# The Regge meson spectrum from holographic Wilson confinement criterion

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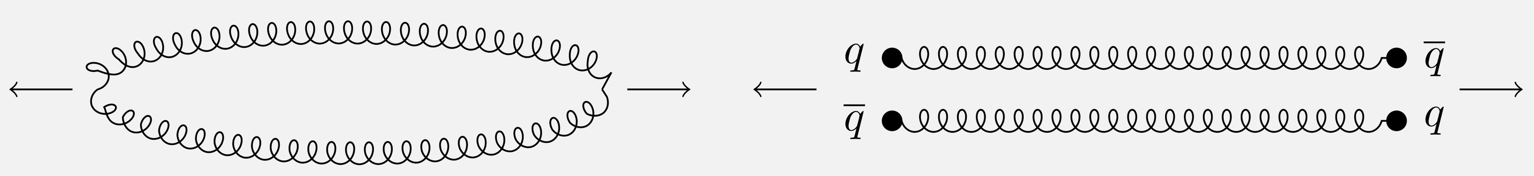
## String interpretation

In the string approach to QCD it is assumed that glueballs and mesons have different spectra with different slopes and intercepts. Can these be connected in some way?

Glueballs are represented as closed strings, with linearly increasing energy when stretched ($\sigma$ is string tension):

$$E \simeq \sigma r + \text{const},$$

which is equivalent to the stretching of two open strings with quark-antiquark pairs at their ends.



Thus, the tension of open strings, which correspond to mesons, is twice smaller than that of closed:

$$\sigma_{\text{mes}} = \frac{1}{2}\sigma_{\text{gl}}.$$

Due to string quantization, spectrum slope is directly related to the tension via $a = 2\pi\sigma$. The difference between intercepts of glueballs and mesons can be acquired by introducing a dependence on external parameter $b$:

$$\sigma \to \sigma(b), \quad \sigma(b_0) = \frac{1}{2}\sigma(0).$$

This results in two different but related spectra:

$$M^2_{\text{gl}}(n) = a(n+1), \quad M^2_{\text{mes}}(n) = \frac{1}{2}a(n+1+b_0)$$

S. Afonin and T. Solomko, *Gluon string breaking and meson spectrum in the holographic Soft Wall model,* Phys. Lett. B **831** (2022), 137185, [2112.00021]

## Modified metrics

In the case of a model with a general background function $f(z)$,

$$S = \int d^5x\sqrt{g}f(z)\mathcal{L},$$

it can be rewritten as

$$S = \int d^5x\sqrt{\tilde{g}}\tilde{\mathcal{L}}, \quad \tilde{g}_{MN} = hg_{MN}, \quad h = f^{(3/2-J)^{-1}}$$

For example, for the standard SW model with the usual metric

$$g_{MN} = \text{diag}\left\{\frac{R^2}{z^2}, -\frac{R^2}{z^2}, \dots, -\frac{R^2}{z^2}\right\},$$

the new background function is $h = e^{-2cz^2}$.

We can add a new external parameter into the model, which will play the role of the arbitrary intercept, as described above. For this we use a background with the Tricomi function $U$:

$$h = e^{-2cz^2}U^4(b, 0, |cz^2|)$$

S. S. Afonin and T. D. Solomko, *Towards a theory of bottom-up holographic models for linear Regge trajectories of light mesons,* Eur. Phys. J. C **82** (2022) no.3, 195, [2106.01846]

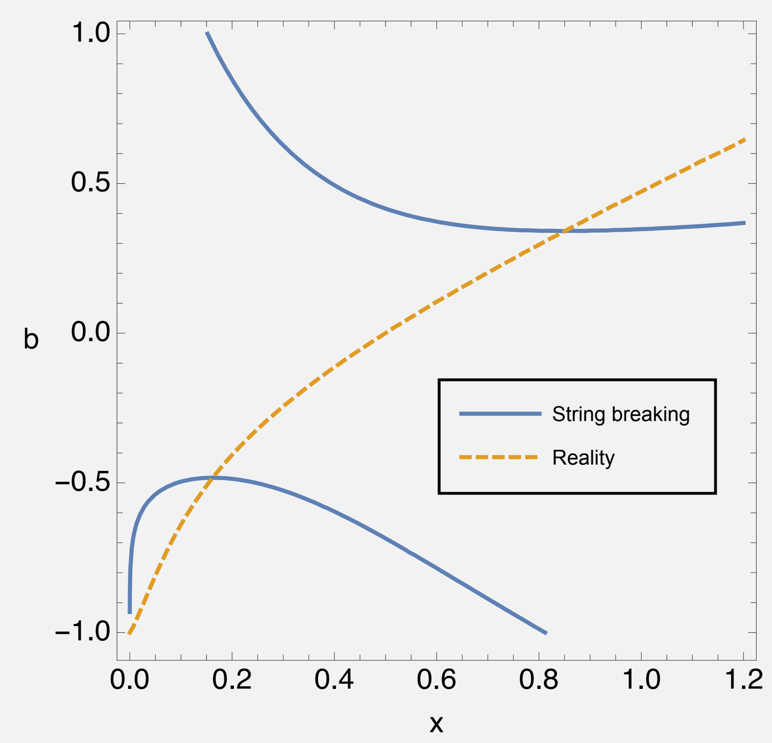
## String breaking condition

The string breaking condition $\sigma(b_0) = \frac{1}{2}\sigma(0)$ results in the equation

$$\frac{e^{2x-1}U^4(b, 0, x)}{2x} = \frac{1}{2},$$

which should be solved together with the "reality" condition of the integral expressions for $E$ and $r$.

There are two solutions




$$b_0 \approx -0.483, \quad x \approx 0.162$$

$$b_0 \approx 0.341, \quad x \approx 0.851.$$

The resulting spectra (using the slope 1.14 GeV$^2$):

$$M(n) \approx 0.77, 1.32, 1.69, 2.00, 2.27, \dots \text{ GeV}$$

$$M(n) \approx 1.24, 1.63, 1.95, 2.22, \dots \text{ GeV}$$

The first solution can be related to the $\rho$-meson spectrum, and the second with $a_1$-meson, which implies a description method of CSB in bottom-up holographic approaches.

## Scalar case

Corresponding string breaking condition:

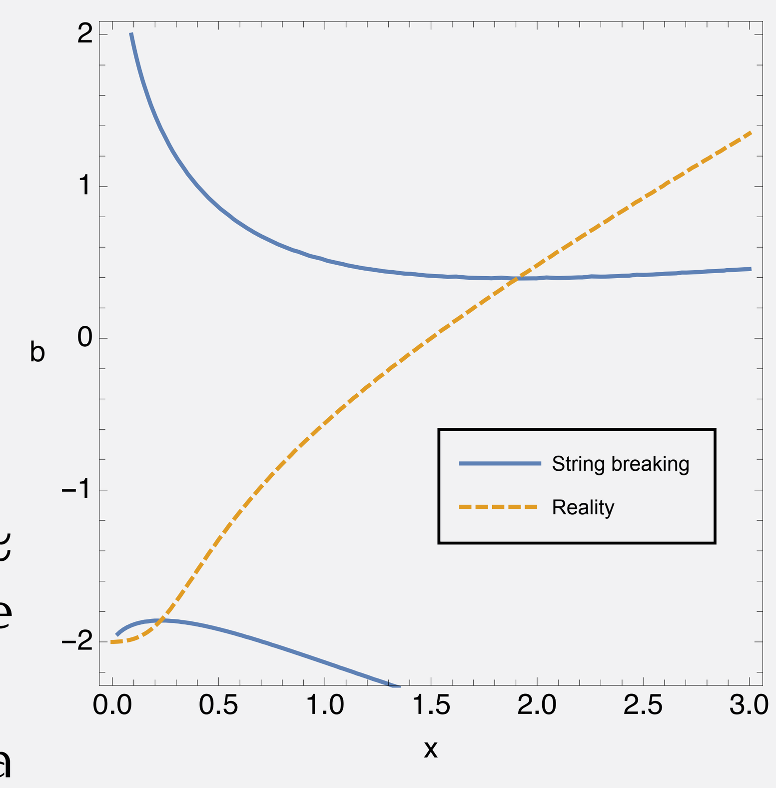
$$\frac{3e^{2x/3-1}U^{4/3}(b, -1, x)}{2x} = \frac{1}{2}.$$

The upper solution,

$$b_0 \approx 0.394, \quad x \approx 1.906,$$

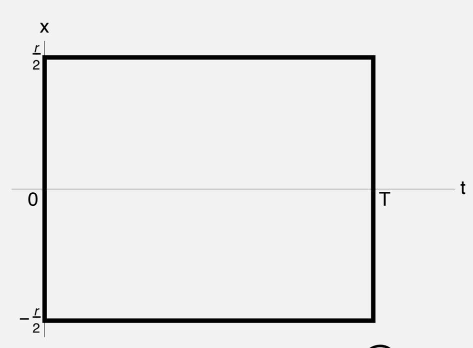
gives the ground state $M(0) \approx$ 1.47 GeV, which is close to the mass of the $a_0(1450)$ meson.

The lower solution results in a tachyonic ground state.




## Addendum: Wilson loop

Consider a Wilson loop, placed at the 4D boundary of AdS. The quark-antiquark potential can be computed using the string world-sheet area.



$$\langle W(\mathcal{C})\rangle \sim e^{-TE(r)}, \quad \langle W(\mathcal{C})\rangle \sim e^{-S} \Rightarrow E = \frac{S}{T}$$

J. M. Maldacena, *Wilson loops in large N field theories,* Phys. Rev. Lett. **80** (1998), 4859-4862, [hep-th/9803002]

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