Mini-workshop on light QCD exotic states

Fully strange tetraquark resonant states as the cousins of X(6900)

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Based on arXiv:2408.00503 and papers in preparation

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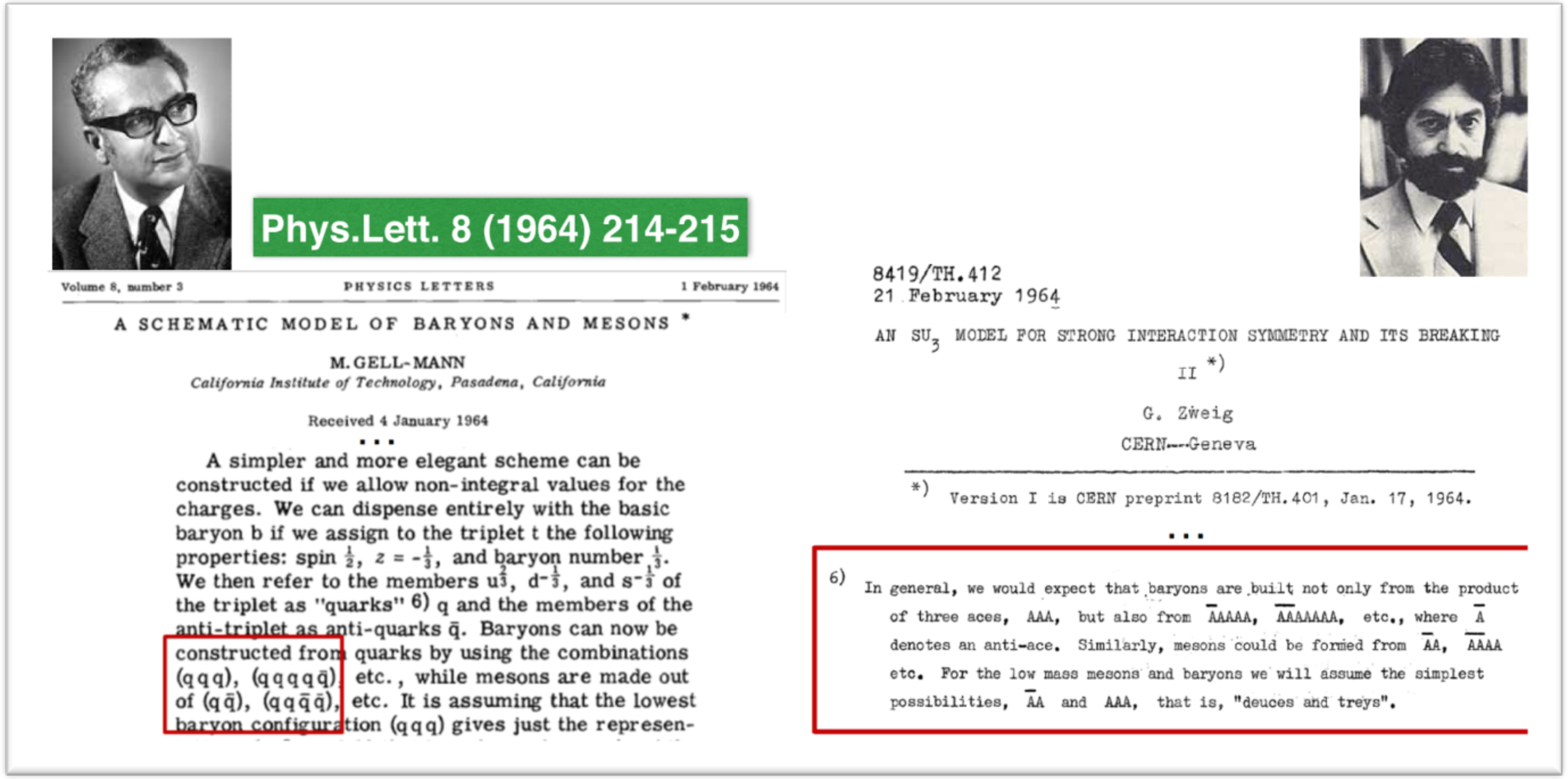
Introduction


Phys.Lett. 8 (1964) 214-215

Volume 8, number 3 PHYSICS LETTERS 1 February 1964

A SCHEMATIC MODEL OF BARYONS AND MESONS *

M. GELL-MANN
California Institute of Technology, Pasadena, California

Received 4 January 1964

...

A simpler and more elegant scheme can be constructed if we allow non-integral values for the charges. We can dispense entirely with the basic baryon b if we assign to the triplet t the following properties: spin $\frac{1}{2}$, $z = -\frac{1}{3}$, and baryon number $\frac{1}{3}$. We then refer to the members $u^{\frac{2}{3}}$, $d^{-\frac{1}{3}}$, and $s^{-\frac{1}{3}}$ of the triplet as "quarks" 6) q and the members of the anti-triplet as anti-quarks $\bar{q}$. Baryons can now be constructed from quarks by using the combinations $(q q q)$, $(q q q q \bar{q})$, etc., while mesons are made out of $(q \bar{q})$, $(q q \bar{q} \bar{q})$, etc. It is assuming that the lowest baryon configuration $(q q q)$ gives just the represen-

8419/TH.412
21 February 1964

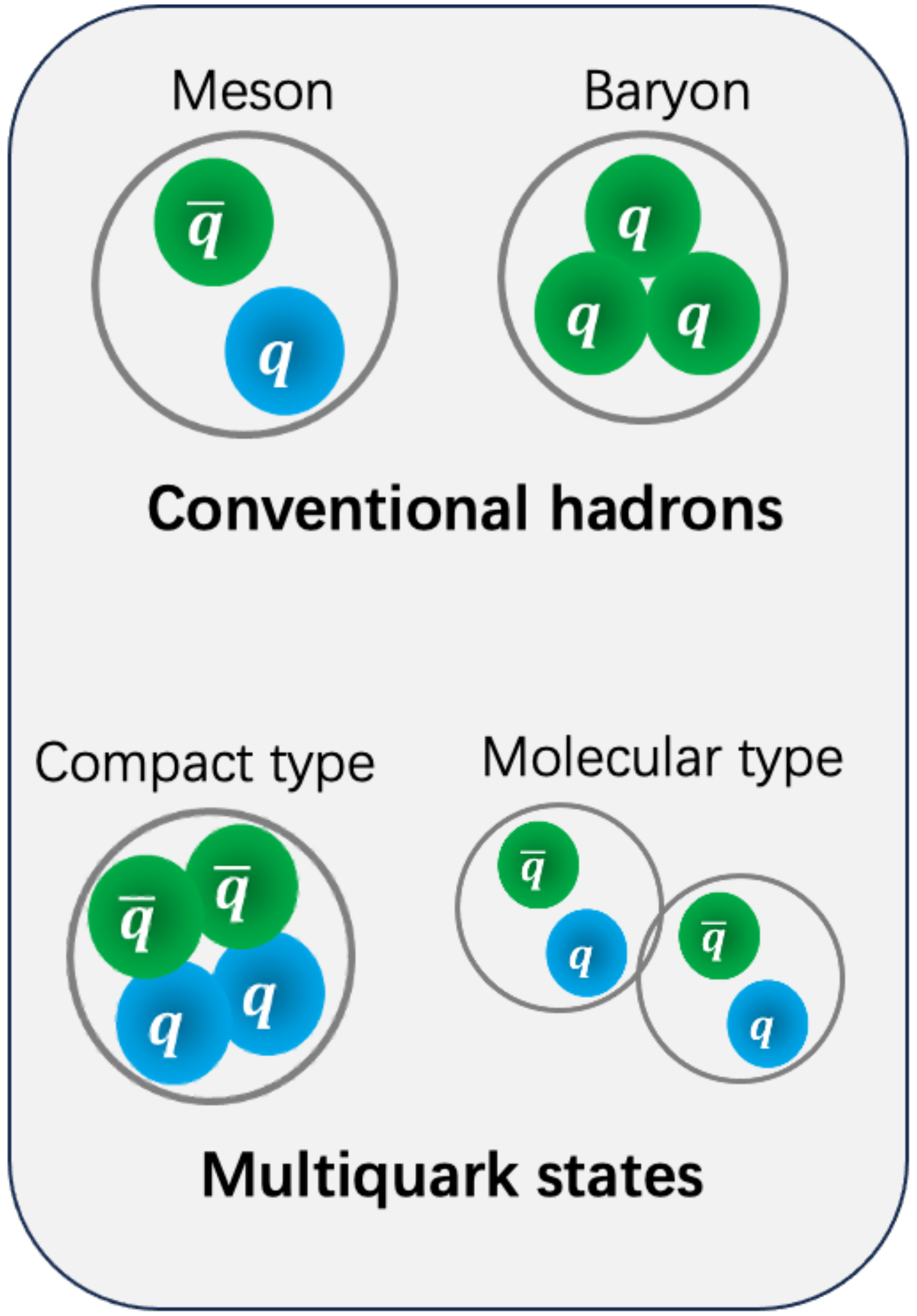
AN SU_3 MODEL FOR STRONG INTERACTION SYMMETRY AND ITS BREAKING II *)

G. Zweig
CERN---Geneva

*) Version I is CERN preprint 8182/TH.401, Jan. 17, 1964.

...

6) In general, we would expect that baryons are built not only from the product of three aces, AAA, but also from $\bar{A}AAAA$, $\bar{A}\bar{A}AAAAA$, etc., where $\bar{A}$ denotes an anti-ace. Similarly, mesons could be formed from $\bar{A}A$, $\bar{A}\bar{A}AA$ etc. For the low mass mesons and baryons we will assume the simplest possibilities, $\bar{A}A$ and AAA, that is, "deuces and treys".



- Multiquark states were predicted at the birth of quark model
- Quark potential model——a useful theoretical tool to describe the interaction between quarks

Quark potential model

- Cornell model

Eichten:1974af, Eichten:1978tg, Eichten:1979ms

$$V_{ij}(r) = \left[\frac{\alpha_s}{r} - \frac{8\pi\alpha_s}{3m_i m_j}\frac{\tau^3}{\pi^{3/2}}e^{-\tau^2 r^2}\boldsymbol{s}_i\cdot\boldsymbol{s}_j + \left(-\frac{3b}{4}r + V_c\right)\right]\frac{\lambda_i\cdot\lambda_j}{4}$$

OGE — Confinement

- Semay-Silvestre-Brac Models

Semay:1994ht, Silvestre-Brac:1996myf

$$V_{ij}(r) = \left[-\frac{\kappa}{r} + \lambda r^p - \Lambda + \frac{2\pi}{3m_i m_j}\kappa' \frac{1}{\pi^{3/2} r_0^3} e^{(-r^2/r_0^2)}\boldsymbol{\sigma}_i\cdot\boldsymbol{\sigma}_j\right]\lambda_i\cdot\lambda_j$$

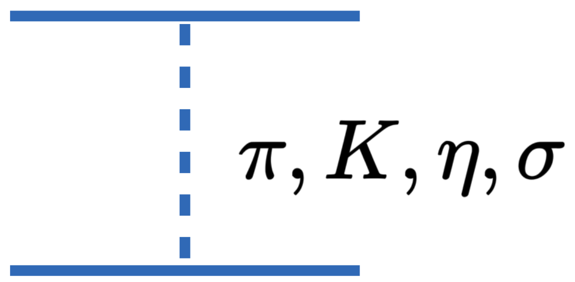
AL1: $p = 1$, AP1: $p = 2/3$

- Chiral constituent quark model (χCQM)

Vijande:2004he, Segovia:2011dg

$$V_{ij}(r) = \left[\frac{\alpha_s}{4}\left(\frac{1}{r} - \frac{1}{6m_i m_j}\frac{e^{-r/r_0}}{r_0^2 r}\boldsymbol{\sigma}_i\cdot\boldsymbol{\sigma}_j\right) + \left(-a_c\left(1 - e^{-\mu_c r}\right) + \Delta\right)\right]\lambda_i\cdot\lambda_j + V_\pi + V_K + V_\eta + V_\sigma$$

Screened confinement



Complex scaling method (CSM)

A method to obtain energies and wave functions of bound and resonant states.

- In CSM, the coordinate r and its conjugate momentum p are transformed as

Avoid mistaking scattering states as resonant states

$$U(\theta)\boldsymbol{r} = \boldsymbol{r}e^{i\theta}, \quad U(\theta)\boldsymbol{p} = \boldsymbol{p}e^{-i\theta}$$

- The complex-scaled Hamiltonian

$$H(\theta) = \sum_{i=1}^{4}\left(m_i + \frac{p_i^2 e^{-2i\theta}}{2m_i}\right) + \sum_{i<j=1}^{4} V_{ij}\left(r_{ij}e^{i\theta}\right)$$

no longer hermitian, has complex eigenvalues

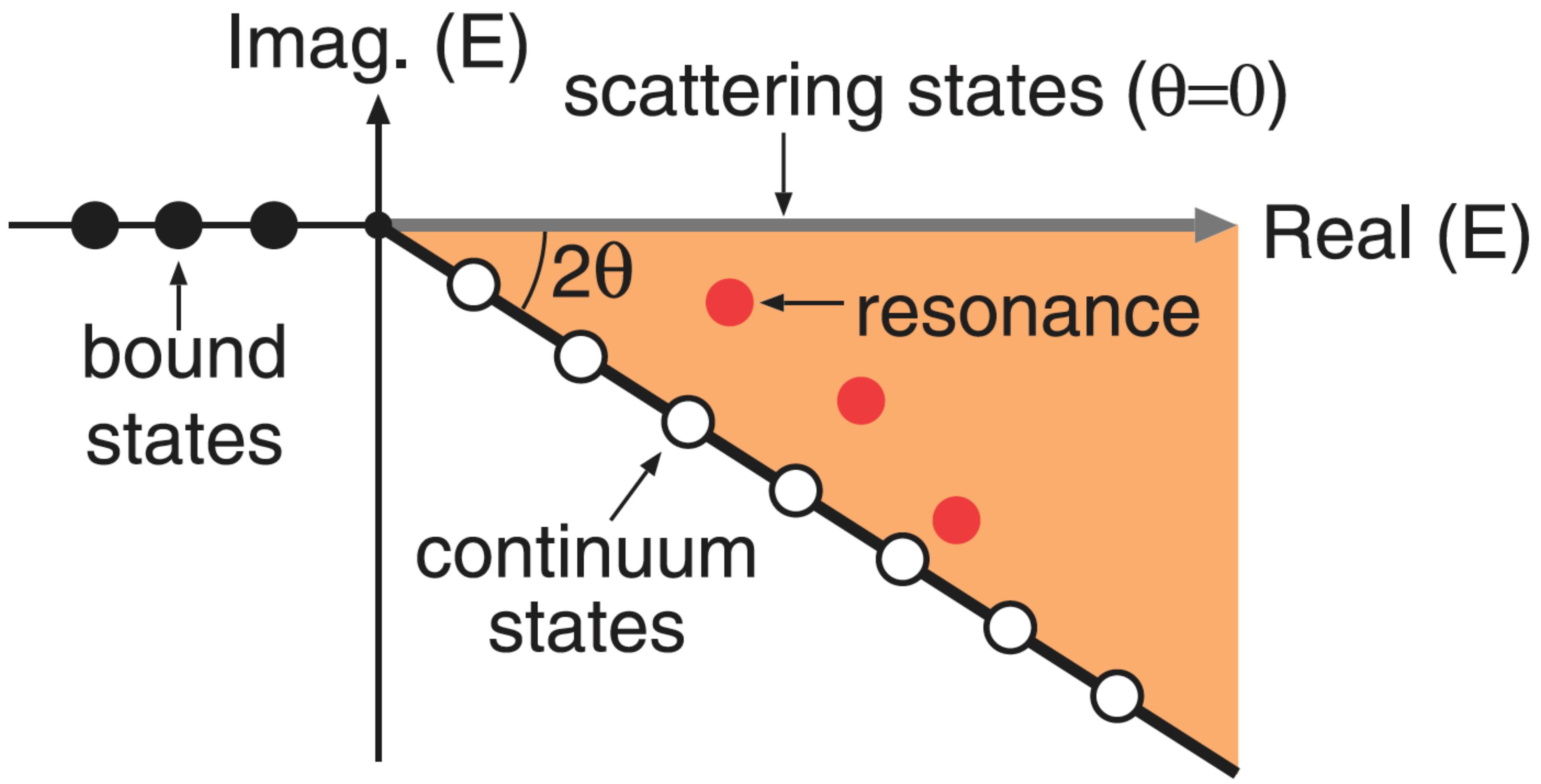
- The properties of solutions of the complex-scaled Schrödinger equation (the ABC theorem):

Aguilar:1971ve, Balslev:1971vb

Bound states: not change by scaling

Resonance: $E_R = M_R - i\Gamma_R/2$ $\xrightarrow[2\theta > |\mathrm{Arg}(E_R)|]{\boldsymbol{r} \to \boldsymbol{r}e^{i\theta}}$ square-integrable function

Continuum states: start at the threshold, rotate clockwise by 2θ



S. Aoyama, T. Myo, K. Kat.o, and K. Ikeda, Progress of theoretical physics 116, 1 (2006)

- CSM was advocated to derive resonances in many-body systems.

B. Simon, Communications in Mathematical Physics, 27(1): 1–9 (1972)

Fully strange tetraquark system

Motivation

- Experimental fully strange tetraquark state candidates

The strangenium-like state $Y(2175)$ was first reported in 2006 by the BaBar Collaboration in the process of $e^+e^- \to \phi(1020)f_0(980)$. Later it was confirmed by BES, BESIII and Belle Collaborations.

BaBar:2006gsq, Belle:2008kuo, BES:2007sqy, BESIII:2014ybv, BESIII:2017qkh

Other promising candidates: $X(2370)$, $X(2500)$, $X(2239)$, $X(2100)$, $X(2436)$,…… inspired by their many strangeness decays.

BESIII:2010gmv, BESIII:2019wkp, BESIII:2016qzq, BESIII:2018ldc, BESIII:2018zbm, BaBar:2007ptr

All candidates have negative parity. Do positive parity states exist?

- Possible strange analogs as the cousins of $X(6900)$

Recently, the LHCb Collaboration discovered a fully charmed tetraquark candidate $X(6900)$, and confirmed by CMS and ATLAS.

LHCb:2020bwg, CMS:2023owd, ATLAS:2023bft

Quark potential model

- AL1 model

Semay:1994ht, Silvestre-Brac:1996myf

$$V_{ij} = -\frac{3}{16}\lambda_i^c \cdot \lambda_j^c \Big(-\frac{\kappa}{r_{ij}} + \lambda r_{ij} - \Lambda + \frac{8\pi\kappa'}{3m_i m_j}\frac{\exp(-r_{ij}^2/r_0^2)}{\pi^{3/2}r_0^3}\boldsymbol{s}_i \cdot \boldsymbol{s}_j \Big)$$

TABLE I. The parameters in the AL1 quark potential model.

κ	$\lambda[\mathrm{GeV}^2]$	$\Lambda[\mathrm{GeV}]$	κ'	$m_s[\mathrm{GeV}]$	$A[\mathrm{GeV}^{B-1}]$	B
0.5069	0.1653	0.8321	1.8609	0.577	1.6553	0.2204

TABLE II. The theoretical masses (in MeV) and rms radii (in fm) of the $s\bar{s}$ mesons in the AL1 model, compared with the experimental results taken from Ref. [67].

J^{PC}	Meson	$m_{\mathrm{Exp.}}$	$m_{\mathrm{Theo.}}$	$r^{\mathrm{rms}}_{\mathrm{Theo.}}$
0^{-+}	η' [a]	-	713.5	0.54
	$\eta'(2S)$	-	1565.2	1.17
	$\eta'(3S)$	-	2140.9	1.65
1^{--}	ϕ	1019.5	1021.0	0.70
	$\phi(2S)$	1680	1695.1	1.25
	$\phi(3S)$	2188	2231.6	1.70

[a] For simplicity, we assume that there is no mixing effects between the $I=0$ $\eta(n\bar{n})$ and $\eta'(s\bar{s})$.

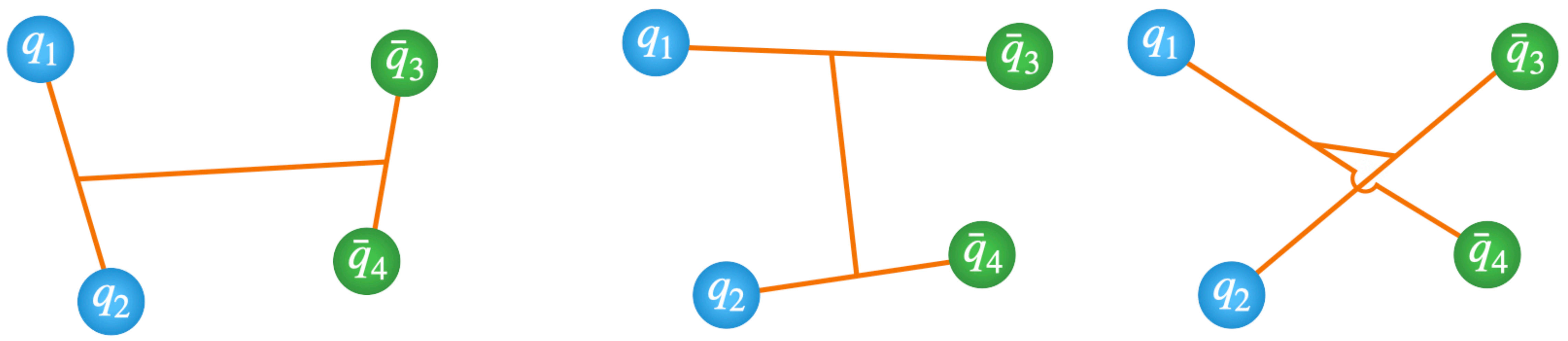
Tetraquark wave function construction

$$\psi = \mathcal{A}\left(\phi \otimes \chi_s \otimes \chi_c\right)$$

- Spatial wave function:

$$\phi_{nlm}(\boldsymbol{r}) = \sqrt{\frac{2^{l+5/2}}{\Gamma\left(l+\frac{3}{2}\right) r_n^3}} \left(\frac{r}{r_n}\right)^l e^{-\frac{r^2}{r_n^2}} Y_{lm}(\hat{r})$$

Only S-wave is considered.



(a) (b)

$$\begin{cases} r_0 = 0.4\ \mathrm{fm}, r_{n_{\max}} = 2.0\ \mathrm{fm} & s - s \text{ or } \bar{s} - \bar{s} \\ r_0 = 0.4\ \mathrm{fm}, r_{n_{\max}} = 2.0\ \mathrm{fm} & (ss) - (\bar{s}\bar{s}) \\ r_0 = 0.4\ \mathrm{fm}, r_{n_{\max}} = 1.3\ \mathrm{fm} & s - \bar{s} \\ r_0 = 0.5\ \mathrm{fm}, r_{n_{\max}} = 4.5\ \mathrm{fm} & (s\bar{s}) - (s\bar{s}) \end{cases}$$

$n = 12$ for each coordinate

- Color wave function:

$$\text{color-I:} \begin{cases} \left[(s_1 s_2)_{\bar{3}} (\bar{s}_3 \bar{s}_4)_3\right]_1 \\ \left[(s_1 s_2)_6 (\bar{s}_3 \bar{s}_4)_{\bar{6}}\right]_1 \end{cases},$$

$$\text{color-II:} \begin{cases} \left[(s_1 \bar{s}_3)_1 (s_2 \bar{s}_4)_1\right]_1 \\ \left[(s_1 \bar{s}_3)_8 (s_2 \bar{s}_4)_8\right]_1 \end{cases}.$$

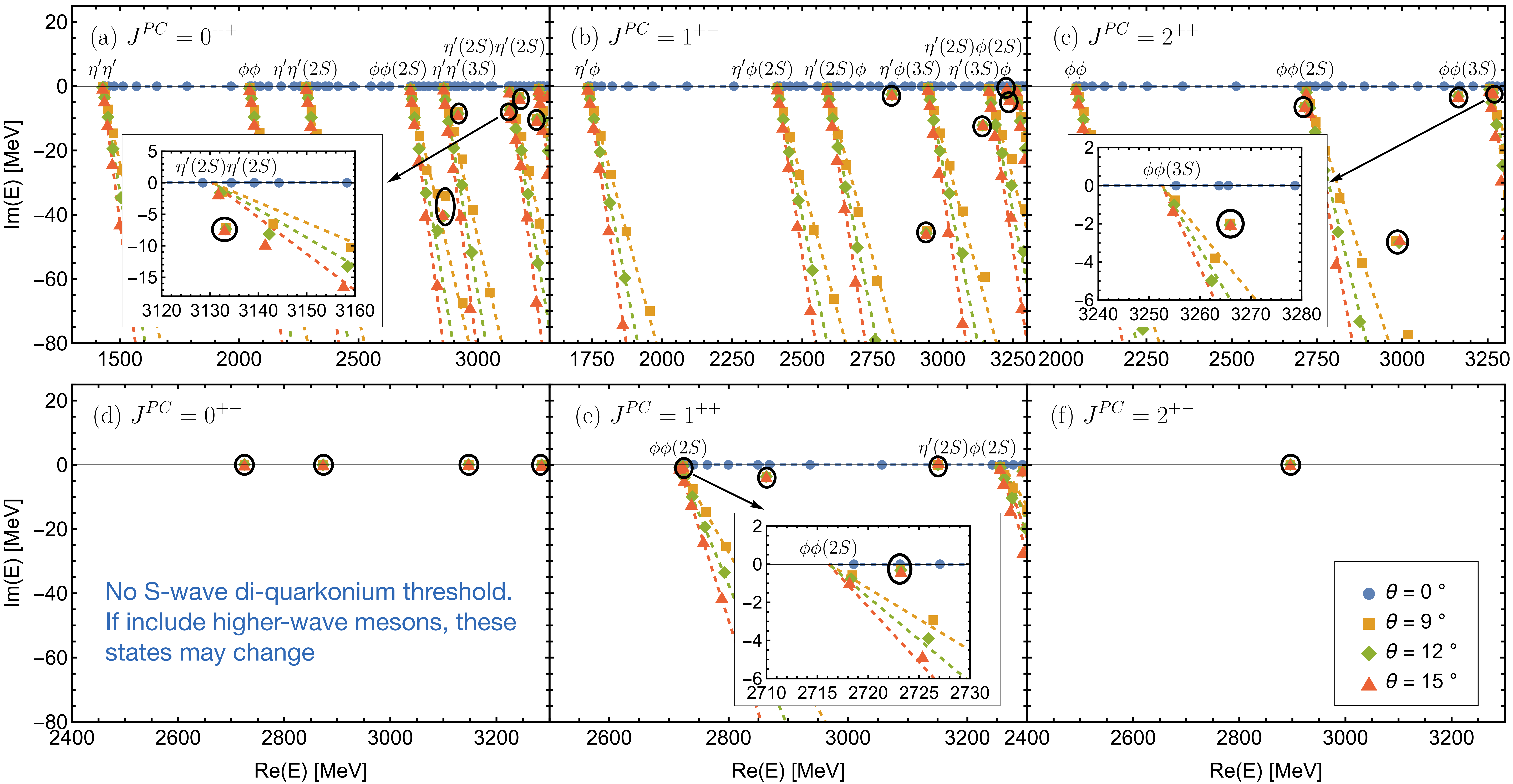
- Spin wave function:

$$S = 0: \begin{cases} \left[(s_1 s_2)_0 (\bar{s}_3 \bar{s}_4)_0\right]_0 \\ \left[(s_1 s_2)_1 (\bar{s}_3 \bar{s}_4)_1\right]_0 \end{cases},$$

$$S = 1: \begin{cases} \left[(s_1 s_2)_0 (\bar{s}_3 \bar{s}_4)_1\right]_1 \\ \left[(s_1 s_2)_1 (\bar{s}_3 \bar{s}_4)_0\right]_1 \\ \left[(s_1 s_2)_1 (\bar{s}_3 \bar{s}_4)_1\right]_1 \end{cases},$$

$$S = 2: \quad \left[(s_1 s_2)_1 (\bar{s}_3 \bar{s}_4)_1\right]_2 .$$

Numerical results



Spatial structure

rms radius→reflect spatial structure

- Conventional definition of the rms radius under CSM

$$r_{ij}^{\mathrm{rms,C}} \equiv \mathrm{Re}\left[\sqrt{\frac{\left(\Psi(\theta)\left|r_{ij}^2 e^{2i\theta}\right|\Psi(\theta)\right)}{(\Psi(\theta)\mid\Psi(\theta))}}\right]$$

c-product:

$$(\phi_n \mid \phi_m) \equiv \int \phi_n(\boldsymbol{r})\phi_m(\boldsymbol{r})\mathrm{d}^3\boldsymbol{r}$$

generally not real, real part can still reflect the clustering behavior

Fail to identify the molecular structure when containing identical quarks

a new definition →

- Newly defined rms radius

$$\begin{aligned}\Psi(\theta) = \sum_{s_1 \le s_2} \Big[& \left[(q_1\bar{q}_3')_{1_c}^{s_1}(q_2\bar{q}_4')_{1_c}^{s_2}\right]_{1_c}^{S}\phi(\boldsymbol{r}_1,\boldsymbol{r}_2,\boldsymbol{r}_3,\boldsymbol{r}_4;\theta) \\ & - \left[(q_2\bar{q}_3')_{1_c}^{s_1}(q_1\bar{q}_4')_{1_c}^{s_2}\right]_{1_c}^{S}\phi(\boldsymbol{r}_2,\boldsymbol{r}_1,\boldsymbol{r}_3,\boldsymbol{r}_4;\theta) \\ & - \left[(q_1\bar{q}_4')_{1_c}^{s_1}(q_2\bar{q}_3')_{1_c}^{s_2}\right]_{1_c}^{S}\phi(\boldsymbol{r}_1,\boldsymbol{r}_2,\boldsymbol{r}_4,\boldsymbol{r}_3;\theta) \\ & + \left[(q_2\bar{q}_4')_{1_c}^{s_1}(q_1\bar{q}_3')_{1_c}^{s_2}\right]_{1_c}^{S}\phi(\boldsymbol{r}_2,\boldsymbol{r}_1,\boldsymbol{r}_4,\boldsymbol{r}_3;\theta)\Big] \\ = & \mathcal{A}\left[\sum_{s_1 \le s_2}\left[(q_1\bar{q}_3')_{1_c}^{s_1}(q_2\bar{q}_4')_{1_c}^{s_2}\right]_{1_c}^{S}\phi(\boldsymbol{r}_1,\boldsymbol{r}_2,\boldsymbol{r}_3,\boldsymbol{r}_4;\theta)\right] \\ \equiv & \mathcal{A}\Psi_{13,24}(\theta), \end{aligned} \tag{16}$$

$$r_{ij}^{\mathrm{rms,M}} \equiv \mathrm{Re}\left[\sqrt{\frac{\left(\Psi_{13,24}(\theta)\left|r_{ij}^2 e^{2i\theta}\right|\Psi_{13,24}(\theta)\right)}{(\Psi_{13,24}(\theta)\mid\Psi_{13,24}(\theta))}}\right]$$

The impact of identical particle exchange on rms radius is removed.

Numerical results

J^{PC}	$M - i\Gamma/2$	$\chi_{\bar{3}_c\otimes 3_c}$	$\chi_{6_c\otimes\bar{6}_c}$	$\chi_{1_c\otimes 1_c}$	$\chi_{8_c\otimes 8_c}$	$r_{ij}^{\rm rms,C}$		$r_{ij}^{\rm rms,M}$				structure
						$r_{ss}^{\rm rms}$	$r_{s\bar{s}}^{\rm rms}$	$r_{s_1\bar{s}_3}^{\rm rms}$	$r_{s_2\bar{s}_4}^{\rm rms}$	$r_{s_1s_2}^{\rm rms} = r_{\bar{s}_3\bar{s}_4}^{\rm rms}$	$r_{s_1\bar{s}_4}^{\rm rms} = r_{s_2\bar{s}_3}^{\rm rms}$	
0^{++}	$2852 - 40i$	86%	14%	38%	62%	0.95	1.16	1.20	1.20	0.91	1.19	C.
	$2917 - 9i$	40%	60%	53%	47%	1.23	1.21	1.12	1.12	1.18	1.35	C.
	$3133 - 7i$	58%	42%	47%	53%	1.51	1.44	1.27	1.27	1.48	1.66	C.
	$3175 - 4i$	46%	54%	51%	49%	1.30	1.27	1.14	1.14	1.28	1.39	C.
	$3248 - 10i$	35%	65%	55%	45%	1.37	1.36	1.31	1.31	1.32	1.49	C.
1^{+-}	$2819 - 3i$	63%	37%	46%	54%	1.01	1.11	1.04	1.05	1.00	1.18	C.
	$2940 - 46i$	87%	13%	38%	62%	1.02	1.12	1.18	1.13	1.03	1.15	C.
	$3142 - 12i$	77%	23%	41%	59%	1.15	1.43	1.51	1.28	1.10	1.49	C.
	$3228 - 2i$	66%	34%	45%	55%	1.22	1.37	1.27	1.29	1.22	1.47	C.
	$3237 - 4i$	64%	36%	45%	55%	1.22	1.33	1.18	1.22	1.22	1.44	C.
2^{++}	$2714 - 6i$	75%	25%	42%	58%	1.06	1.09	1.11	1.11	0.98	1.14	C.
	$2993 - 48i$	85%	15%	38%	62%	1.00	1.03	1.14	1.14	1.03	1.03	C.
	$3164 - 3i$	92%	8%	36%	64%	0.94	1.47	1.47	1.47	0.93	1.50	C.
	$3266 - 2i$	66%	34%	45%	55%	1.29	1.38	1.22	1.22	1.28	1.50	C.

No molecular spatial characteristic.
All states are compact.

Numerical results

J^{PC}	$M - i\Gamma/2$	$\chi_{\bar{3}_c\otimes 3_c}$	$\chi_{6_c\otimes\bar{6}_c}$	$\chi_{1_c\otimes 1_c}$	$\chi_{8_c\otimes 8_c}$	$r_{ij}^{\mathrm{rms,C}}$		$r_{ij}^{\mathrm{rms,M}}$				structure
						r_{ss}^{rms}	$r_{\bar{s}\bar{s}}^{\mathrm{rms}}$	$r_{s_1\bar{s}_3}^{\mathrm{rms}}$	$r_{s_2\bar{s}_4}^{\mathrm{rms}}$	$r_{s_1s_2}^{\mathrm{rms}} = r_{\bar{s}_3\bar{s}_4}^{\mathrm{rms}}$	$r_{s_1\bar{s}_4}^{\mathrm{rms}} = r_{s_2\bar{s}_3}^{\mathrm{rms}}$	
0^{+-}	2725	33%	67%	56%	44%	1.13	0.96	0.96	0.96	1.10	0.96	C.
	2873	65%	35%	45%	55%	1.17	1.03	1.02	1.02	1.13	1.02	C.
	3148	21%	79%	60%	40%	1.44	1.20	1.20	1.20	1.41	1.20	C.
	3285	78%	22%	41%	59%	1.30	1.28	1.28	1.28	1.24	1.28	C.
1^{++}	$2723 - 0.5i$	59%	41%	47%	53%	1.14	1.09	0.90	1.03	0.99	1.13	C.
	$2863 - 4i$	99%	1%	34%	66%	1.07	1.01	1.05	0.95	1.07	1.01	C.
	$3151 - 0.1i$	66%	34%	45%	55%	1.17	1.31	1.14	1.23	1.18	1.42	C.
2^{+-}	2896	100%	0%	33%	67%	1.10	1.02	1.02	1.02	1.10	1.02	C.

Lowest S-wave state: ~2.7 GeV
The compact P-wave states are expected to be heavier.
→ $Y(2175)$ and $X(2370)$ are unlikely to be compact tetraquark states.

No molecular spatial characteristic.
All states are compact.

Three- and four-lepton systems - Preliminary results

Three- and four-lepton systems

Motivation

- Theoretical research on three-lepton resonant states is scarce. Research on four-lepton resonant states is limited to the di-positronium system Ps_2.
- If resonant states such as $\mu^+\mu^+e^-e^-$ exist, they may be detectable in future experiments.

QED Coulomb potential

$$V_{ij}(r) = \frac{Q_i Q_j}{r_{ij}}$$

Wave function construction

- No color wave function
- No coupling between spin channels.

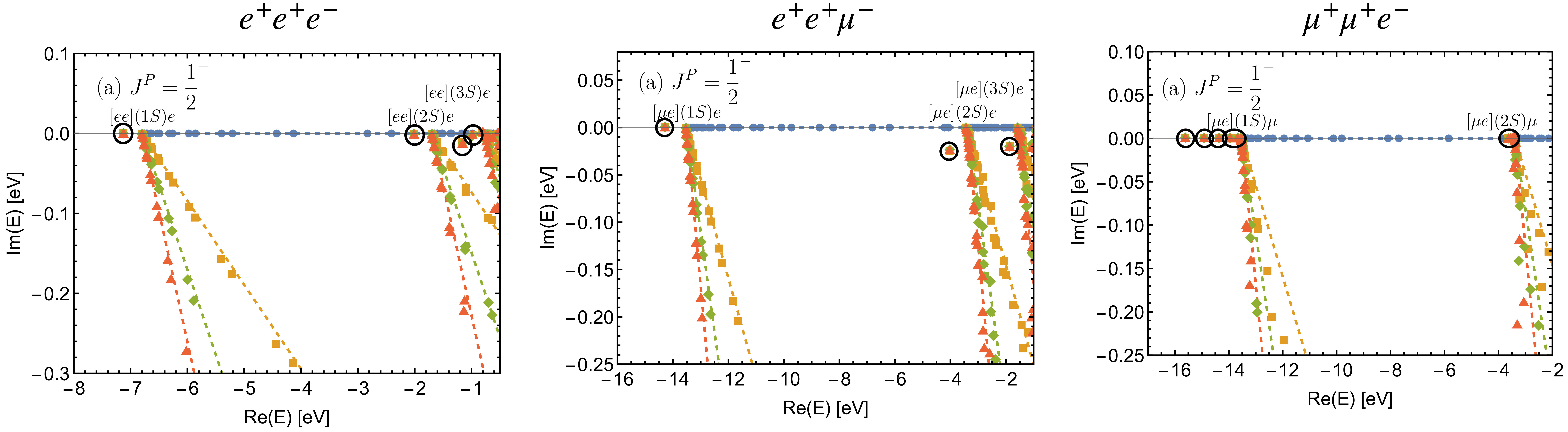
J^P	System	CSM
$0^{-+}/1^{--}$	$\mathrm{Ps}(1S)$	-6.80 eV
	$\mathrm{Ps}(2S)$	-1.70 eV
	$\mathrm{Ps}(3S)$	-0.76 eV
	$\mu^+\mu^-(1S)$	-1.41 keV
	$\mu^+\mu^-(2S)$	-0.35 keV
	$\mu^+\mu^-(3S)$	-0.16 keV
	$\mu^+e^-(1S)$	-13.6 eV
	$\mu^+e^-(2S)$	-3.4 eV
	$\mu^+e^-(3S)$	-1.5 eV

Spin and C-parity degenerate

$\Rightarrow$ threshold degenerate

Numerical results

- 3-lepton systems with bound state or resonant state solutions

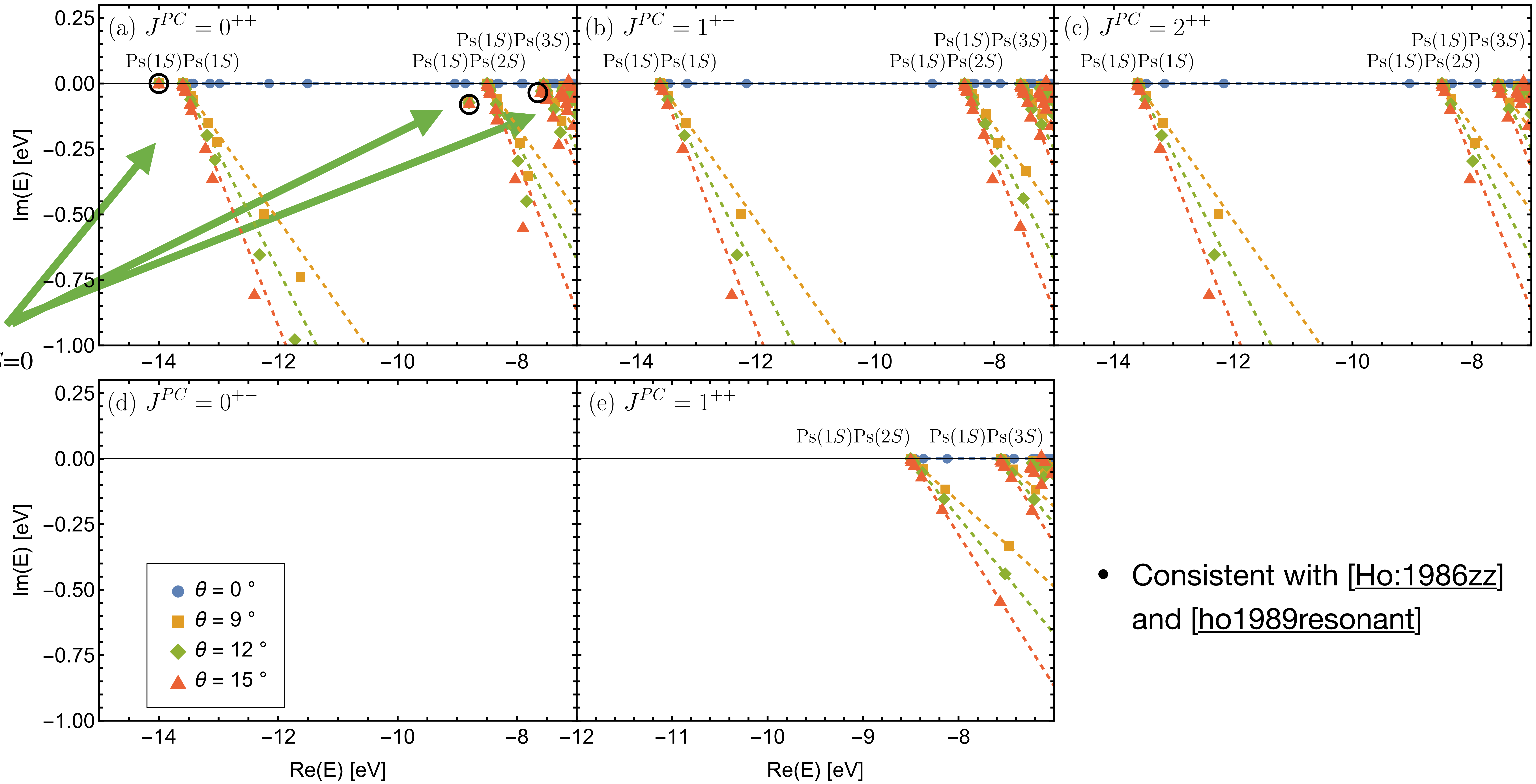


- Only the S=1/2 systems have bound and resonant states. → $[ll]_{s=0}$ component is necessary.
- Consistent with the previous calculations [Ho:1979zz] and [liverts2013three]. We obtain more states.
- No bound states or resonant states in $\mu^+\mu^-e^+$ and $e^+e^-\mu^+$ systems.

Numerical results

- 4-lepton systems with bound state or resonant state solutions

$e^+e^+e^-e^-$



$[(e^+e^+)_0(e^-e^-)_0]_{S=0}$

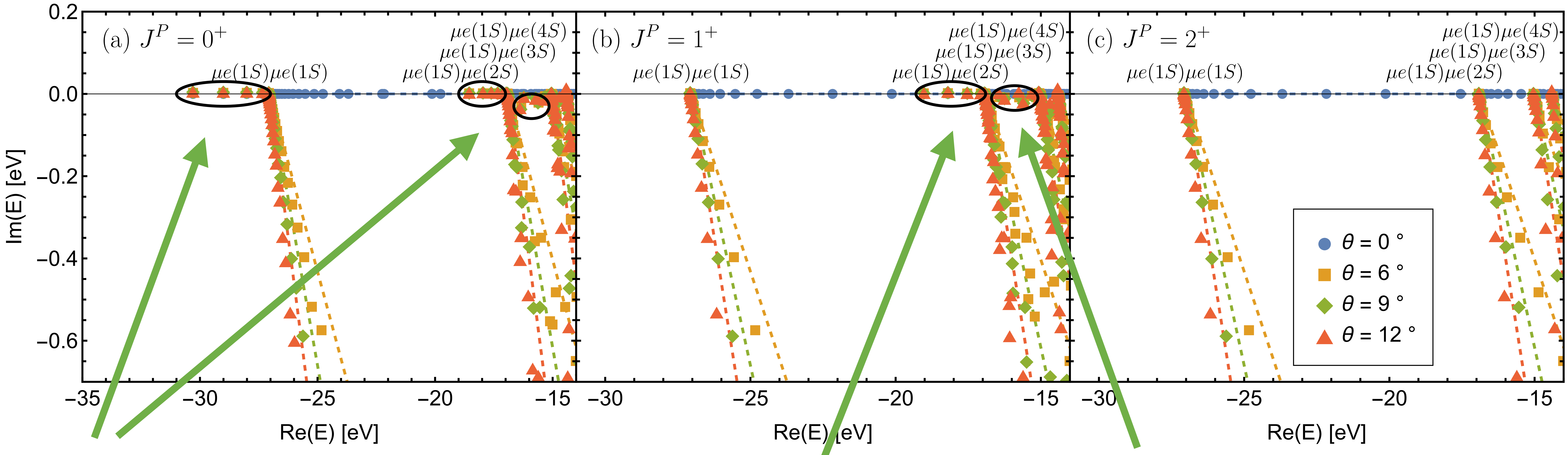
lower energy

- Consistent with [Ho:1986zz] and [ho1989resonant]

Numerical results

- 4-body systems with bound state or resonant state solutions

$\mu^+\mu^+e^-e^-$



$[(\mu^+\mu^+)_0(e^-e^-)_0]_{S=0}$

$[(\mu^+\mu^+)_0(e^-e^-)_1]_{S=1}$ or $[(\mu^+\mu^+)_1(e^-e^-)_0]_{S=1}$

$[(\mu^+\mu^+)_0(e^-e^-)_1]_{S=1}$

- S=2 system: pure $[(\mu^+\mu^+)_1(e^-e^-)_1]_{S=2}$ component, higher energy, more difficult to form bound states and resonant states.

Summary

Fully strange tetraquark system

- We calculate the mass spectrum of the S-wave fully strange tetraquark systems with $\left(J^{PC}=0^{++},1^{+-},2^{++}\right)$ and $\left(J^{PC}=0^{+-},1^{++},2^{+-}\right)$ using AL1 quark potential model and complex scaling method. We obtain a series of resonant and zero-width states in the mass region $(2.7,3.3)$ GeV, with widths ranging from less than 1 MeV to around 50 MeV.
- All these states are compact tetraquark states.
- Since the lowest S-wave state is already as high as 2.7 GeV, $Y(2175)$ and $X(2370)$ are unlikely to be compact tetraquark states.

Three- and four-lepton systems

- We obtain a series of bound and resonant states in $e^+e^+e^-$, $e^+e^+\mu^-$ and $\mu^+\mu^+e^-$ systems, and no bound or resonant states in $\mu^+\mu^-e^+$ and $e^+e^-\mu^+$ systems.
- In the three-lepton systems, only the S=1/2 systems have bound and resonant states.
- In the four-lepton systems, $e^+e^+e^-e^-$ and $\mu^+\mu^+e^-e^-$ have a series of bound and resonant states, and no bound or resonant states are found in $\mu^+\mu^-e^+e^-$ system.

Thanks for your attention!

Backup

Three- and four-lepton systems

system	$\Delta E - i\Gamma/2$
$e^+e^+e^-$	-7.12
	-2.01
	$-1.15 - 0.01i$
	-0.98
$e^+e^+\mu^-$	-14.29
	$-4.03 - 0.02i$
	$-1.86 - 0.02i$
$\mu^+\mu^+e^-$	-15.61
	-14.92
	-14.37
	-13.95
	-13.67
	-3.63
	-3.55
	-3.48

J^{PC}	$\Delta E - i\Gamma/2$	component	$r_{e^+e^+} = r_{e^-e^-}$	$r_{e^+e^-}$
0^{++}	-14.00	$[00]_0$	0.37	0.29
	$-8.80 - 0.07i$	$[00]_0$	0.63	0.56
	$-7.59 - 0.03i$	$[00]_0$	1.30	1.16

J^P	$\Delta E - i\Gamma/2$	component	$r_{\mu^+\mu^+}$	$r_{e^-e^-}$	$r_{\mu^+e^-}$
0^+	-30.30	$[00]_0$	0.08	0.14	0.10
	-29.01	$[00]_0$	0.11	0.16	0.11
	-28.01	$[00]_0$	0.13	0.18	0.13
	-27.34	$[00]_0$	0.18	0.22	0.16
	-18.55	$[00]_0$	0.12	0.41	0.29
	-17.96	$[00]_0$	0.16	0.41	0.29
	-17.61	$[00]_0$	0.21	0.41	0.30
	-17.34	$[00]_0$	0.26	0.44	0.31
	-17.12	$[00]_0$	0.32	0.48	0.34
	-16.98	$[00]_0$	0.41	0.56	0.40
	$-16.33 - 0.03i$	$[00]_0$	0.12	1.27	0.90
	$-16.22 - 0.01i$	$[00]_0$	0.15	0.91	0.65
	$-15.72 - 0.01i$	$[00]_0$	0.18	0.86	0.61
	$-15.60 - 0.02i$	$[00]_0$	0.16	1.30	0.92
	$-15.33 - 0.01i$	$[00]_0$	0.24	0.85	0.60
1^+	-18.20	$[01]_1$	0.13	0.39	0.27
	-17.53	$[01]_1$	0.16	0.41	0.29
	-17.07	$[10]_1$	0.35	0.48	0.34
	-17.04	$[01]_1$	0.16	0.66	0.47
	-17.03	$[01]_1$	0.17	0.64	0.45
	-16.95	$[10]_1$	0.46	0.58	0.41
	$-16.42 - 0.01i$	$[01]_1$	0.12	1.22	0.87
	$-16.95 - 0.01i$	$[01]_1$	0.14	0.95	0.68
	$-15.75 - 0.01i$	$[01]_1$	0.17	1.00	0.72
	$-15.58 - 0.02i$	$[01]_1$	0.17	1.18	0.84
	-15.30	$[01]_1$	0.23	0.88	0.63