# NON-$q\overline{q}$ MESONS

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The constituent quark model describes the observed meson spectrum as bound $q\overline{q}$ states grouped into SU(N) flavor multiplets (see our review on the 'Quark Model' in this issue of the *Review*). However, the self-coupling of gluons in QCD suggests that additional mesons made of bound gluons (glueballs), or $q\overline{q}$-pairs with an excited gluon (hybrids), may exist. Multiquark color singlet states such as $qq\overline{q}\overline{q}$ (tetraquarks as compact diquark-antidiquark systems and 'molecular' bound states of two mesons) or $qqq\overline{q}\overline{q}\overline{q}$ (six-quark and 'baryonium' bound states of two baryons) have also been predicted. For a more detailed discussion on exotic mesons we refer to [1,2].

In recent years experimental evidence for states beyond the quark model has accumulated in the heavy quark sector. We therefore split this mini-review into three parts discussing separately light systems, heavy–light systems and heavy–heavy systems.

## 1. Light systems

### 1.1. Glueball candidates

Among the signatures naively expected for glueballs are (i) no free space in $q\overline{q}$ nonets, (ii) enhanced production in gluon-rich channels such as central production and radiative $J/\psi(1S)$ decay, (iii) decay branching fractions incompatible with SU(N) predictions for $q\overline{q}$ states, and (iv) reduced $\gamma\gamma$ couplings. However, mixing effects with isoscalar $q\overline{q}$ mesons [3–10] and decay form factors [11] obscure these simple signatures.

Lattice calculations, QCD sum rules, flux tube, and constituent glue models agree that the lightest glueballs have quantum numbers $J^{PC} = 0^{++}$ and $2^{++}$. Lattice calculations predict for the ground state (a $0^{++}$ glueball) a mass around 1600 – 1700 MeV [8,12–14]) with an uncertainty of about 100 MeV, while the first excited state ($2^{++}$) has a mass of about 2300 MeV. Hence, the low-mass glueballs lie in the same mass region as ordinary isoscalar $q\overline{q}$ states, in the mass range of the

$1^3P_0(0^{++})$, $2^3P_2(2^{++}), 3^3P_2(2^{++})$, and $1^3F_2(2^{++})$ $q\overline{q}$ states. The $0^{-+}$ state and exotic glueballs (with non-$q\overline{q}$ quantum numbers such as $0^{--}$, $0^{+-}$, $1^{-+}$, $2^{+-}$, *etc.*) are expected above 2 GeV [14]. The lattice calculations were performed so far in the quenched approximation. Thus neither quark loops nor mixing with conventional mesons were included, although quenching effects seem to be small [15]. For a recent comparison between quenched and unquenched lattice studies see [16].

However, one expects that glueballs will mix with nearby $q\overline{q}$ states of the same quantum numbers. The presence of a glueball mixed with $q\overline{q}$ would lead to a supernumerary isoscalar state in the SU(3) classification of $q\overline{q}$ mesons. A lattice study in full QCD (performed at unphysical quark masses corresponding to a pion mass of 400 MeV) did not identify any state with sizable overlap with pure gluonic sources [17].

In the following we focus on glueball candidates in the scalar sector. For the $2^{++}$ sector we refer to the section on non-$q\bar{q}$ mesons in the 2006 issue of this *Review* [18], and for the $0^{-+}$ glueball to the note on 'The Pseudoscalar and Pseudovector Mesons in the 1400 MeV Region' in the *Meson Listings*.

Five isoscalar resonances are well established: the very broad $f_0(500)$ (or $\sigma$), the $f_0(980)$, the broad $f_0(1370)$, and the comparatively narrow $f_0(1500)$ and $f_0(1710)$, see the note on 'Scalar Mesons below 2 GeV' in the *Meson Listings*, and also [19]. The $f_0(1370)$ and $f_0(1500)$ decay mostly into pions ($2\pi$ and $4\pi$) while the $f_0(1710)$ decays mainly into $K\overline{K}$ final states. Naively, this suggests an $n\bar{n}$ ($= u\bar{u} + d\bar{d}$) structure for the $f_0(1370)$ and $f_0(1500)$, and $s\bar{s}$ for the $f_0(1710)$. The latter is not observed in $p\overline{p}$ annihilation [20], as expected from the OZI suppression for an $s\overline{s}$ state.

In $\gamma\gamma$ collisions leading to $K_SK_S$ [21] and $K^+K^-$ [22] a spin-0 signal is observed at the $f_0(1710)$ mass (together with a dominant spin-2 component), while the $f_0(1500)$ is not observed in $\gamma\gamma \to K\bar{K}$ nor $\pi^+\pi^-$ [23]. The $f_0(1500)$ is also not observed by Belle in $\gamma\gamma \to \pi^0\pi^0$, although a shoulder is seen which could also be due to the $f_0(1370)$ [24]. The absence of a signal in the $\pi\pi$ channel in $\gamma\gamma$ collisions does not favor an $\overline{n}n$ interpretation for the $f_0(1500)$. The upper limit from $\pi^+\pi^-$ excludes a large

$n\overline{n}$ content, and hence points to a mainly $s\overline{s}$ content [25]. This is in contradiction with the small $K\overline{K}$ decay branching ratio of the $f_0(1500)$ [26–28]. Hence, the $f_0(1500)$ is hard to accommodate as a $q\bar{q}$ state. This state could be mainly glue due its absence of $2\gamma$-coupling, while the $f_0(1710)$ coupling to $2\gamma$ would be compatible with an $s\bar{s}$ state. Indeed, Belle finds that in $\gamma\gamma \to K_S K_S$ collisions the 1500 MeV region is dominated by the $f'_2(1525)$. The $f_0(1710)$ is also observed but its production $\times$ decay rate is too large for a glueball [29]. However, the $2\gamma$-couplings are sensitive to glue mixing with $q\bar{q}$ [30].

Since the $f_0(1370)$ does not couple strongly to $s\overline{s}$ [28], the $f_0(1370)$ or $f_0(1500)$ appear to be supernumerary. The narrow width of the $f_0(1500)$, and its enhanced production at low transverse momentum transfer in central collisions [31–33] also favor the $f_0(1500)$ to be non-$q\overline{q}$. In [3] the ground state scalar nonet is made of the $a_0(1450)$, $f_0(1370)$, $K_0^*(1430)$, and $f_0(1710)$. The isoscalars $f_0(1370)$ and $f_0(1710)$ contain a small fraction of glue, while the $f_0(1500)$ is mostly gluonic. The light scalars $f_0(500)$, $f_0(980)$, $a_0(980)$, and $\kappa(800)$ are four-quark states or two-meson resonances (see [1] for a review). In the mixing scheme of [30], which uses central production data from WA102 and the recent hadronic $J/\psi$ decay data from BES [34,35], glue is shared between the $f_0(1370)$, $f_0(1500)$ and $f_0(1710)$. The $f_0(1370)$ is mainly $n\bar{n}$, the $f_0(1500)$ mainly glue and the $f_0(1710)$ dominantly $s\bar{s}$. This agrees with previous analyses [3,9], but, as already pointed out, alternative schemes have been proposed, see, e.g. [8,36]. In particular, for a scalar glueball the two-gluon coupling to $n\bar{n}$ appears to be suppressed by chiral symmetry [37] and therefore $K\bar{K}$ decay could be enhanced. It was argued that chiral symmetry constraints in a multichannel analysis imply that the $f_0(1710)$ is an unmixed scalar glueball [38], a view that is challenged [39].

The contribution of $f_0(1500)$ production in (the supposedly gluon rich) radiative $J/\psi$ decay is not well known. The $f_0(1500)$ is observed by BESII in $J/\psi \to \gamma\pi\pi$ [40] and by BESIII in $J/\psi \to \gamma\eta\eta$ [41] with a much smaller rate than for the $f_0(1710)$, which speaks against a glueball interpretation for the former. However, the mass found by BES is significantly lower than the expected value. The overlap with the $f_0(1370)$ and $f_2'(1525)$ and the statistically limited data sample prevent a proper $K$-matrix analysis to be performed. Hence more data are needed in radiative $J/\psi$ decay and in $\gamma\gamma$ collisions to clarify the spectrum of scalar mesons.

The Dalitz plots of $B^{\pm} \to \pi^{\pm}\pi^{\pm}\pi^{\mp}$ have been studied by BaBar [42]. A broad $2\pi$ signal is observed around 1400 MeV which is attributed to the $f_0(1370)$, but could also be due to the $f_0(1500)$. In $B^{\pm} \to K^{\pm}K^{\pm}K^{\mp}$ both BaBar [43] and Belle [44] observe a strong spin-0 activity in $K\bar{K}$ around 1550 MeV. $B^0$ decay into $J/\psi X$ filters out the $d\bar{d}$ content of $X$ while $B_s^0$ decay selects its $s\bar{s}$ component. $B$ decay into $J/\psi X$ may therefore be the ideal environment to determine the flavor content of neutral mesons [45], or to distinguish $q\bar{q}$ from tetraquark states [46]. LHCb has analyzed $\overline{B}^0$ decay into $J/\psi\,\pi^+\pi^-$ [47]. The fit to the $\pi\pi$ mass spectrum above $\sim$1.2 GeV does not show any significant scalar component. However, the data analysis has been challenged [48]. For $\overline{B}_s^0 \to J/\psi\,\pi^+\pi^-$ a scalar contribution from the $f_0(1370)$ [49] or the $f_0(1500)$ [50] is required in the 1400–1500 MeV region.

### 1.2. Tetraquark candidates and molecular bound states

The $a_0(980)$ and $f_0(980)$ could be tetraquark states [51–53] or $K\overline{K}$ molecular states [54–56] due to their strong affinity for $K\overline{K}$, in spite of their masses being very close to threshold. For $q\bar{q}$ states, the expected $\gamma\gamma$ widths [57,58] are not significantly larger than for molecular states [57,59], both predictions being consistent with data. Radiative decays of the $\phi(1020)$ into $a_0(980)$ and $f_0(980)$ were claimed to enable disentangling compact from molecular structures. Interpreting the data from DAPHNE [60,61] and VEPP - 2M [62,63] along the lines of [64,65] seems to favor these mesons to be tetraquark states. In [66] they are made of a four-quark core and a virtual $K\bar{K}$ cloud at the periphery. This is challenged in [67] showing that $\phi$ radiative decay data are consistent with a molecular structure of the light scalars. The $f_0(980)$ is strongly produced in $D_s^+$ decay [68]. This points to a large $s\bar{s}$ component, assuming Cabibbo favored $c \to s$ decay. However, the mainly $n\bar{n}$ $f_0(1370)$ is also strongly produced in $D_s^+$ decay, indicating that other graphs must contribute [69]. On the other hand, the contributions from the $f_0(500)$ and $f_0(980)$ in the decay $\overline{B}^0 \to J/\psi\,\pi^+\pi^-$ seem to exclude a tetraquark structure for these states [47], while the corresponding ones in $\overline{B}_s^0 \to J/\psi\,\pi^+\pi^-$ are compatible with tetraquarks [50].

COMPASS reports a new $1^{++}$ isovector meson at 1414 MeV, decaying into $f_0(980)\pi$ [70]. The resonance is observed in diffractive dissociation $\pi^- p \to \pi^-(\pi^+\pi^-)p$. Traditionally, the $1^{++}$ ground state nonet is believed to contain the $a_1(1260)$, $f_1(1285)$ and $f_1(1420)$ (see the mini-review on 'The Pseudoscalar and Pseudovector Mesons in the 1400 MeV Region' in the *Meson Listings*). However, a molecular $K\overline{K}\pi$ structure has been proposed for the $f_1(1420)$ [71] in view of the proximity of the $K^*\overline{K}$ threshold. The new $a_1(1414)$ could then also be a molecular state, the isovector partner of the $f_1(1420)$.

## 1.3. Baryonia

Bound states of two nucleons have been predicted, but have remained elusive. The $f_2(1565)$ which is only observed in $\overline{p}p$ annihilation [72,73] is a good candidate for a $2^{++}$ $\bar{p}p$ bound state. Enhancements in the $\bar{p}p$ mass spectrum have also been reported below $\bar{p}p$ threshold, in $J/\psi \to \gamma\bar{p}p$ [74–76] and in $B^+ \to K^+\bar{p}p$, $B^0 \to K_S^0\bar{p}p$ [77,78] and $\bar{B}^0 \to D^0\bar{p}p$ [79]. This enhancement could be due to a $0^{-+}$ baryonium [80] but other explanations have been proposed, such as the dynamics of the fragmentation mechanism [78] or the attractive $^1S_0$ $(\bar{p}p)$ wave [81–83].

The pronounced signal observed in $e^+e^- \to \Lambda_c^+\Lambda_c^-$ around $\sqrt{s} = 4.63$ GeV by Belle [84] was argued to be a strong evidence in favor of an interpretation of $Y(4660)$ as charmed baryonium [85]. However, this picture was challenged in [86].

## 1.4. Hybrid mesons

Hybrids may be viewed as $q\bar{q}$ mesons with a vibrating gluon flux tube. In contrast to glueballs, they can have isospin 0 or 1. The mass spectrum of hybrids with exotic (non-$q\bar{q}$) quantum numbers was predicted in [87], while [88] also deals with non-exotic quantum numbers. The ground state hybrids with quantum numbers ($0^{-+}$, $1^{-+}$, $1^{--}$, and $2^{-+}$) are expected around 1.7 to 1.9 GeV. Lattice calculations predict that the hybrid with exotic quantum numbers $1^{-+}$ lies at a mass of 1.9 $\pm$ 0.2 GeV [89,90]. Most hybrids are expected to be rather broad, but some can be as narrow as 100 MeV [91]. They prefer to decay into a pair of $S$- and $P$-wave mesons. The lattice study in [17], based on full QCD with pion masses around 400 MeV, finds that several of the high–lying states observed in their spectrum show significant overlap with gluon rich source terms.

A $J^{PC} = 1^{-+}$ exotic meson, $\pi_1(1400)$, was reported in $\pi^- p \to \eta\pi^- p$ [92,93] and in $\pi^- p \to \eta\pi^0 n$ [94]. It was observed as an interference between the angular momentum $L = 1$ and $L = 2$ $\eta\pi$ amplitudes, leading to a forward/backward asymmetry in the $\eta\pi$ angular distribution. This state has been reported earlier in $\pi^- p$ reactions [95], but ambiguous solutions in the partial wave analysis were pointed out in [96,97]. A resonating $1^{-+}$ contribution to the $\eta\pi$ $P$-wave is also required in the Dalitz plot analysis of $\bar{p}n$ annihilation into $\pi^-\pi^0\eta$ [98], and in $\bar{p}p$ annihilation into $\pi^0\pi^0\eta$ [99]. Mass and width are consistent with the results of Ref. [92].

Another $1^{-+}$ state, $\pi_1(1600)$, decaying into $\rho\pi$, was reported by COMPASS with 190 GeV pions hitting a lead target [100]. It was observed earlier in $\pi^- p$ interactions in the decay modes $\eta'\pi$ [101], $f_1(1285)\pi$ [102], and $\omega\pi\pi$ [103], $b_1(1235)\pi$, but not $\eta\pi$ [104]. A strong enhancement in the $1^{-+}$ $\eta'\pi$ wave, compared to $\eta\pi$, was reported at this mass in [105]. Ref. [106] suggests that a Deck-generated $\eta\pi$ background from final state rescattering in $\pi_1(1600)$ decay could mimic $\pi_1(1400)$. However, this mechanism is absent in $\bar{p}p$ annihilation. The $\eta\pi\pi$ data require $\pi_1(1400)$ and cannot accommodate a state at 1600 MeV

[107]. Finally, evidence for a $\pi_1(2015)$ has also been reported [102,103].

The flux tube model and the lattice concur to predict a hybrid mass of about 1.9 GeV while the $\pi_1(1400)$ and $\pi_1(1600)$ are lighter. As isovectors, $\pi_1(1400)$ and $\pi_1(1600)$ cannot be glueballs. The coupling to $\eta\pi$ of the former points to a four-quark state [108], while the strong $\eta'\pi$ coupling of the latter is favored for hybrid states [109,110]. The mass of $\pi_1(1600)$ is also not far below the lattice prediction.

Hybrid candidates with $J^{PC} = 0^{-+}$, $1^{--}$, and $2^{-+}$ have also been reported. The $\pi(1800)$ decays mostly to a pair of $S$- and $P$-wave mesons [100,111], in line with expectations for $0^{-+}$ hybrid mesons. This meson is also somewhat narrow if interpreted as the second radial excitation of the pion. The evidence for $1^{--}$ hybrids required in $e^+e^-$ annihilation and in $\tau$ decays has been discussed in Ref. [112]. A candidate for the $2^{-+}$ hybrid, the $\eta_2(1870)$, was reported in $\gamma\gamma$ interactions [113], in $\overline{p}p$ annihilation [114], and in central production [115]. The near degeneracy of $\eta_2(1645)$ and $\pi_2(1670)$ suggests ideal mixing in the $2^{-+}$ $q\overline{q}$ nonet, and hence, the second isoscalar should be mainly $s\overline{s}$. However, $\eta_2(1870)$ decays mainly to $a_2(1320)\pi$ and $f_2(1270)\pi$ [114], with a relative rate compatible with a hybrid state [88].

## 2. Heavy-light systems

Two very narrow states, $D_{s0}^*(2317)^\pm$ and $D_{s1}(2460)^\pm$, were observed at B factories [116,117]. They lie far below the predicted masses for the two expected broad $P$-wave $c\overline{s}$ mesons. These states have hence been interpreted as four-quark states [118–120] or $DK$ ($DK^*$) molecules [121–123]. However, strong cusp effects, due to the nearby $DK$ ($DK^*$) thresholds, could shift their masses downwards and quench the observed widths, an effect similar to that occurring for the $a_0(980)$ and $f_0(980)$ mesons, which lie just below $K\overline{K}$ threshold. A hadronic width of typically 100 keV would be the unequivocal signature for the molecular nature of $D_{s0}^*(2317)^\pm$ [123,124]. Its measured width is currently less than 3.8 MeV.

## 3. Heavy-heavy systems

A search for multiquark states containing a $c$ (or a $b$) quark is promising since the charmonium spectrum can be predicted accurately, and because those mesons lying below the $D\bar{D}$ or $D\bar{D}^*$ thresholds should be narrow. Several states have been observed recently in the charmonium region. With the discovery of the $X(3872)$ in $B^\pm \to K^\pm X$ ($X \to J/\psi\,\pi^+\pi^-$) by Belle [126], soon confirmed by BaBar [127], many searches for states beyond the standard quark model were initiated both in the charm and in the bottom sectors. In the decay $\Lambda_b^0 \to J/\psi\,K^- p$ the LHCb collaboration has recently reported the observation of two new baryons decaying into $J/\psi\,p$, which are candidates for heavy pentaquark states [128]. For an updated collection of the currently available experimental information on multiquark states we refer to the mini-review on 'Heavy Quarkonium Spectroscopy' in the *Meson Listings.*

When restricting ourselves to confirmed states we are faced with eight states that do not seem to fit into the standard quark model. This is clear for the four established charged states ($Z_c(3900)^\pm$ and $Z_c(4430)^\pm$ in the charmonium sector, and $Z_b(10610)^\pm$ and $Z_b(10650)^\pm$ in the bottomonium sector). The neutral ones ($X(3872)$, $Y(4260)$, $Y(4360)$, $Y(4660)$) also challenge the standard quark model since their masses and decay properties are in conflict with expectations.

The quantum numbers of the $X(3872)$ have been determined by LHCb to be $J^{PC} = 1^{++}$, first by assuming the angular momentum zero between the $J/\psi$ and the dipion [129] and then by relaxing this constraint [130]. The $X(3872)$ can hardly be identified with the $2^3P_1$ $\chi'_{c1}$ since the latter is predicted to lie about 100 MeV higher in mass [131]. Instead, the $X(3940)$ reported by Belle in $e^+e^- \to J/\psi X$, decaying into $D^*\bar{D}$ but not into $D\bar{D}$ [132], and also observed in $B \to K(X \to \omega J/\psi)$ [133] could be the $\chi'_{c1}$. The $2^3P_2$ tensor partner ($\chi'_{c2}$) was reported by Belle at 3931 MeV in $\gamma\gamma$ interactions [134].

The $X(3872)$ lies close to the $D^0\bar{D}^{*0}$ threshold and therefore the most natural explanation for this state is a $1^{++}$ $D\bar{D}^*$ molecule [135] for which strong isospin breaking is predicted [135,136] due to the nearby $D^+D^{*-}$ threshold. Indeed, the comparable rates for $\omega J/\psi$ and $\rho^0 J/\psi$ are consistent with an interpretation of $X(3872)$ as an isoscalar $D\bar{D}^*$ molecule when the different widths of the $\rho$ and $\omega$ are taken into account [137]. A four-quark state $cq\bar{c}\bar{q}'$ is also possible [120] but unlikely, since the charged partner of the $X(3872)$ has not been observed (e.g. in $B^- \to \bar{K}^0 X^-$ nor in $B^0 \to K^+ X^-$, where $X^- \to J/\psi\,\pi^-\pi^0$ [138]) . The claim that $X(3872)$ must be a compact (tetraquark) state, since it is also produced at very high $p_T$ in $\bar{p}p$ collisions [139], was challenged in [140] which stresses the importance of rescattering, see also Ref. [141].

A broad structure, $Y(4260)$, decaying into $J/\psi\,\pi^+\pi^-$ was reported by BaBar in initial state radiation $e^+e^- \to \gamma(e^+e^- \to Y(4260))$ [142]. A charmonium state with the quantum numbers $1^{--}$ is not expected in this mass region. In addition, a charmonium at this mass should have a significant coupling to $\bar{D}D$, a decay channel that is not observed for the $Y(4260)$. This state could be a hybrid charmonium with a spin-1 $\bar{c}c$ core [143,144]. However, provided that the observation of $Y(4260)$ decay into $h_c(1P)\pi\pi$ by BESIII [145] is confirmed, the hybrid hypothesis would be under pressure, since the spin of the heavy quarks (coupled to zero in the $h_c(1P)$) should be conserved in leading order in the expansion in $(\Lambda_{\rm QCD}/m_c)$. (The individual conservation of the heavy quark spin and the total angular momentum of the light quark cloud is a consequence of the heavy quark spin symmetry, see the review on 'Heavy-Quark and Soft-Collinear Effective Theory' in this issue of the *Review*.)

The same criticism applies to the hadrocharmonium interpretation of the $Y(4260)$ which describes this state as spin-1 quarkonium surrounded by a light quark cloud [146]. To circumvent the spin symmetry argument Ref. [147] argues that $Y(4260)$ and $Y(4360)$ could be mixtures of two hadrocharmonia with spin–triplet and spin–singlet heavy quark pairs. The same kind of mixing could also operate for a hybrid.

A dominant $D_1\bar{D}$ component in the $Y(4260)$ [148] would explain naturally why $Z_c(3900)^\pm$ (interpreted by the authors as a $\bar{D}D^*$ bound state) is seen in $Y(4260) \to \pi^\mp Z_c(3900)^\pm$. A prominent $D_1\bar{D}$ component in the $Y(4260)$ would in addition explain the copious production of $X(3872)$ in $Y(4260)$ radiative decays [149]. The $Y(4360)$ as $D_1\bar{D}^*$ bound state could be the spin partner of the $Y(4260)$ [150,151], but a detailed microscopic calculation is still lacking.

The tetraquark picture explains the observed $Y$ states and, when including a tailor-made spin-spin interaction, is also capable to describe both $Z_c(3900)^{\pm,0}$ and $Z_c(4020)^{\pm}$ [152], and even the recently confirmed $Z(4430)^{\pm}$ by Belle [153]. However, the model predicts many additional charged and neutral states which have not yet been discovered.

The charged states $Z_c(3900)^{\pm}$, first observed by BESIII [154] and the to be confirmed $Z_c(4020)^{\pm}$ [155] decay predominantly into $\bar{D}D^*$ and $\bar{D}^*D^*$, respectively, while $Z_b(10610)^{\pm,0}$ and $Z_b(10650)^{\pm}$ [156,157] decay predominantly into $\bar{B}B^*$ and $\bar{B}^*B^*$, respectively, although all of them were discovered in the decay mode heavy quarkonium and pion. This suggests that the states are close relatives and their interactions are connected via heavy quark flavor symmetry. A molecular interpretation for the bottomonium states was proposed shortly after the discovery of the $Z_b^{\pm}$ states [158] and also shortly after that of the $Z_c(3900)^{\pm}$ [148]. However, their properties also appear to be consistent with tetraquark structures [159].

The heaviest confirmed charged state in the charmonium sector is the $Z(4430)^{\pm}$ observed by Belle [153]. It is interpreted as hadrocharmonium [146], $\bar{D}_1D^*$ molecule [160] as well as tetraquark state [152]. Alternatively, in [161] the $Z(4430)^{\pm}$ can be explained as a cross-channel effect.

It should be stressed that the various scenarios, while describing the data, also make decisive predictions, e.g. for other decay channels. The forthcoming data on heavy meson spectroscopy from various facilities should soon provide a much deeper understanding on how QCD forms matter out of quarks and gluons.

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