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Mesonic Resonances with Charm & Beauty

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I. Introduction

Mesons with Open-Beauty: Experimental Status (average values)

J^P	bn	J^P	bs	J^P	bc
0^-	B	0^-	B_s	0^-	$B_c[6276]$
1^-	B^*	1^-	B_s^*		
0^+	?	0^+	?		
1^+ ?	$B_1(5721)$, $5726 - i14$	1^+ ?	$B_{s1}(5830)$		
2^+ ?	$B_2^*(5747)$, $5740 - i12$	2^+ ?	$B_{s2}(5840)$		
?	$B(5732)$, $5698 - i64$	?	$B_s(5850)$, $5853 - i23$	?	6842
?	$B(5840)$, $5863 - i63$				
?	$B(5970)$, $5971 - i40$				

- What are the quantum numbers of the resonances that have been seen?
- Where are the radial excitations?

Mesons with Open-Charm: Experimental Status (average values)

J^P	cn	J^P	cs
0^-	D	0^-	D_s
1^-	D^*	1^-	D_s^*
1^-		1^-	$D_{s1}^*(2700)$, $2708 - i60$
1^-		1^-	$D_{s1}^*(2860)$, $2859 - i80$
0^+	$D_0^*(2400)$	0^+	$D_{s0}^*(2317)$
1^+	$D_1(2420)$, $D_1(2430)$	1^+	$D_{s1}(2460)$, $D_{s1}(2536)$
2^+	$D_2^*(2460)$	2^+	$D_{s2}^*(2573)$
3^-	$D(2750)$, $2763 - i32$	3^-	$D_{s3}(2860)$, $2861 - i26$
?	$D(2550)$, $2564 - i67$	?	$D_s(3040)$, $3044 - i120$
?	$D(2600)$, $2617 - i48$		
?	$D(2640)$, $2637 - i < 15$		
?	$D(2740)$, $2737 - i36$		
?	$D(3000)$, $2990 - i70$		

- General motivation : To understand the underlying confining potential

Unquenching in the models

Quenched models, e.g., Godfrey-Isgur model, assume meson spectrum as a bare spectrum of the underlying Cornell potential (i.e. Coulomb + linear term), with spin-orbit corrections, without considering any other relevant hadronic degrees of freedom.

However experimental data reveals many nonperturbative effects, namely deformation of Breit-Wigner line shapes and mass-energies that are very different from any underlying spectrum.

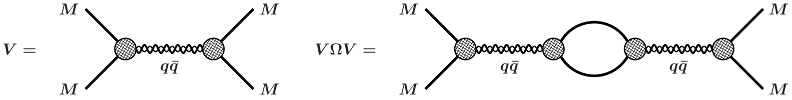
Unquenched approaches consider that resonances are not pure states, instead they are strongly coupled to other important components of the hadronic sea and to the nearby decay channels.

What is a “conventional” meson?

II. Spectroscopy with Potential Models: The Resonance-Spectrum-Expansion (RSE)

Elastic-Scattering: $AB \to CD$, A, B, C, D are strongly interacting objects.

Scattering Theory - Born expansion:



In the present model model one considers:

– A, B, C, D are mesonic resonances M.

– a whole spectrum of confined $q\bar{q}$ states.

– decays obey the the Okubo-Zweig-Iizuka OZI - allowed rule.

– transition mechanism, i.e., $q\bar{q}$ annihilation/creation at the vertices according to the $^3P_0$ model.

One defines an effective potential, in momentum space:

$$V_{ij}(p_i, p'_j; E) = \lambda^2 j^i_{L_i}(p_i a)\mathcal{R}_{ij}(E) j^j_{L_j}(p'_j a)$$

Spherical Bessel function $\Leftrightarrow$ spherical delta function: string breaking

Free parameters:

a - “string-breaking” distance

λ - global coupling

The RSE formula:

$$\mathcal{R}_{ij} = \sum_{l_c, S} \sum_{n=0}^{\infty} \frac{g^i_{nl_cS}\ g^j_{nl_cS}}{E - E_n^{(l_c)}}$$

Partial coupling constants $g^i_{nl_cS}$, i, j - decay channels

the g's are computed within the $^3P_0$ model using expansions on a harmonic-oscillator basis

$g_n = r_n/4^n$, where r_n is a polynomial - rapid convergence of the series.

Separable potential, Lippmann-Schwinger equation is evaluated in closed form.

Transition matrix:

$$T_{ij}^{L_i,L_j}(p_i,p_j';E) = -2a\lambda^2\sqrt{\mu_i p_i}\, j_{L_i}^i(p_i a)\sum_{m=1}^{N}\mathcal{R}_{im}\{[\mathbb{1}-\Omega\mathcal{R}]^{-1}\}_{mj}\, j_{L_j}^j(p_j' a)\sqrt{\mu_j p_j'},$$

Loop function:

$$\Omega_{ij}(k_j) = -2ia\lambda^2\mu_j k_j\, j_{L_j}^j(k_j a)\, h_{L_j}^{(1)j}(k_j a)\,\delta_{ij}\ .$$

Manifest unitarity of the scattering matrix

$$S = \mathbb{1} + 2iT$$

Resonances and bound states are poles of the scattering matrix

(found in the 2nd Riemann Sheet with relation to the nearest threshold)

The transition operator T, in term of a complex variable z, is given by

$$T(z) = V + VG_0(z)T$$

or

$$\langle\vec{p}|T|\vec{p'}\rangle = \langle\vec{p}|V|\vec{p'}\rangle + \int d^3k' \int d^3k \ \langle\vec{p}|V|\vec{k'}\rangle \langle\vec{k'}|G_0(z)|\vec{k}\rangle \langle\vec{k}|T(z)|\vec{p'}\rangle \,,$$

where the Green function G_0 may be expressed as

$$G_0(z) = (z - H_0)^{-1}.$$

The potential V is spherically symmetric and given by

$$V(\vec{r}, \vec{r'}) = \delta^{(3)}(\vec{r} - \vec{r'})V(r),$$

which reads, in momentum space,

$$V(\vec{k}, \vec{k'}) = \frac{1}{2\pi^2} \sum_{l=0}^{\infty} (2l+1) P_l(\hat{k} \cdot \hat{k}') \int_0^{\infty} r^2 dr V(r) j_l(kr) j_l(k'r).$$

III. RSE with the Harmonic-Oscillator confining potential:

$$\mathcal{R}_{ij} = \sum_{l_c,S} \sum_{n=0}^{\infty} \frac{g^i_{nl_cS}\ g^j_{nl_cS}}{E - E_n^{(l_c)}}$$

$$E_n = m_q + m_{\bar{q}} + \omega(2n + l_c + 3/2)$$

Parameters (MeV), cf. PRD 27, 1527 (1983). For m_b cf. EPJ 32, 493 (2004):

$$\omega = 190, \quad m_n = 406, \quad m_s = 508, \quad m_c = 1562, \quad m_b = 4877$$

• Allows analytical solutions of the Schrödinger equation.

• Although it is not QCD inspired, it is a good phenomenological potential for strong interactions.

Axials with charm-light flavor (cn and cs) - PV and VV channels

	Channel	Th (MeV)	ℓ	$g_{1^{++}}^{2(n=0)}$	$g_{1^{+-}}^{2(n=0)}$
1	$D^*\pi$	2146	0	0.02778	0.01389
2	$D^*\pi$	2146	2	0.03472	0.06944
3	$D^*\eta$	2556	0	0.00586	0.00293
4	$D^*\eta$	2556	2	0.00733	0.01465
5	D_s^*K	2608	0	0.01852	0.00926
6	D_s^*K	2608	2	0.02315	0.04630
7	$D\rho$	2643	0	0.02778	0.01389
8	$D\rho$	2643	2	0.03472	0.06944
9	$D\omega$	2650	0	0.00926	0.00463
10	$D\omega$	2650	2	0.01157	0.02315
11	$D^*\rho$	2784	0	0	0.01389
12	$D^*\rho$	2784	2	0.10417	0.06944
13	$D^*\omega$	2791	0	0	0.00463
14	$D^*\omega$	2791	2	0.03472	0.02315
15	D_sK^*	2862	0	0.01852	0.00926
16	D_sK^*	2862	2	0.02315	0.04630
17	$\eta' D^*$	2996	0	0.00341	0.00170
18	$\eta' D^*$	2996	2	0.00425	0.00850
19	$D_s^*K^*$	3006	0	0	0.00926
20	$D_s^*K^*$	3006	2	0.06944	0.04630

	Channel	Th (MeV)	ℓ	$g_{1^{++}}^{2(n=0)}$	$g_{1^{+-}}^{2(n=0)}$
1	D^*K	2504	0	0.03704	0.01852
2	D^*K	2504	2	0.04630	0.09259
3	$D_s^*\eta$	2660	0	0.00680	0.00340
4	$D_s^*\eta$	2660	2	0.00850	0.01700
5	DK^*	2761	0	0.03704	0.01852
6	DK^*	2761	2	0.04630	0.09259
7	D^*K^*	2902	0	0	0.01852
8	D^*K^*	2902	2	0.13889	0.09259
9	$D_s\phi$	2988	0	0.01852	0.00926
10	$D_s\phi$	2988	2	0.02315	0.04630
11	$D_s^*\eta'$	3069	0	0.01718	0.00586
12	$D_s^*\eta'$	3069	2	0.01465	0.02930
13	$D_s^*\phi$	3132	0	0	0.00926
14	$D_s^*\phi$	3132	2	0.06944	0.04630

$E_{n=0,1}\ (MeV):\quad (cn)\ \ 2433\quad 2813\qquad (cs)\ \ 2535\quad 2915$

		RSE (HO)†	Exp Data	Quenched Models ‡
cn	$1^3P_1,\ 1^1P_1$	$2439 - i4$	$2423 - i13$	(1^3P_1) 2.39-2.44
r_0=3.40 GeV^{-1}	$1^3P_1,\ 1^1P_1$	$2432 - i192$	$2427 - i192$	(1^1P_1) 2.41-2.49
λ=1.30	$2^3P_1,\ 2^1P_1$	$2814 - i8$		(2^3P_1) 2.79-3.00
	$2^3P_1,\ 2^1P_1$	$2753 - i48$	$2737 - i36$?	(2^1P_1) 2.80-3.05
cs	$1^3P_1,\ 1^1P_1$	2457	2460	(1^3P_1) 2.46-2.54
r_0=3.12 GeV^{-1}	$1^3P_1,\ 1^1P_1$	$2541 - i6$	2535	(1^1P_1) 2.51-2.61
λ=1.19	$2^3P_1,\ 2^1P_1$	$2915 - i7$		(2^3P_1) 2.93-3.11
	$2^3P_1,\ 2^1P_1$	$2862 - i26$		(2^1P_1) 2.94-3.17

† in PRD 84, 094020 (2011) ‡ cf. EPJC 71, 1585 (2011)

$$r_{0f} = \sqrt{\frac{\mu_i}{\mu_f}}\, r_{0i},\quad \lambda_f = \sqrt{\frac{\mu_i}{\mu_f}}\,\lambda_i,\quad i,f = \bar{q}q$$

Axials with beauty-light flavor (bn and bs) - PV and VV channels

	Channel	Th (MeV)	ℓ	$g_{1^{++}}^{2(n=0)}$	$g_{1^{+-}}^{2(n=0)}$
1	$B^*\pi$	5463	0	0.02778	0.01389
2	$B^*\pi$	5463	2	0.03472	0.06944
3	$B^*\eta$	5873	0	0.00586	0.00293
4	$B^*\eta$	5873	2	0.00733	0.01465
5	B_s^*K	5911	0	0.01852	0.00926
6	B_s^*K	5911	2	0.02315	0.04630
7	$B\rho$	6055	0	0.02778	0.01389
8	$B\rho$	6055	2	0.03472	0.06944
9	$B\omega$	6062	0	0.00926	0.00463
10	$B\omega$	6062	2	0.01157	0.02315
11	$B^*\rho$	6101	0	0	0.01389
12	$B^*\rho$	6101	2	0.10417	0.06944
13	$B^*\omega$	6108	0	0	0.00463
14	$B^*\omega$	6108	2	0.03472	0.02315
15	B_sK^*	6261	0	0.01852	0.00926
16	B_sK^*	6261	2	0.02315	0.04630
17	$\eta'B^*$	6283	0	0.00341	0.00170
18	$\eta'B^*$	6283	2	0.00425	0.00850
19	$B_s^*K^*$	6309	0	0	0.00926
20	$B_s^*K^*$	6309	2	0.06944	0.04630

	Channel	Th (MeV)	ℓ	$g_{1^{++}}^{2(n=0)}$	$g_{1^{+-}}^{2(n=0)}$
1	B^*K	5821	0	0.03704	0.01852
2	B^*K	5821	2	0.04630	0.09259
3	$B_s^*\eta$	5963	0	0.00680	0.00340
4	$B_s^*\eta$	5963	2	0.00850	0.01700
5	BK^*	6173	0	0.03704	0.01852
6	BK^*	6173	2	0.04630	0.09259
7	B^*K^*	6219	0	0	0.01852
8	B^*K^*	6219	2	0.13889	0.09259
9	$B_s^*\eta'$	6373	0	0.01172	0.00926
10	$B_s^*\eta'$	6373	2	0.01465	0.04630
11	$B_s\phi$	6386	0	0.01852	0.00586
12	$B_s\phi$	6386	2	0.02315	0.02930
13	$B_s^*\phi$	3132	0	0	0.00926
14	$B_s^*\phi$	3132	2	0.06944	0.04630

$E_{n=0,1}$ (MeV) : (bn) 5758 6138 (bs) 5860 6240

		RSE (HO)†	Exp Data	Quenched Models ‡
bn	$1^3P_1,\ 1^1P_1$	$5703 - i28$	$5726 \pm 2 - i(15 \pm 2)$	(1^3P_1) 5.70-5.78
r_0=3.15 GeV^{-1}	$1^3P_1,\ 1^1P_1$	$5755 - i0.8$		(1^1P_1) 5.74-5.78
λ=1.21	$2^3P_1,\ 2^1P_1$	$6129 - i7$		
	$2^3P_1,\ 2^1P_1$	$6494 - i12$		
bs	$1^3P_1,\ 1^1P_1$	5784	5750(17)(19) (lattice*)	(1^1P_1) 5.81-5.86
r_0=2.85 GeV^{-1}	$1^3P_1,\ 1^1P_1$	$5856 - i1$	$5828.6 \pm 0.3 - i(0.3 \pm 0.3)$	(1^3P_1) 5.84-5.87
λ=1.09	$2^3P_1,\ 2^1P_1$	$6229 - i6$		
	$2^3P_1,\ 2^1P_1$	$6248 - i267$		

† cf. EPJC 32, 493 (2004), $\star$ PLB 750, 17 (2015)
‡ cf. PRD 89, 054026 (2014)

Vectors with charm-light flavor (cn and cs) - PP, PV and VV channels

	Ch	Th (MeV)	ℓ,s	$g^{2(n=0)}_{1^{--}(\ell=0)}$	$g^{2(n=0)}_{1^{--}(\ell=2)}$
1	$D\pi$	2005	1,0	0.02083	0.00694
2	$D^*\pi$	2146	1,1	0.08333	0.00694
3	$D\eta$	2415	1,0	0.00437	0.00146
4	D_sK	2464	1,0	0.01389	0.00463
5	$D^*\eta$	2557	1,1	0.01749	0.00146
6	D_s^*K	2608	1,1	0.05556	0.00463
7	$D\rho$	2643	1,1	0.08333	0.00694
8	$D\omega$	2650	1,1	0.02778	0.00231
9	$D^*\rho$	2784	1,0	0.00694	0.00231
10	$D^*\rho$	2784	1,2	0.13889	0.00046
11	$D^*\omega$	2791	1,0	0.00231	0.00077
12	$D^*\omega$	2791	1,2	0.04630	0.00015
13	$D\eta'$	2825	1,0	0.00257	0.00086
14	D_sK^*	2862	1,1	0.05556	0.00463
15	$D^*\eta'$	2966	1,1	0.01029	0.00086
16	$D_s^*K^*$	3006	1,0	0.00463	0.00154
17	$D_s^*K^*$	3006	1,2	0.09259	0.00031

	Ch	Th (MeV)	ℓ, s	$g^{2(n=0)}_{1^{--}(\ell=0)}$	$g^{2(n=0)}_{1^{--}(\ell=2)}$
1	DK	2363	1,0	0.02778	0.00926
2	D^*K	2504	1,1	0.11111	0.00926
3	$D_s\eta$	2516	1,0	0.00515	0.00172
4	$D_s^*\eta$	2660	1,1	0.02058	0.00172
5	DK^*	2761	1,1	0.11111	0.00926
6	D^*K^*	2903	1,0	0.00926	0.00309
7	D^*K^*	2903	1,2	0.18519	0.00062
8	$D_s\eta'$	2926	1,0	0.00874	0.00291
9	$D_s\phi$	2988	1,1	0.05556	0.00463
10	$D_s^*\eta'$	3070	1,1	0.03498	0.00291
11	$D_s^*\phi$	3132	1,0	0.00463	0.00154
12	$D_s^*\phi'$	3132	1,2	0.09259	0.00031

$E_{n=0,1}\ (MeV):\quad (cn)\ \ 2253\quad 2633\qquad (bs)\ \ 2355\quad 2735$

		RSE (HO)†	Experimental Data	Quenched Models ‡
cn	$1S$	2023	2009	(1S) 2.01-2.04
r_0=3.40 GeV^{-1}	$2S,\ 1D$	$2491 - i10$		(2S) 2.60-2.69
λ=5.45	$2S,\ 1D$	$2577 - i12$		(1D) 2.71-2.82
cs	$1S$	2112	2112	(1S) 2.11-2.13
r_0=3.12 GeV^{-1}	$2S,\ 1D$	$2595 - i7$	$2708 - i60$	(2S) 2.71-2.81
λ=5.0	$2S,\ 1D$	$2686 - i11$	$2859 - i80$	(1D) 2.80-2.91

† for *cs* cf. PRL 93, 202001 (2004) ‡ cf. EPJC 71, 1585 (2011)

Vectors with beauty-light flavor (bn and bs) - PP, PV and VV channels

	Ch	Th (MeV)	ℓ, s	$g^{2(n=0)}_{1^{--}(\ell=0)}$	$g^{2(n=0)}_{1^{--}(\ell=2)}$
1	$B\pi$	5417	1,0	0.02083	0.00694
2	$B^*\pi$	5463	1,1	0.08333	0.00694
3	$B\eta$	5827	1,0	0.00437	0.00146
4	B_sK	5862	1,0	0.01389	0.00463
5	$B^*\eta$	5873	1,1	0.01758	0.00146
6	B_s^*K	5911	1,1	0.05556	0.00463
7	$B\rho$	6055	1,1	0.08333	0.00694
8	$B\omega$	6062	1,1	0.02778	0.00231
9	$B^*\rho$	6101	1,0	0.00694	0.00231
10	$B^*\rho$	6101	1,2	0.13889	0.00046
11	$B^*\omega$	6108	1,0	0.00231	0.00077
12	$B^*\omega$	6108	1,2	0.04630	0.00015
13	$B\eta'$	6237	1,0	0.00257	0.00086
14	B_sK^*	6261	1,1	0.05556	0.00463
15	$B^*\eta'$	6283	1,1	0.01020	0.00086
16	$B_s^*K^*$	6309	1,0	0.00463	0.00154
17	$B_s^*K^*$	6309	1,2	0.09259	0.00031

	Ch	Th (MeV)	ℓ, s	$g^{2(n=0)}_{1^{--}(\ell=0)}$	$g^{2(n=0)}_{1^{--}(\ell=2)}$
1	BK	5775	1,0	0.02778	0.00926
2	B^*K	5821	1,1	0.11111	0.00926
3	$B_s\eta$	5915	1,0	0.00510	0.00170
4	$B_s^*\eta$	5963	1,1	0.02040	0.00170
5	BK^*	6173	1,1	0.11111	0.00926
6	B^*K^*	6219	1,0	0.00926	0.00309
7	B^*K^*	6219	1,2	0.18519	0.00062
8	$B_s\eta'$	6324	1,0	0.00879	0.00293
10	$B_s^*\eta'$	6373	1,1	0.03515	0.00293
9	$B_s\phi$	6386	1,1	0.05556	0.00463
11	$B_s^*\phi$	6435	1,0	0.00463	0.00154
12	$B_s^*\phi'$	6435	1,2	0.09259	0.00031

$E_{n=0,1}\ (MeV):\quad (bn)\ \ 5568\quad 5948\qquad (bs)\quad 5670\quad 6050$

		RSE (HO)	Exp Data	Quenched Models ‡
bn	$1S$	5382	5325	(1S) 5.32-5.37
r_0=3.15 GeV^{-1}	$2S,\ 1D$	$5811 - i7$	$5698 - i64$?	(2S) 5.90-5.94
λ=5.05	$2S,\ 1D$		$5863 - i63$?	(1D) 6.02-6.12
		$5899 - i9$	$5971 - i40$?	
bs	$1S$	5484	5415	(1S) 5.41-5.45
r_0=2.85 GeV^{-1}	$2S,\ 1D$	$5914 - i4$		(2S) 5.99-6.02
λ=4.57	$2S,\ 1D$	$6008 - i8$		(1D) 6.12-6.21

‡ cf. PRD 89, 054026 (2014)

Scalars with charm-light flavor (cn and cs) - PP and VV channels

	Channel	Th (MeV)	ℓ	$g_{0^{++}}^{2(n=0)}$
1	$D\pi$	2363	0	0.02083
2	$D\eta$	2415	0	0.00439
3	$D_s K$	2464	0	0.01389
4	$D^*\rho$	2784	0	0.00694
5	$D^*\rho$	2784	2	0.13889
6	$D^*\omega$	2791	0	0.00231
7	$D^*\omega$	2791	2	0.04630
8	$D\eta'$	2825	0	0.00255
9	$D_s^* K^*$	3006	0	0.00463
10	$D_s^* K^*$	3006	2	0.09259

	Channel	Th (MeV)	ℓ	$g_{0^{++}}^{2(n=0)}$
1	DK	2363	0	0.02778
2	$D_s\eta$	2516	0	0.00510
3	$D^* K^*$	2903	0	0.00926
4	$D^* K^*$	2903	2	0.18519
5	$D_s\eta'$	2926	0	0.00879
6	$D_s^*\phi$	3132	0	0.00463
7	$D_s^*\phi$	3132	2	0.09259

$E_{n=0,1}\ (MeV):\quad (cn)\ \ 2443\quad 2823\quad (bs)\ \ 2545\quad 2925$

		RSE (HO)†	Exp Data	Quenched Models ‡
cn	$1P$	$2171 - i95$	$2335 - i124$	(1P) 2.25-2.41
r_0=2.68 GeV^{-1}	$2P$	$2735 - i27$		(2P) 2.75-2.95
λ=3.82	$2P$ (dyn)	$2708 - i222$		
cs	$1P$	2317	2318	(1P) 2.32-2.51
r_0=2.46 GeV^{-1}	$2P$	$2841 - i24$		(2P) 2.83-3.07
λ=3.50	$2P$ (dyn)	$2774 - i232$		

† cf. PRL 97, 202001 (2006), PRL 91, 012003 (2003), EPJA 31, 698 (2007).

‡ cf. EPJC 71, 1585 (2011)

Scalars with beauty-light flavor (bn and bs) - PP and VV channels

	Channel	Th (MeV)	ℓ	$g_{0^{++}}^{2(n=0)}$
1	$B\pi$	5417	0	0.02083
2	$B\eta$	5827	0	0.00439
3	$B_s K$	5862	0	0.01389
4	$B^*\rho$	6101	0	0.00694
5	$B^*\rho$	6101	2	0.13889
6	$B^*\omega$	6108	0	0.00231
7	$B^*\omega$	6108	2	0.04630
8	$B\eta'$	6237	0	0.00255
9	$B_s^* K^*$	6309	0	0.00463
10	$B_s^* K^*$	6309	2	0.09259

	Channel	Th (MeV)	ℓ	$g_{0^{++}}^{2(n=0)}$
1	BK	5775	0	0.02778
2	$B_s\eta$	5915	0	0.00510
3	$B^* K^*$	6219	0	0.00926
4	$B^* K^*$	6219	2	0.18519
5	$B_s\eta'$	6324	0	0.00879
6	$B_s^*\phi$	6435	0	0.00463
7	$B_s^*\phi$	6435	2	0.09259

$E_{n=0,1}$ (MeV) : (bn) 5758 6138 (bs) 5670 6050

		RSE (HO)	Experimental Data	Quenched Models ‡
bn	$1P$	$5541 - i57$		(1P) 5.71-5.76
r_0=2.49 GeV^{-1}	$2P$	$6044 - i26$		(2P) 6.16-6.22
λ=3.54				
bs	$1P$	5698	5711(13)(19) (lattice†)	(1P) 5.80-5.83
r_0=2.24 GeV^{-1}	$2P$	$6151 - i27$		(2P) 6.28-6.32
λ=3.20				

† arXiv: 1501.01646 [hep-lat]

‡ cf. PRD 89, 054026 (2014)

IV. Unquenching the Funnel (Coulomb + linear) Potential

Motivation for the Cornell potential:

$$V(r) = -\frac{4}{3}\frac{\alpha_s}{r} + \sigma r$$

Coulombic term (small distances): coulombic one-gluon-exchange between qq, qg, and gg in perturbative QCD.

Linear term: inferred from the lattice gauge theory at large distances.

The Funnel potential in the RSE:

$$\mathcal{R}_{ij} = \sum_{l_c,S}\sum_{n=0}^{\infty}\frac{g^{i}_{nl_cS}\; g^{j}_{nl_cS}}{E - E_n^{(l_c)}}$$

- Choose the appropriate energy spectrum
- Compute the appropriate partial coupling constants g

V. Summary

• Relevance of meson spectroscopy to understand the confining potential

• Relevance of the unquenching, namely of coupled-channel effects, to understand resonances

• The RSE model using an Harmonic Oscillator confining potential leads to different predictions than quenched models using the Cornell potential

• The unquenching of the Cornell potential, namely by employing the RSE model, may lead to different results than the traditional quenched approaches, that are typically altered by screened potentials or spin-orbit corrections.

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