Holography, strongly coupled plasmas and magnetic fields

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In collaboration with Leonardo Patiño

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- Holographic techniques have been used to study its properties.
- It is an experimental fact that for non-central collisions, a magnetic field is present in the resulting plasma.

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$$S = \int d^5x\sqrt{-g}(R + 12 - F^2)$$
- Many observables have been studied using this dual.
- But the real world QGP contains quarks, that is, fields in the fundamental representation. And SYM $\mathcal{N} = 4$ only have fields in the adjoint representation.

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- D'Hoker and Kraus solution is a consistent truncation of 10-dimensional IIB SUGRA. Cvetic et al. (1999).

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$$S = \int d^5x\sqrt{-g}\left[R - \frac{1}{2}(\partial\varphi)^2 + 4\left(X^2 + 2X^{-1}\right) - X^{-2}(F)^2\right]$$

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- The numerical solution is specified by the parameters r_h, φ_h and B.
- The geometry fails to be asymptotically AdS_5 for some values.

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- ψ_0 corresponds to the non-normalizable mode, dual to a source for the operator $\mathcal{O}_\varphi$.
- To solve the problem we fixed $\psi_0 = 0$. Numerically this amounts to fix φ_h for every value of B.

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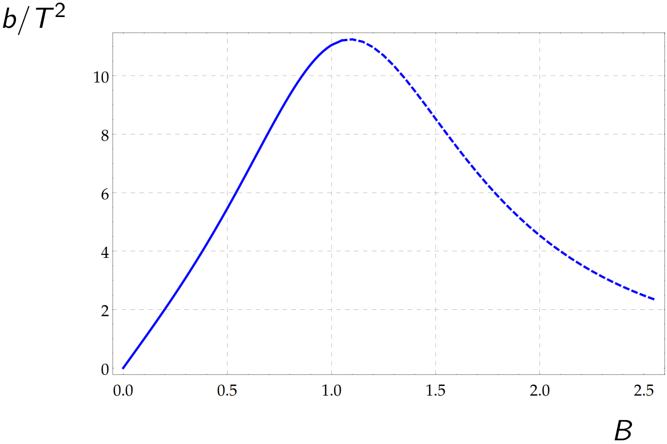
with the magnetic field intensity

$$b = \frac{B}{C_1}$$

Family of solutions

- There is a maximum value for b/T^2



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- Horowitz found that for Einstein-Maxwell system in $4D$ there exists a maximum value for the electric field above which a naked singularity appears.
- Interestingly, Horowitz (2018) latter found that performing a differential rotation to the boundary metric has the same effect.

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$$S_{ct} = \int d^4x \sqrt{\gamma} \left(6 + \varphi^2 \left(1 + \frac{1}{2 \log \epsilon} \right) + F^{ij} F_{ij} \log \epsilon \right),$$

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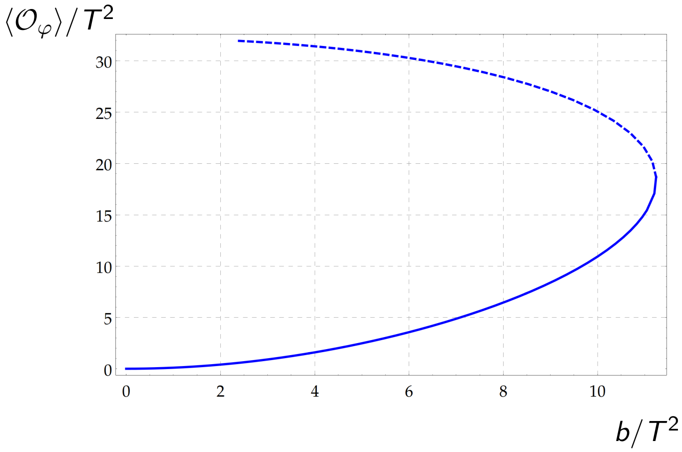
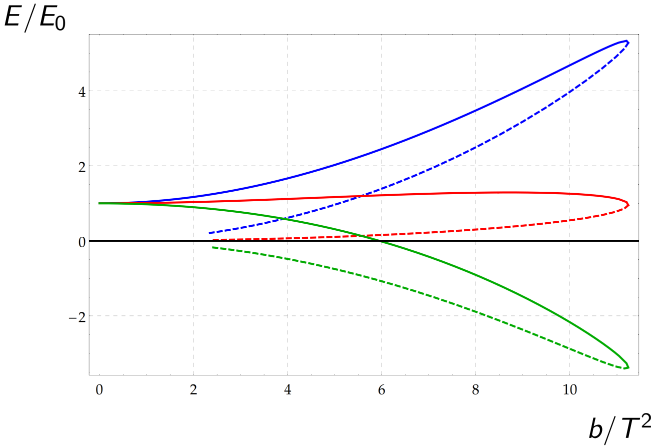
- Choosing C_{sch} amounts to choosing a renormalization scheme.
- In the following $C_{sch} = -5$ (blue), $C_{sch} = 0$ (red) and $C_{sch} = 5$ (green).

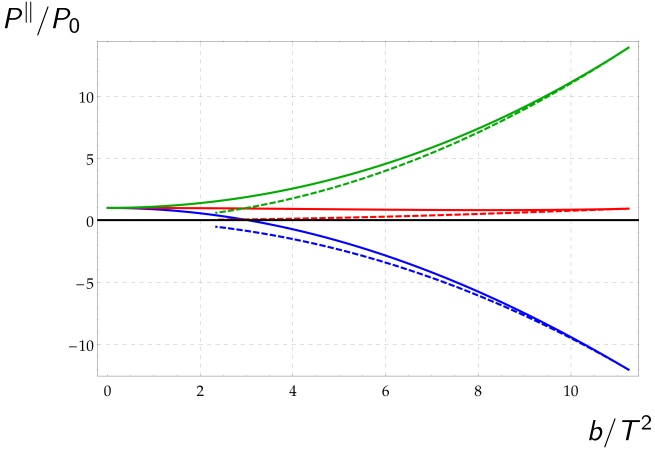
Scalar condensate



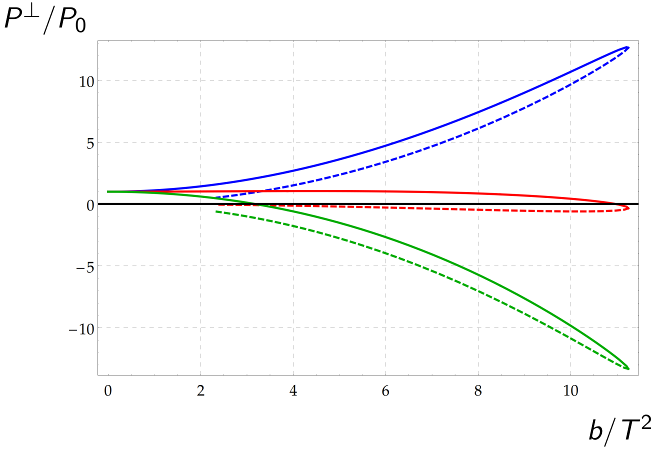
Energy density



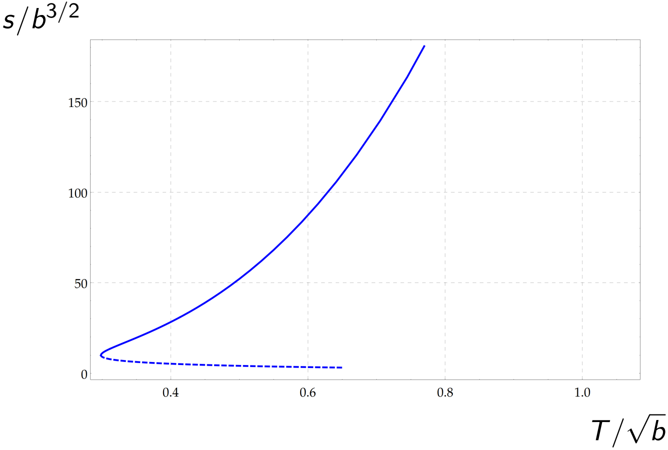
Pressure parallel to the magnetic field



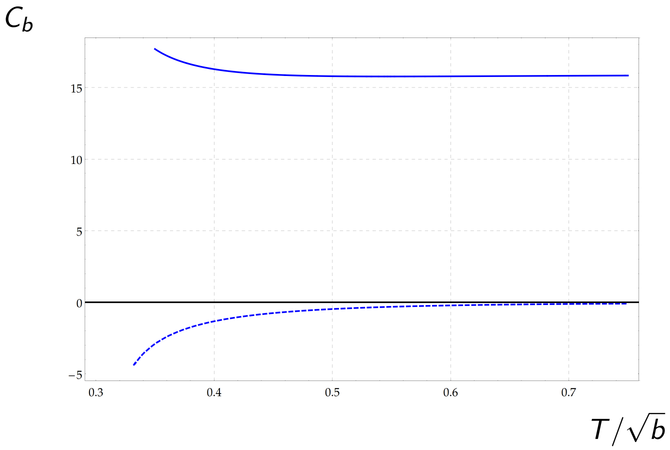
Pressure perpendicular to the magnetic field



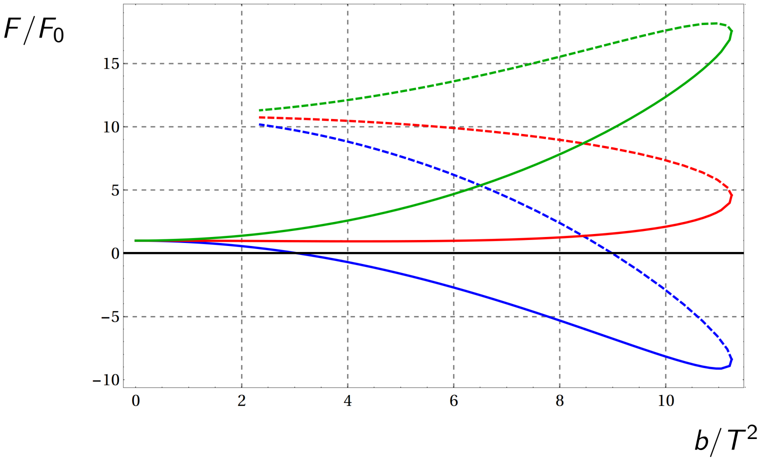
Entropy density



Specific heat



Free energy density



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- The family of solutions features a constant magnetic field and a scalar field.
- We studied its thermodynamics, and found the branch of stable solutions.
- The next step is to add fundamental matter. We have already done some progress in this direction.

Thank you for your attention!