the 5-dim black hole;
  - $A_0(z) = \mu_B - \rho_B z^2 + \mathcal{O}(z)$, where $A_0(z)$ is the 0-component of the electromagnetic field $A_\mu(z)$, μ_B is the baryonic chemical potential, ρ_B is the density and z is the 5-dimentional coordinate;
  - $S_{BH} = s$, where S_{BH} is the entropy of the black hole, which as usual is defined by the square of the black hole horizon, s is the thermodynamical entropy;
  - $F_{BH} = -\, p$, where F_{BH} is the free energy of the black hole, p is the thermodynamical pressure.