Oddballs and a low odderon intercept

Pedro Bicudo - CFTP & Dep Física, IST , Lisboa,

Work done with

Felipe Llanes-Estrada -U Complutense, Madrid,

Stephen Cotanch - North Carolina SU, Rayleigh,

Elsa Abreu - GOLP & Dep Física, IST, Lisboa.

Low x Workshop

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Summary

1. **Modelling quark and gluon systems with truncated Coulomb Gauge QCD**
   - 1.1 **The soft pomeron and glueballs**
   - 1.2 **Deriving constituent gluon models**

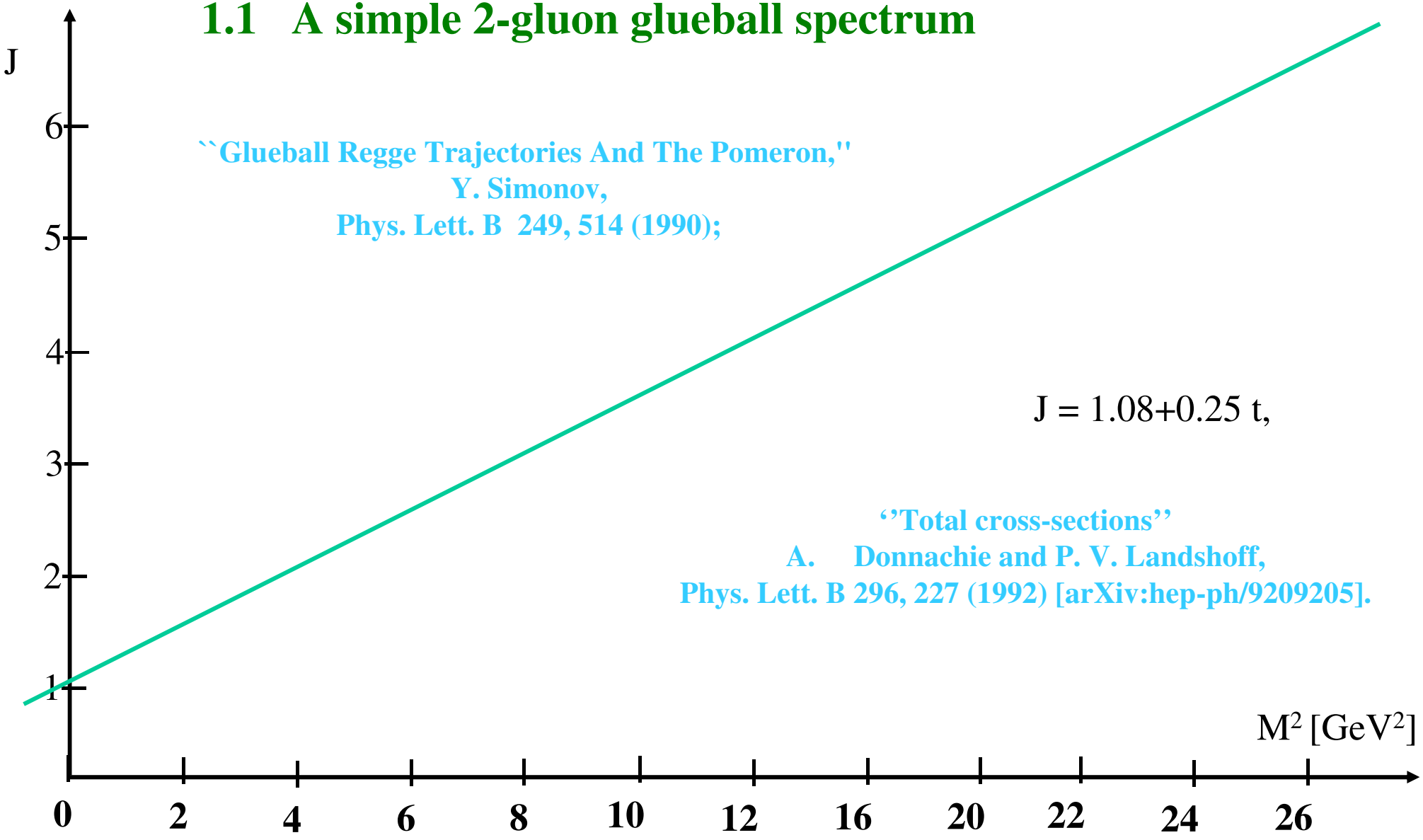
2. **Practicing with simple 2-particle hadrons**
   - 2.1 **Glueballs and quarkonia**
   - 2.2 **diquark-gluon hybrids**

3. **The 3-gluon glueballs and the soft odderon**
   - 3.1 **Lattice results**
   - 3.2 **Constituent Gluon model results**

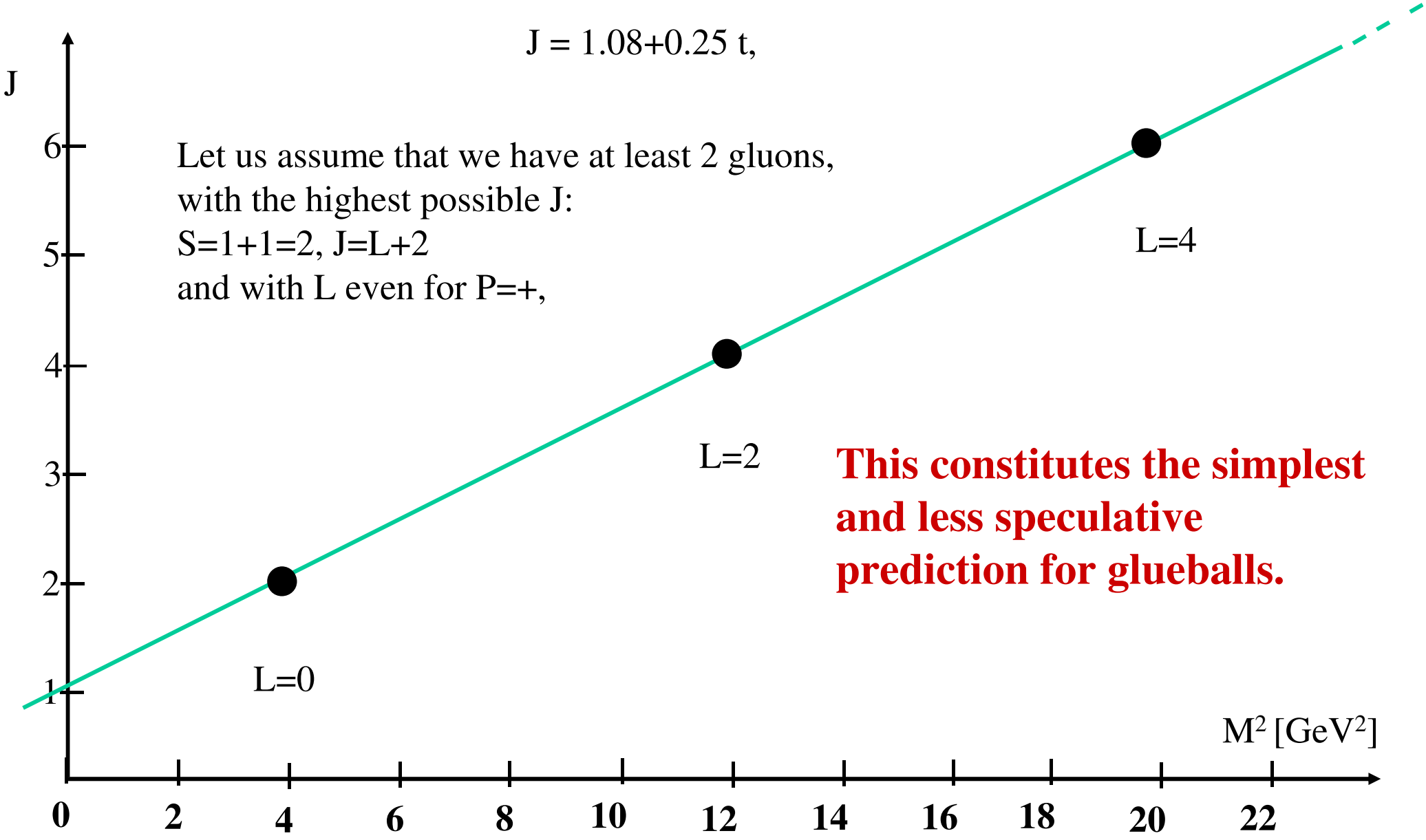
1. Modelling quark and gluon systems with truncated Coulomb Gauge QCD

Non-pertubative

1.1 A simple 2-gluon glueball spectrum



$J = 1.08+0.25\ t,$



Let us assume that we have at least 2 gluons,
with the highest possible J:
S=1+1=2, J=L+2
and with L even for P=+,

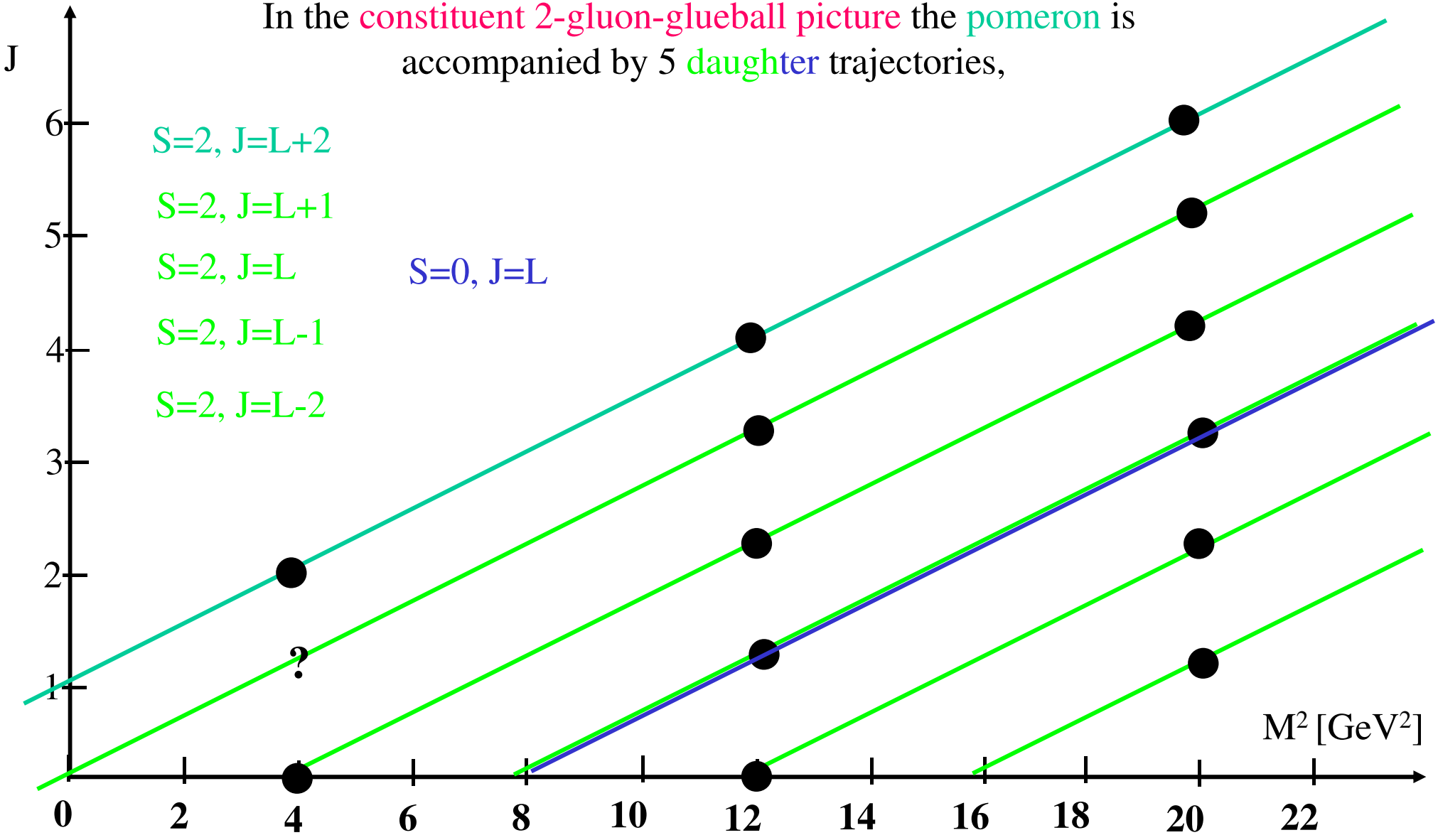
This constitutes the simplest and less speculative prediction for glueballs.

To verify that we have a straight line, at least 3 points should be measured. The first 3 points are expected to be observed up to $M_{glueball}$=3.4GeV.

However, we also know the example of the meson Regge trajectory, where the first point is below the straight line, and then we need more points to see the line. With M>5.3GeV it may be possible to see 4 points.

Jpc	0++	2++	4++	6++	8++	10++	12++
M[GeV]	-	1.92	3.41	4.43	5.26	5.97	6.61

In the constituent 2-gluon-glueball picture the pomeron is accompanied by 5 daughter trajectories,



In this picture, just for illustration, we neglected the possible spin-dependent interactions

1.2 Deriving constituent gluon models

Quenched Lattice QCD have found, already 20 years ago, evidence for na effective gluon mass of 0.7 to 1.0 Gev.

This has been recently confirmed by Schwinger-Dyson solutions for the gluon propagator, see

``Vertex functions and infrared fixed point in Landau gauge SU(N) Yang-Mills theory,'' R. Alkofer, C. Fischer and F.Llanes-Estrada, Phys. Lett. B 611, 279 (2005) [arXiv:hep-th/0412330].

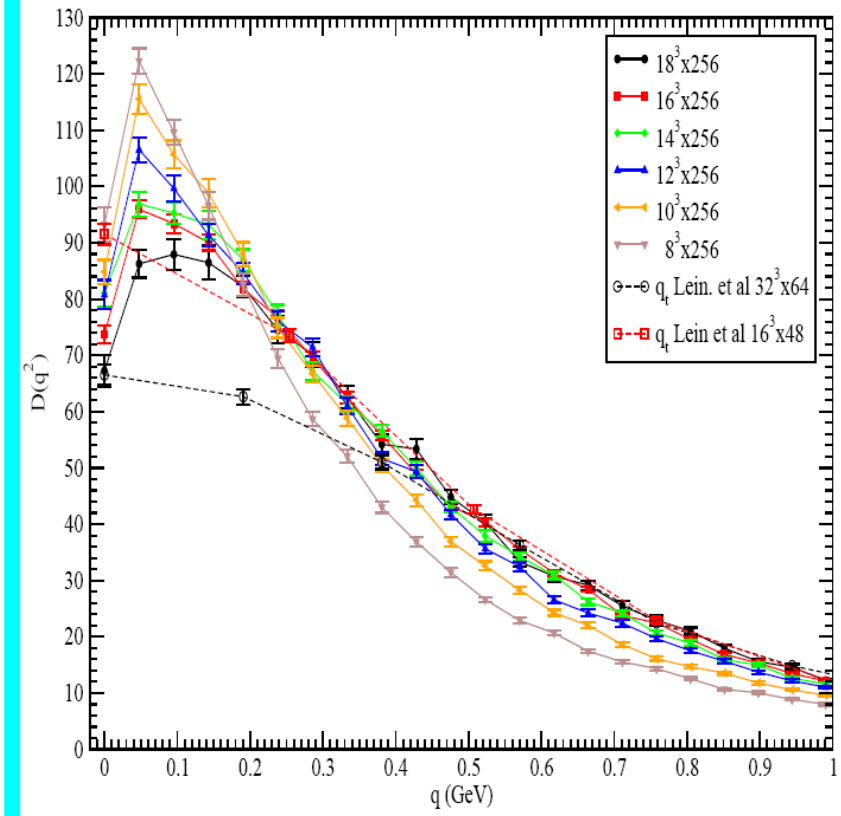


Figure 2: Bare gluon dressing function for temporal momenta for all lattices volumes. For comparisation, the figure includes the $16^3 \times 48$ and $32^3 \times 64$ propagators computed at $\beta = 6.0$ in [28].

``On the infrared gluon propagator,'' P. Silva and O.Oliveira, arXiv:hep-lat/0511043.

For a quark model-like framework, in Coulomb Gauge QCD, minimizing the vacuum energy, provides constituent quark masses and effective gluon masses.

Funnel confining potential

``Current Quark Model In A P Wave Triplet Condensed Vacuum. 1. The Dynamical Breaking Of Chiral Symmetry,''
P. Bicudo and J. Ribeiro,
Phys. Rev. D 42, 1611 (1990);

``Glueball Spectroscopy in a Relativistic Many-Body Approach to Hadron Structure,''
A. Szczepaniak, E. Swanson, C. Ji and S. Cotanch,
Phys. Rev. Lett. 76 , 2011 (1996)

QCD COULOMB GAUGE APPROACH

- effective quark-gluon Hamiltonian

$$H_{\rm eff} = H_q + H_g + H_{qg} + H_C$$
$$H_q = \int d\mathbf{x}\Psi^\dagger(\mathbf{x})(-i\boldsymbol{\alpha}\cdot\boldsymbol{\nabla} + \beta m)\Psi(\mathbf{x})$$
$$H_g = \frac{1}{2}\int d\mathbf{x}\,[\boldsymbol{\Pi}^a(\mathbf{x})\cdot\boldsymbol{\Pi}^a(\mathbf{x}) + \mathbf{B}^a(\mathbf{x})\cdot\mathbf{B}^a(\mathbf{x})]$$
$$H_{qg} = g\int d\mathbf{x}\mathbf{J}^a(\mathbf{x})\ \cdot\mathbf{A}^a(\mathbf{x}) \Longrightarrow V_T$$
$$H_C = -\frac{1}{2}\int d\mathbf{x}d\mathbf{y}\rho^a(\mathbf{x})V(|\mathbf{x}-\mathbf{y}|)\rho^a(\mathbf{y})$$

- color charge density & current $a, b, c = 1, 2, ...8$

$$\rho^a(\mathbf{x}) = \Psi^\dagger(\mathbf{x})T^a\Psi(\mathbf{x}) + f^{abc}\mathbf{A}^b(\mathbf{x})\cdot\boldsymbol{\Pi}^c(\mathbf{x})$$
$$\mathbf{J}^a = \Psi^\dagger(\mathbf{x})\boldsymbol{\alpha}T^a\Psi(\mathbf{x}),$$
$$T^a = \frac{\lambda^a}{2}$$

- non-abelian magnetic fields

$$\mathbf{B}^a = \nabla\times\mathbf{A}^a + \frac{1}{2}gf^{abc}\mathbf{A}^b\times\mathbf{A}^c$$

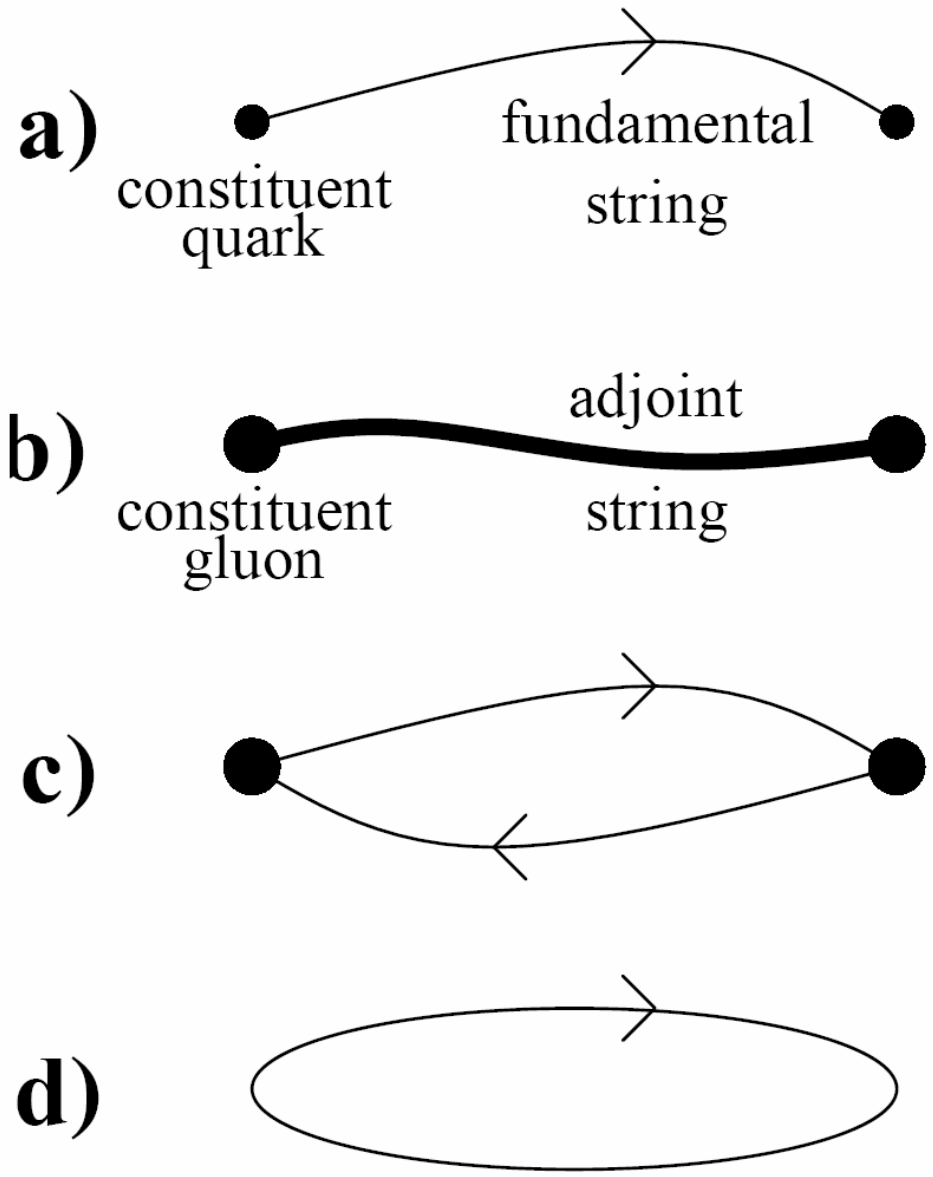
2-Practicing with simple 2-particle hadrons

2.1 Glueballs and quarkonia

The confining quark-antiquark interaction a) is well defined.

Different models b), c), d) for glueballs exist.

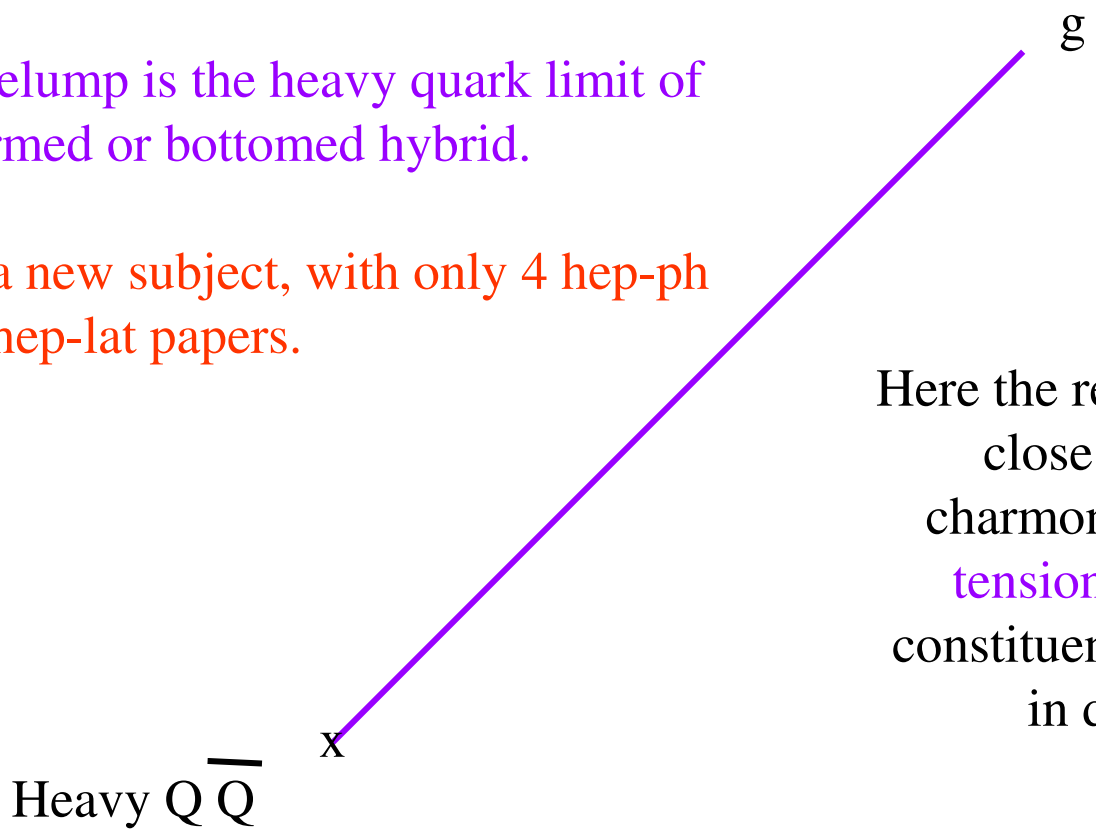
Here we study models b) and c) for the gluon-gluon confining interaction.



2.2 Hybrids and gluelumps

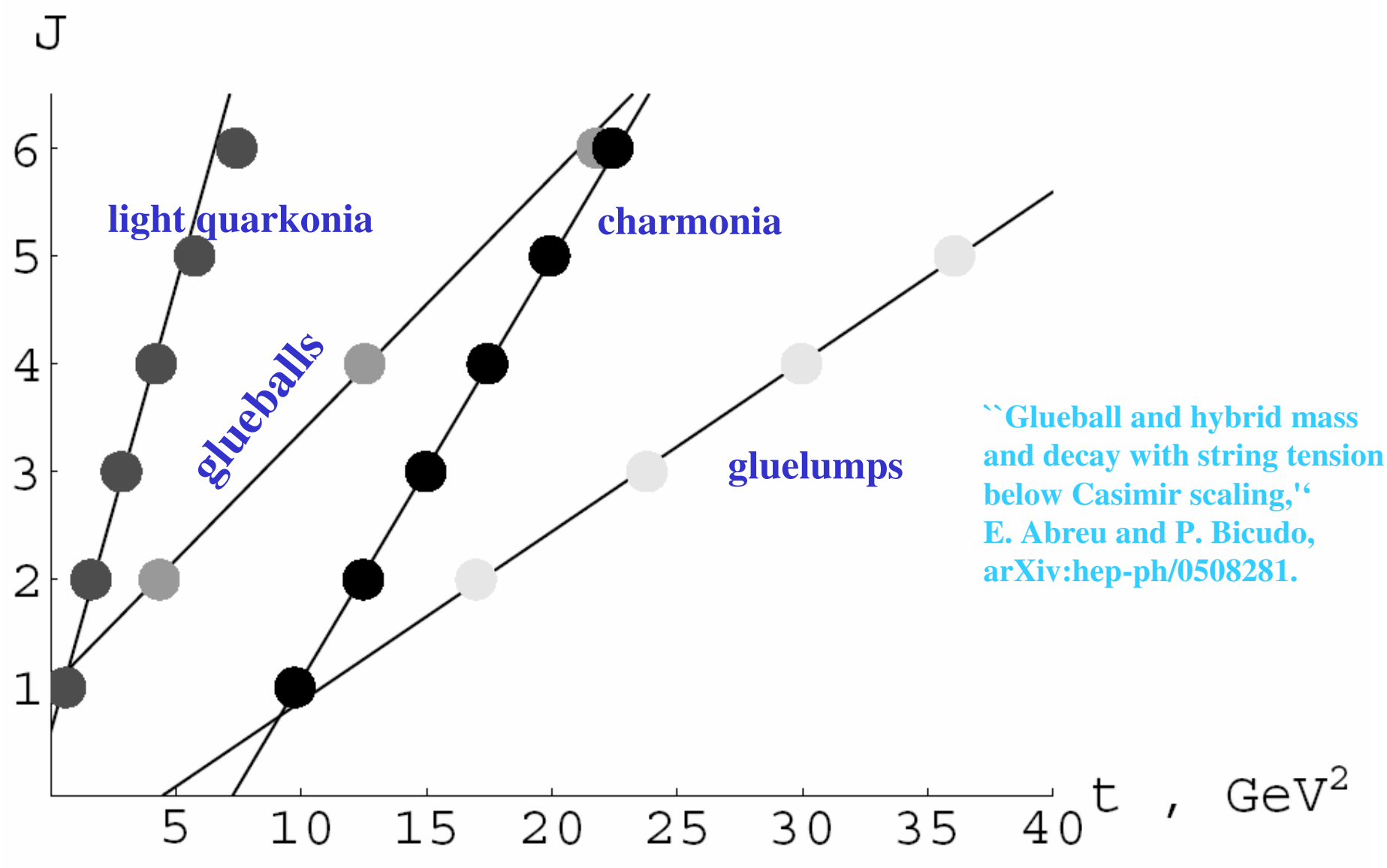
The gluelump is the heavy quark limit of the charmed or bottomed hybrid.

This is a new subject, with only 4 hep-ph and 10 hep-lat papers.



Here the reduced mass of the gluon is close to the c quark mass in charmonium. However the string tension is doubled. In a simple constituent gluon picture this results in different trajectories.

Parent regge trajectories for the simplest hadrons



``Glueball and hybrid mass and decay with string tension below Casimir scaling,''
E. Abreu and P. Bicudo, arXiv:hep-ph/0508281.

3- Glueballs with 3 gluons and the soft odderon

3.1 Lattice results

Quenched (no quarks) Lattice QCD is adequate to compute the glueball spectra up to Jpc=4++.

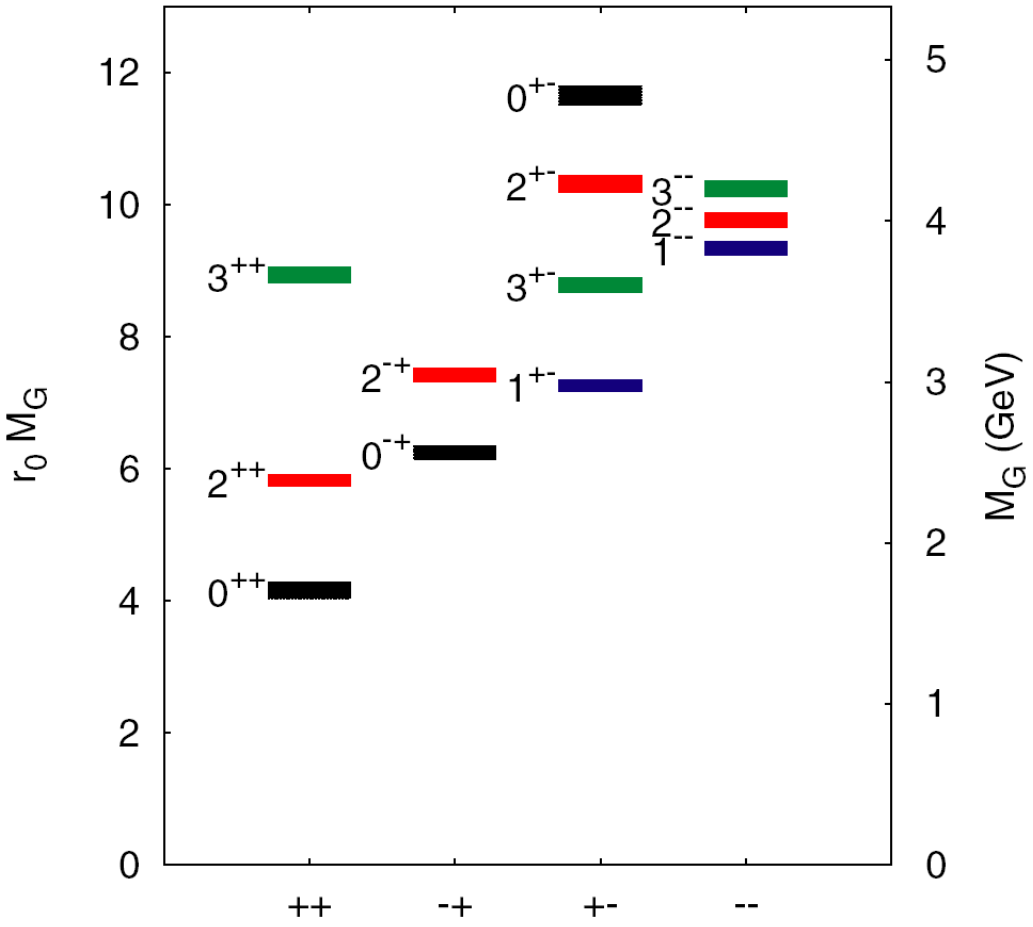
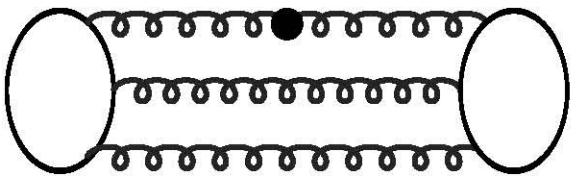


FIG. 16 (color online). The mass spectrum of glueballs in the pure $SU(3)$ gauge theory. The masses are given both in terms of r_0 ($r_0^{-1} = 410$ MeV) and in GeV. The height of each colored box indicates the statistical uncertainty of the mass.

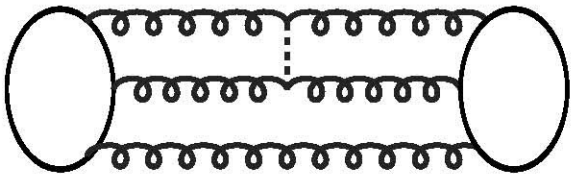
``Glueball spectrum and matrix elements on anisotropic lattices,'' Y. Chen et al., Phys. Rev. D {\bf 73}, 014516 (2006) [arXiv:hep-lat/0510074].

3.2 Constituent Gluon model results

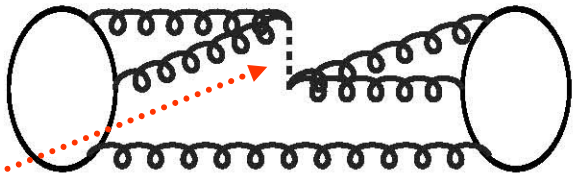
1 gluon energy



Gluon-gluon interaction



Gluon-gluon annihilation

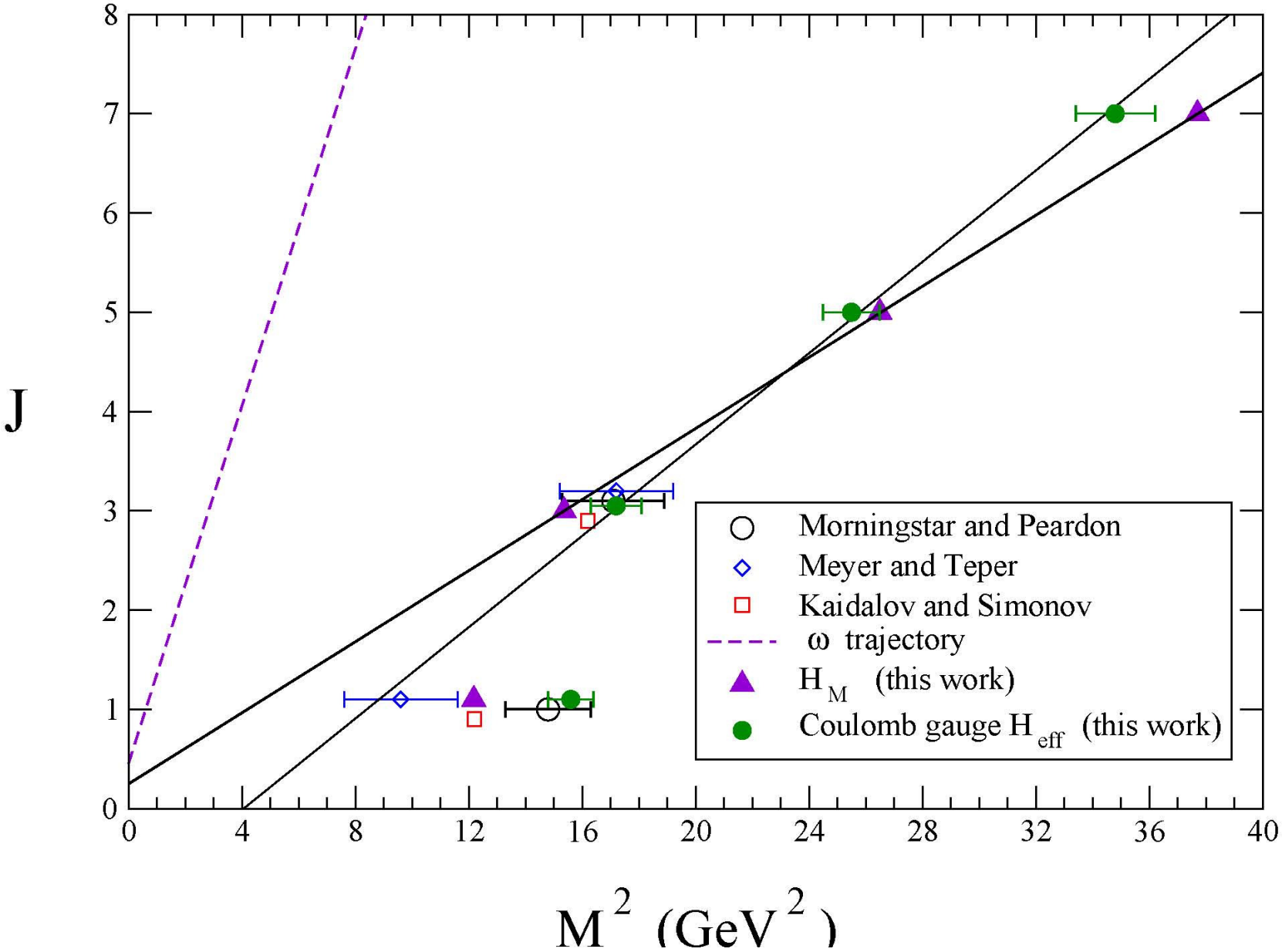


Funnel confining potential

Low x

Oddball Chew-Frautschi plot

C=P= -1 pure glue states



References of the plot:

These models:

- F. Llanes-Estrada, P. Bicudo and S. Cotanch, Phys. Rev. Lett. **96**, 081601 (2006) .

Lattice:

- H. B. Meyer and M. Teper, Phys. Lett. B **605**, 344 (2005).

- C. J. Morningstar and M. Peardon, Phys. Rev. **D 60**, 034509 (1999).

Wilson Loops:

- A. B. Kaidalov and Y. A. Simonov, Phys. Lett. **B 477**, 163 (2000).

Conclusion

The odd C (and P) trajectories are modelled by 3 gluon glueballs.

The glueball spectra of constituent gluon models, with gluon ''masses'' of 0.7 to 1.0 GeV, and of quenched lattice simulations, are similar.

Soft odderon intercepts are smaller than 0.5, lower than the meson parent trajectory, an this makes odderon harder to detect,

nevertheless see Adam Bzdak talk of this morning