# Heavy Meson Dissociation in a Rotating Plasma from Holography

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# Motivation

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- Many particles are formed in the initial collision.
- A fraction of charmonia and bottomonia arrive to the detectors.
- Properties of the plasma like temperature, density, magnetic fields, and angular momentum affect how many of these particles arrive to the detectors.

# Correspondência AdS/CFT
# (Maldacena, 1997)

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- The meson is represented by a vector field subjected to an action of the form

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- The 4D field theory is **conformal**.

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Soft-Wall Model:

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where $\phi(z) = \kappa^2 z^2$.

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- **Solution**
  Modify the soft-wall model:

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onde $\phi(z) = \kappa^2 z^2 + Mz + \tanh\left( \frac{1}{Mz} - \frac{\kappa}{\sqrt{\Gamma}} \right)$.

# Masses and Decay Constants

| Resultados holográficos (e experimentais) para o charmônio | | |
|---|---|---|
| Estado | Massa (MeV) | Constante de decaimento (MeV) |
| 1S | $2943(3096.900 \pm 0.006)$ | $399(416.4 \pm 3.8)$ |
| 2S | $3959(3686.097 \pm 0.025)$ | $255(294.3 \pm 2.5)$ |
| 3S | $4757(4039 \pm 1)$ | $198(187.1 \pm 7.6$ |
| 4S | $5426(4421 \pm 4)$ | $169(160.8 \pm 9.7)$ |

| Resultados holográficos (e experimentais) para o botomônio | | |
|---|---|---|
| Estado | Massa (MeV) | Constante de decaimento (MeV) |
| 1S | $6905(9460.30 \pm 0.26)$ | $719(715.0 \pm 2.4)$ |
| 2S | $8871(10023.26 \pm 0.32)$ | $512(497.4 \pm 2.2)$ |
| 3S | $10442(10355.2 \pm 0.5)$ | $427(430.1 \pm 1.9)$ |
| 4S | $11772(10579.2 \pm 1.2)$ | $375(340.7 \pm 9.1)$ |

# Masses and Decay Constants

- **Two point function:**

$$\Pi(p^2) = \sum_{n=0}^{\infty} \frac{f_n^2}{-p^2 - m_n^2 + \mathrm{i}\varepsilon}, \tag{6}$$

where

$$\langle 0|J_\mu(0)|n\rangle = \varepsilon_\mu f_n m_n \qquad \text{and} \qquad f_n^2 = \frac{3 m_n \Gamma_{n\to e^+e^-}}{4\pi\alpha^2 c_V^2} \tag{7}$$

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- Gauge/String duality provides a tool to calculate the LHS of Eq. (**??**).

# AdS/CFT Correspondence at Finite Temperature

# Finite Temperature

- AdS Black Hole:

$$\mathrm{d}s^2 = \frac{R^2}{z^2}\left(-f(z)\mathrm{d}t^2 + \mathrm{d}\mathbf{x}\cdot\mathrm{d}\mathbf{x} + \frac{1}{f(z)}\mathrm{d}z^2\right), \qquad f(z) = 1 - \frac{z^4}{z_h^4}. \tag{8}$$

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- The action has the same form:

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where $\phi(z) = \kappa^2 z^2 + Mz + \tanh\left(\frac{1}{Mz} - \frac{\kappa}{\sqrt{\Gamma}}\right)$.

# Other Properties

- **Density:**

$$ds^2 = \frac{R^2}{z^2}\left(-f(z)dt^2 + d\mathbf{x}\cdot d\mathbf{x} + \frac{1}{f(z)}dz^2\right), \tag{11}$$

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- **Magnetic Field:**

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where $f(z)$, $d(z)$ e $h(z)$ depend on $B$ and $z_h$.

- In any case,

$$T = \frac{1}{4\pi}|f'(z_h)|. \tag{13}$$

# Angular momentum

- **Metric:**

$$ds^2 = \frac{R^2}{z^2}\Big[-\mathrm{d}t^2 + \ell^2 \mathrm{d}\varphi^2 + (\mathrm{d}x^1)^2 + (\mathrm{d}x^2)^2 + \frac{1}{f(z)}\mathrm{d}z^2\Big]. \tag{14}$$

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- **Boost-like transformation:**

$$t \to \gamma\big(t - \ell^2\Omega\varphi\big), \qquad \varphi \to \gamma(\varphi + \Omega t) \qquad \text{where} \qquad \gamma = \frac{1}{\sqrt{1-\ell^2\Omega^2}} \tag{15}$$

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- Why do we have to consider plasma rotation?

# Dissociation

# Spectral Functions

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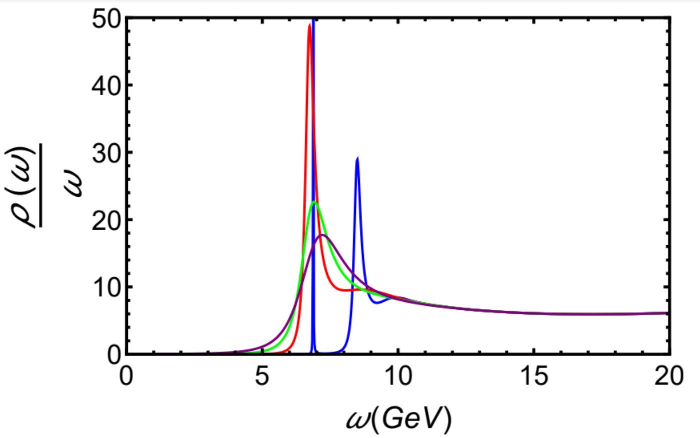
whose imaginary part is proportional to

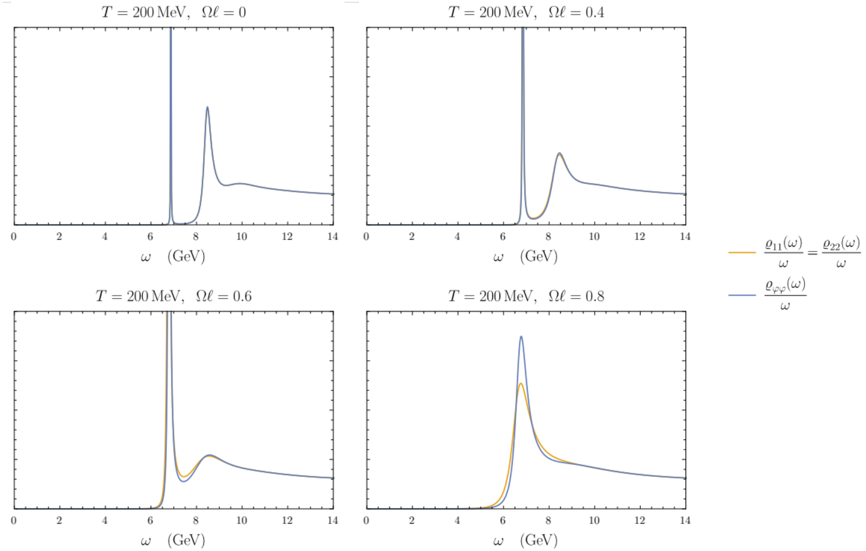
$$-\sum_{n=1}^{\infty} \begin{cases} f_n^2/\varepsilon & \text{if } p^2 = -m_n^2 \\ 0 & \text{if } p^2 \neq -m_n^2 \end{cases} \quad \propto \quad \sum_{n=1}^{\infty} f_n^2\, \delta(p^2 + m_n^2), \tag{18}$$

# Spectral Functions ($\Omega = 0$)




Blue: $T = 195\text{MeV}$, Red: $T = 330\text{MeV}$, Green: $T = 465\text{MeV}$, Purple: $T = 600\text{MeV}$

# Spectral Functions ($T = 200\text{MeV}$)



# Quasinormal Modes

- Consider $T = 0$ again.
- We have the action

$$\mathcal{S} = -\frac{1}{4g_5^2}\int \mathrm{d}^4x \int_0^\infty \mathrm{d}z \sqrt{-g}\, \mathrm{e}^{-\phi(z)} F_{mn}F^{mn}. \tag{19}$$

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- Taking $V_\mu(x^\mu, z) = \epsilon_\mu v(\omega, z)\mathrm{e}^{-\mathrm{i}\omega t}$, we write the equation for the mode:

$$\frac{\omega^2}{f(z)^2}v + P(z)v' + v'' = 0 \quad \longrightarrow \quad -\psi''(z) + V(z)\psi(z) = \omega^2\psi(z). \tag{20}$$

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- Boundary conditions:
  - Normalization condition at the AdS boundary:

$$v(z \to 0) = 0 \quad \longrightarrow \quad \psi(z \to 0) = 0. \tag{21}$$

  - Normalization condition as $z \to \infty$:

$$v(z \to \infty) = 0 \quad \longrightarrow \quad \psi(z \to \infty) = 0. \tag{22}$$

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- The quasionormal modes are determined through the imposition of the boundary conditions
  - The Dirichlet condition at the AdS boundary:

$$v(z \to 0) = 0 \qquad \longrightarrow \qquad \psi(r_*) = 0, \tag{24}$$

  - The field at the horizon has the form of an infilling wave:

$$v = \left(1 - \frac{z}{z_h}\right)^{-\mathrm{i}\omega/4\pi T} \qquad \longrightarrow \qquad \psi(r_*) = \mathrm{e}^{-\mathrm{i}\omega r_*}. \tag{25}$$

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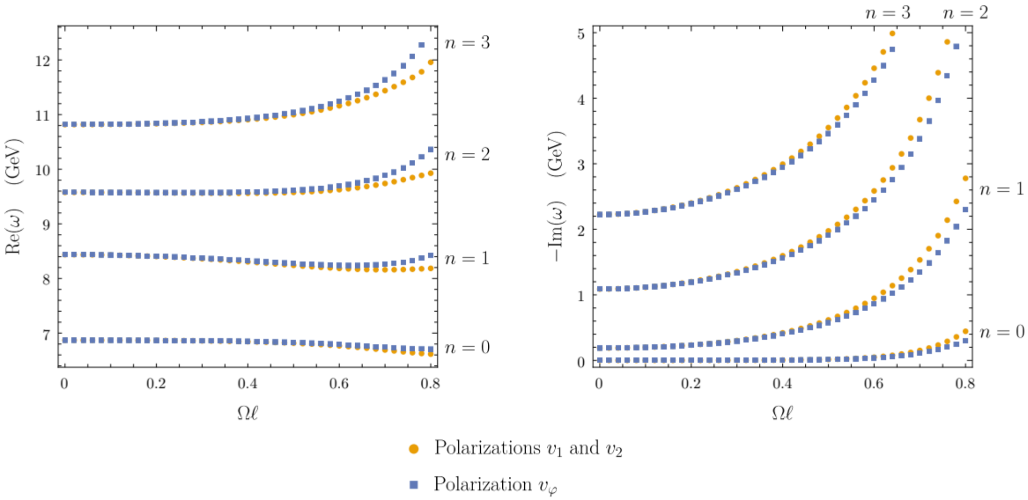

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¡Gracias!