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Abstract. The Belle experiment at the KEKB asymmetric-energy e^+e^- collider has proven to be an excellent environment for studies in hadron spectroscopy. These studies have led to discoveries of many meson candidates that behave like charmonium states, but due to some of their properties cannot be explained as pure conventional $c\bar{c}$ mesons within the classical quark model. Similar exotic states have been observed also in the $s\bar{s}$ and $b\bar{b}$ systems. In this report, recent Belle results on these newly observed states are reviewed.

1 Introduction

The Belle detector[1] at the asymmetric-energy e^+e^- collider KEKB[2] has accumulated about 1 ab^{-1} of data by the end of its operation in June 2010. The KEKB collider, called a *B-factory*, operated near the $\Upsilon(4S)$ resonance with a peak luminosity that exceeded 2.1×10^{34} $\text{cm}^{-2}\text{s}^{-1}$. Large amount of collected experimental data and excellent detector performance enabled searches for new hadronic states as well as studies of their properties. Many interesting spectroscopic results have indeed been obtained at the Belle experiment, and this report covers most recent and interesting ones.

There has been a renewed interest in charmonium spectroscopy since 2002. The attention to this field was drawn by the discovery of the two missing $c\bar{c}$ states below the open-charm threshold, $\eta_c(2S)$ and $h_c(1P)$,[3,4] but even more by observations of a number of new particles [5,6] above the threshold for the open-charm production. Newly observed states – collectively called XYZ– resemble charmonia, but differ from regular $c\bar{c}$ states by some of their properties, or can simply not be identified as charmonia due to lack of available $c\bar{c}$ potential model assignments (see for example Ref. [7]). As a consequence of these properties, XYZ states – although probably containing a $c\bar{c}$ quark pair – could be explained as more complex, exotic type of particles. These include: tightly bound four-quark states called *tetraquarks*; two loosely bound charm mesons forming the so-called *molecular states*; *charmonium hybrids* interpreted as $c\bar{c}$-gluon states with excited gluonic degrees of freedom; or *hadro-charmonium* states, where the traditional charmonium states like J/ψ or η_c are "submerged" in a light hadronic matter. On the other hand, there also exist some alternative models, which try to explain experimental results simply by effects of various open charm thresholds

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on the conventional charmonium levels. All these different ideas have been extensively explored in numerous theoretical papers, published recently; the list of these papers is far too long to be quoted in this review. However, it is important to know that many aspects of these spectroscopic questions were also subject of several studies presented by participants of the Bled 2010 workshop [8].

In this review we will present results from some recent Belle analyses of new charmoniun(-like) XYZ states. We will also mention some results, suggesting the existence of similar exotic states in the $s\overline{s}$ and $b\overline{b}$ systems.

2 Charmonium and Charmonium-like States

Experimentaly, many different measurements in charmonium spectroscopy can be performed at a B-factory, since charmonium(-like) particles are produced there by various different mechanisms: via B decays; in e^+e^- annihilation into double $c\overline{c}$; C-even states can be formed in $\gamma\gamma$ processes; and $J^{PC} = 1^{--}$ resonances can be created in e^+e^- annihilation after the photon radiative return.

2.1 The $X(3872)$ news

The story about new charmonium-like states began in 2003, when Belle reported on $B^+ \to K^+J/\psi\pi^+\pi^-$ analysis,[1] where a new state decaying to $J/\psi\pi^+\pi^-$ was discovered [9]. The new state, called $X(3872)$, was soon confirmed and also intensively studied by the CDF, DØ and *BABAR* collaborations [10–18]. So far it has been established that this narrow state ($\Gamma = (3.0^{+1.9}_{-1.4} \pm 0.9)$ MeV) has a mass of (3872.2 ± 0.8) MeV/c^2, which is very close to the $D^0\overline{D}^{*0}$ threshold [19]. The intensive studies of several $X(3872)$ production and decay modes suggest two possible J^{PC} assignments, 1^{++} and 2^{-+}, and establish the $X(3872)$ as a candidate for a loosely bound $D^0\overline{D}^{*0}$ molecular state. However, results provide substantial evidence that the $X(3872)$ state must contain a significant $c\overline{c}$ component as well.

Just very recently, Belle performed a study of $B \to (c\overline{c}\gamma)K$ using 712 fb^{-1} data sample collected at the $\Upsilon(4S)$ resonance [20]. Pure $D^0\overline{D}^{*0}$ molecular model [21] predicts $\mathcal{B}(X(3872) \to \psi'\gamma)$ to be less than $\mathcal{B}(X(3872) \to J/\psi\gamma)$. Results by the *BABAR* collaboration [18] show that $\mathcal{B}(X(3872) \to \psi'\gamma)$ is almost three times that of $\mathcal{B}(X(3872) \to J/\psi\gamma)$, which is inconsistent with the pure molecular model, and can be interpreted as a large $c\overline{c} - D^0\overline{D}^{*0}$ admixture. We observe $X(3872) \to J/\psi\gamma$ together with an evidence for $\chi_{c2} \to J/\psi\gamma$ in $B^\pm \to J/\psi K^\pm$, while in our search for $X(3872) \to \psi'\gamma$ no significant signal is found (see Table 2). We also observe $B \to \chi_{c1}K$ in both, charged as well as neutral B decays.

The obtained results suggest that the $c\overline{c}$-$D^0\overline{D}^{*0}$ admixture in $X(3872)$ may not be as large as discussed above. This might get us one step closer to resolving the nature of the $X(3872)$ state even without a much larger data sample.

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[1] In this review, the inclusion of charge-conjugated states is always implied.

Table 1. Summary of newly observed states adapted from Ref. [6]. The naming convention for these new XYZ states indicates the lack of knowledge about their structure and properties at the time of discovery.

State	M [MeV]	Γ [MeV]	J^{PC}	Decay Modes	Production Modes	Observed by
$Y_s(2175)$	2175 ± 8	58 ± 26	1^{--}	$\phi f_0(980)$	e^+e^- (ISR), $J/\psi \to \eta Y_s(2175)$	*BABAR*, BESII, Belle
$X(3872)$	3871.4 ± 0.6	$3.0^{+2.1}_{-1.7}$	1^{++} or 2^{-+}	$\pi^+\pi^- J/\psi$, $\gamma J/\psi$, $D\bar{D}^*$	$B \to KX(3872)$, $p\bar{p}$	Belle, CDF, DØ, *BABAR*
$X(3915)$	3914 ± 4	28^{+12}_{-14}	$0/2^{++}$	$\omega J/\psi$	$\gamma\gamma \to X(3915)$	Belle
$Z(3930)$	3929 ± 5	29 ± 10	2^{++}	$D\bar{D}$	$\gamma\gamma \to Z(3940)$	Belle
$X(3940)$	3942 ± 9	37 ± 17	$0^{?+}$	$D\bar{D}^*$ (not $D\bar{D}$, $\omega J/\psi$)	$e^+e^- \to J/\psi X(3940)$	Belle
$Y(3940)$	3943 ± 17	87 ± 34	$?^{?+}$	$\omega J/\psi$ (not $D\bar{D}^*$)	$B \to KY(3940)$	Belle, *BABAR*
$Y(4008)$	4008^{+82}_{-49}	226^{+97}_{-80}	1^{--}	$\pi^+\pi^- J/\psi$	e^+e^-(ISR)	Belle
$Y(4140)$	4143.0 ± 3.1	$11.7^{+9.1}_{-6.2}$	$?^{?+}$	$\phi J/\psi$	$B^\pm \to K^\pm Y(4140)$	CDF
$X(4160)$	4156 ± 29	139^{+113}_{-65}	$0^{?+}$	$D^*\bar{D}^*$ (not $D\bar{D}$)	$e^+e^- \to J/\psi X(4160)$	Belle
$Y(4260)$	4264 ± 12	83 ± 22	1^{--}	$\pi^+\pi^- J/\psi$	e^+e^-(ISR)	*BABAR*, CLEO, Belle
$Y(4350)$	4361 ± 13	74 ± 18	1^{--}	$\pi^+\pi^-\psi'$	e^+e^-(ISR)	*BABAR*, Belle
$X(4630)$	4634^{+9}_{-11}	92^{+41}_{-32}	1^{--}	$\Lambda_c^+\Lambda_c^-$	e^+e^-(ISR)	Belle
$Y(4660)$	4664 ± 12	48 ± 15	1^{--}	$\pi^+\pi^-\psi'$	e^+e^-(ISR)	Belle
$Z_1^\pm(4050)$	4051^{+24}_{-23}	82^{+51}_{-29}	?	$\pi^\pm\chi_{c1}$	$B \to KZ_1^\pm(4050)$	Belle
$Z_2^\pm(4250)$	4248^{+185}_{-45}	177^{+320}_{-72}	?	$\pi^\pm\chi_{c1}$	$B \to KZ_2^\pm(4250)$	Belle
$Z^\pm(4430)$	4433 ± 5	45^{+35}_{-18}	?	$\pi^\pm\psi'$	$B \to KZ^\pm(4430)$	Belle
$Y_b(10890)$	$10,890 \pm 3$	55 ± 9	1^{--}	$\pi^+\pi^-\Upsilon(1,2,3S)$	$e^+e^- \to Y_b$	Belle

Table 2. Summary of recent $B \to (c\bar{c}\gamma)K$ results [20]. In all measurements the two consecutive errors indicate statistical and systematic uncertainties, respectively. Significances also include systematic uncertainties.

Decay mode	Signal	Significance (σ)	Branching fraction ($\mathcal{B}$)
$B^\pm \to \chi_{c1}K^\pm$	2308 ± 52	79	$(4.9 \pm 0.1 \pm 0.3) \cdot 10^{-4}$
$B^0 \to \chi_{c1}K^0$	542 ± 24	37	$(3.78^{+0.17}_{-0.16} \pm 0.3) \cdot 10^{-4}$
$B^\pm \to \chi_{c2}K^\pm$	$32.8^{+10.9}_{-10.2}$	3.6	$(1.11^{+0.36}_{-0.34} \pm 0.09) \cdot 10^{-5}$
$B^0 \to \chi_{c2}K^0$	$2.8^{+4.7}_{-3.9}$	0.7	$< 2.6 \cdot 10^{-5}$ at 90%C.L.
$B^\pm \to (X(3872) \to J/\psi\gamma)K^\pm$	$30.0^{+8.2}_{-7.4}$	4.9	$(1.78^{+0.48}_{-0.44} \pm 0.12) \cdot 10^{-6}$
$B^0 \to (X(3872) \to J/\psi\gamma)K^0$	$5.7^{+3.5}_{-2.8}$	2.4	$< 2.4 \cdot 10^{-6}$ at 90%C.L.
$B^\pm \to (X(3872) \to \psi'\gamma)K^\pm$	$5.0^{+11.9}_{-11.0}$	0.4	$< 3.4 \cdot 10^{-6}$ at 90%C.L.
$B^0 \to (X(3872) \to \psi'\gamma)K^0$	$1.5^{+4.8}_{-3.9}$	0.2	$< 6.6 \cdot 10^{-6}$ at 90%C.L.

2.2 Charged $c\bar{c}$-like states: $Z^+(4430)$; $Z^+(4050)$& $Z^+(4250)$

In 2008 an exciting discovery of a new charmonium-like state was reported [22] by Belle in the $B^{+,0} \to K^{0,-}\pi^+\psi(2S)$ analysis, performed on a data sample with $657{\cdot}10^6$ $B\bar{B}$ pairs. After excluding the $K\pi$ Dalitz regions that correspond to $K^*(890)$ and $K_2^*(1430)$ mesons (*i.e.* K^* veto), a strong enhancement is obtained in the $\pi^+\psi(2S)$ invariant mass distribution. A fit with an S-wave Breit-Wigner function for the signal and a phase-space-like background function yields a peak mass and width of $M = (4433 \pm 4 \pm 2)$ MeV/c^2 and $\Gamma = (45^{+18}_{-13}{}^{+30}_{-13})$ MeV, with a 6.5σ statistical significance. The observed resonance, named $Z^+(4430)$, is characterised by a product branching fraction of $\mathcal{B}(\bar{B}^0 \to K^-Z^+(4430)) \times \mathcal{B}(Z^+(4430) \to \pi^+\psi(2S)) = (4.1 \pm 1.0 \pm 1.4) \cdot 10^{-5}$. The $Z^+(4430)$ is thus seen as the first charmonium-like charged meson with a minimal quark content of $c\bar{c}u\bar{d}$ – a serious tetraquark candidate.

The signature of this exotic state was also searched for by the BABAR collaboration [23]. The performed analysis of the $B^{-,0} \to \psi\pi^-K^{0,+}$ (ψ = J/ψ or $\psi(2S)$) decays focuses on a detailed study of the $K\pi^-$ system, since its mass and angular-distribution structures strongly influence the Dalitz plots. Using the final BABAR data sample of 413 fb^{-1}, no significant evidence for an invariant mass signal peak is obtained for any of the processes investigated, not even in the K^* veto region for the $\psi(2S)\pi^+$ distribution, where the $Z^+(4430)$ was observed by Belle. The most prominent structure in the $\psi(2S)\pi^-$ mass distribution for all events is an excess of 2.7σ with a mass and width of $M = (4476 \pm 8((stat.))$ MeV/c^2 and $\Gamma = 32 \pm 16((stat.))$ MeV. Using the measured Belle parameters [22] for the $Z^+(4430)$, only the upper limit for the product branching fraction is obtained as $\mathcal{B}(\bar{B}^0 \to K^-Z^+(4430)) \times \mathcal{B}(Z^+(4430) \to \pi^+\psi(2S)) < 3.1 \cdot 10^{-5}$ at a 95% confidence level. This result does neither refute nor confirm the existence of the $Z^+(4430)$, seen by Belle.

Soon after the BABAR group report, the Belle collaboration reanalysed the same data set as used previously in [22]. In order to check for the possible $\psi(2S)\pi^-$

mass reflections from the $K\pi$ system, a full Dalitz plot analysis is performed [24], using the same data sample as above and a fit model that takes into account all known $K\pi$ resonances below 1780 MeV/c^2. Dalitz plot is divided in five $M^2(K\pi)$-regions and the $Z^+(4430)$ signal is clearly seen for the K^*-veto-equivalent $M^2(\pi^+\psi(2S))$ distribution. The fit results with 6.4σ peak significance agree with previous Belle measurement, and provide the updated $Z^+(4430)$ parameters: $M = (4443^{+15+19}_{-12-13})\ \mathrm{MeV}/c^2$, $\Gamma = (109^{+86+74}_{-43-56})$ MeV and $\mathcal{B}(\overline{B}^0 \to K^- Z^+(4430)) \times \mathcal{B}(Z^+(4430) \to \pi^+\psi(2S)) = (3.2^{+1.8+5.3}_{-0.9-1.6}) \cdot 10^{-5}$.

The observation of the $Z^+(4430)$ state suggests that studies of $B \to K\pi(c\overline{c})$ decays could reveal other similar neutral and charged partners. Belle thus reports also on a Dalitz plot analysis of $\overline{B}^0 \to K^-\pi^+\chi_{c1}$ decays with $657 \cdot 10^6$ $B\overline{B}$ pairs.[25] The fit model for $K\pi$ resonances is the same as in the $Z^+(4430)$ Dalitz analysis, but here it includes also the $K_3^*(1780)$ meson. The fit results suggest that a broad doubly peaked structure in the $\pi^+\chi_{c1}$ invariant mass distribution should be interpreted by two new states, called $Z^+(4050)$ and $Z^+(4250)$. The double-Z^+ hypothesis is favoured when compared to the single-Z^+ (no-Z^+) hypothesis by the statistical significance of 5.7σ (13.2σ), and even with various systematic variations of the fit model, the significance is still at least 5.0σ (8.1σ). The masses, widths and product branching fractions for the two states are: $M(Z^+(4050)) = (4051 \pm 14^{+20}_{-41})\ \mathrm{MeV}/c^2$, $\Gamma(Z^+(4050)) = (82^{+21+47}_{-17-22})$ MeV, $M(Z^+(4250)) = (4248^{+44+180}_{-29-35})\ \mathrm{MeV}/c^2$, $\Gamma(Z^+(4250)) = (177^{+54+316}_{-39-61})$ MeV; and $\mathcal{B}(\overline{B}^0 \to K^- Z^+(4050)) \times \mathcal{B}(Z^+(4050) \to \pi^+\chi_{c1}) = (3.0^{+1.5+3.7}_{-0.8-1.6}) \cdot 10^{-5}$, $\mathcal{B}(\overline{B}^0 \to K^- Z^+(4250)) \times \mathcal{B}(Z^+(4250) \to \pi^+\chi_{c1}) = (4.0^{+2.3+19.7}_{-0.9-0.5}) \cdot 10^{-5}$.

3 XYZ counterparts in $b\overline{b}$ and $s\overline{s}$ systems

An interesting question is whether in the $s\overline{s}$ and $b\overline{b}$ systems there exist analogous "XYZ" states, predicted by many of the models proposed to explain the charmonium-like exotic states.

3.1 $Y(2175)$

A possible candidate in the $s\overline{s}$ system is $Y(2175)$, a 1^{--} state, first observed by BaBar in the ISR process $e^+e^- \to \gamma_{\mathrm{ISR}} f_0(980)\phi(1020)$ [26] and later confirmed by BES [27]. At Belle experiment, both $\pi^+\pi^-\phi(1020)$ and $f_0(980)\phi(1020)$ cross sections for the ISR processes $e^+e^- \to \gamma_{ISR}\pi^+\pi^-\phi(1020)$ and $e^+e^- \to \gamma_{ISR} f_0(980)\phi(1020)$ were measured [28]. The mass and width of the high mass peak in the cross section, corresponding to $Y(2175)$, are found to be $M = 2079 \pm 13^{+79}_{-28}$ MeV and $\Gamma = 192 \pm 23^{+25}_{-61}$ MeV, which are consistent with the previous measurements. For First measurements of mass and width are reported for the low mass peak in the $\pi^+\pi^-\phi(1020)$ cross section distribution, corresponding to the $\phi(1680)$, the measured values are: $M = 1689 \pm 7 \pm 10$ MeV and $\Gamma = 211 \pm 14 \pm 19$ MeV. The widths for both, $\phi(1680)$ and $Y(2175)$, are about 200 MeV. This may suggest that the $Y(2175)$ is an excited 1^{--} $s\overline{s}$ state. Since the $f_0(980)$ is expected to have a large $s\overline{s}$ component, $Y(2175) \to f_0(980)\phi(1020)$ can be understood as an open-flavor decay, different from $Y(4260) \to \pi^+\pi^- J/\psi$, which is a hadronic transition. Studies of Y(2175) in other decay modes are therefore needed to determine if Y(2175) is a conventional $s\overline{s}$ state or an s-quark analogue of the Y(4260).

3.2 $Y_b(10890)$

The Belle experiment used a data sample at the CM energy around the $\Upsilon(5S)$ mass 10.89 GeV, and found large signals for decays into $\pi^+\pi^-\Upsilon(1S)$, $\pi^+\pi^-\Upsilon(2S)$ and $\pi^+\pi^-\Upsilon(3S)$ final states. If these transitions are only from the $\Upsilon(5S)$ resonance, then the corresponding partial widths are between 0.5 and 0.9 MeV. These values are more than two orders of magnitude larged than the corresponding partial widths for $\Upsilon(4S)$, $\Upsilon(3S)$ and $\Upsilon(2S)$ decays to $\pi^+\pi^-\Upsilon(1S)$. This could be explained by $b\overline{b}$ analogue of the Y(4260) state, called $Y_b(10890)$, which overlaps with the $\Upsilon(5S)$. Alternatively, this phenomenon could be explained by the existence of a tetraquark intermediate state, the effect of final state interactions or by a nonperturbative approach for the calculation of the decay widths of dipion transitions of heavy quarkonia.

To distinguish between different possibilities, the Belle experiment performed a measurement of the energy dependence of the cross sections for $e^+e^- \to \pi^+\pi^-\Upsilon(nS)$ $(n = 1, 2, 3)$ at energies around 10.89 GeV [29]. The peak mass and width, obtained by performing a fit with a common Breit-Wigner function to the measured $\pi^+\pi^-\Upsilon(nS)$ cross section distribution, is measured to be $M = 10889.6 \pm 1.8 \pm 1.6$ MeV and $\Gamma = 54.7^{+8.5}_{-7.2} \pm 2.5$ MeV. A fit with the $\Upsilon(5S)$ and $\Upsilon(6S)$ resonance parameters [19], fails to describe the observed $\pi^+\pi^-\Upsilon(nS)$ cross section.

4 Summary and Conclusions

The Belle experiment at the KEKB collider provides an excellent environment for charm and charmonium spectroscopy. As a result, many new particles have already been discovered during the Belle operation, and some of them are mentioned in this report. Some recent Belle results also indicate that analogs to exotic charmonium-like states can be found in $s\overline{s}$ and $b\overline{b}$ systems. As the operation of the experiment heas just finished in June 2010, some interesting results on spectroscopy could still be expected from Belle in the near future.

The Belle experimental results have already raised substantial interest and various interpretations for the nature and properties of newly observed states have been proposed. Perhaps some of the issues about these states might be resolved soon, following also the ideas and studies presented at this workshop.

References

1. A. Abashian *et al.* (Belle Coll.), *Nucl. Instrum. Methods* A **479**, 117 (2002).
2. S. Kurokawa and E. Kikutani, *Nucl. Instrum. Methods* A **499**, 1 (2003), and other papers included in this Volume.

3. S.-K. Choi *et al.* (Belle Collaboration), *Phys. Rev. Lett.* **89**, 102001 (2002).
4. J. L. Rosner *et al.* (Cleo Collaboration), *Phys. Rev. Lett.* **95**, 102003 (2005).
5. For a review of XYZ states see the Eric S. Swanson's contribution to the conference proceedings of Moriond QCD and High Energy Interactions '09, 14-21 March 2009, La Thuile, Italy.
6. S. L. Olsen, *Nucl. Phys.* A **827**, 53 (2009) (arXiv:0901.2371v1 [hep-ex]).
7. T. Barnes, S. Godfrey and E. S. Swanson, *Phys. Rev.* D **72**, 054026 (2005).
8. For approaches and results of these studies see several contributions to these proceedings.
9. S.-K. Choi *et al.* (Belle Collaboration), *Phys. Rev. Lett.* **91**, 262001 (2003).
10. D. Acosta *et al.* (CDF Collaboration), *Phys. Rev. Lett.* **93**, 072001 (2004)
V. M. Abazov *et al.* (DØ Collaboration), *Phys. Rev. Lett.* **93**, 162002 (2004);
B. Aubert *et al.* (*BABAR* Collaboration), *Phys. Rev.* D **71**, 071103 (2005).
11. K. Abe *et al.* (Belle Collaboration), arXiv:hep-ex/0505037, arXiv:hep-ex/0505038; submitted to the Lepton-Photon 2005 Conference.
12. G. Gokhroo *et al.* (Belle Collaboration), *Phys. Rev. Lett.* **97**, 162002 (2006).
13. B. Aubert *et al.* (*BABAR* Collaboration), *Phys. Rev.* D **74**, 071101 (2006).
14. I. Adachi *et al.* (Belle Collaboration), arXiv:0809.1224v1 [hep-ex]; contributed to the ICHEP 2008 Conference.
15. N. Zwahlen *et al.* (Belle Collaboration), arXiv:0810.0358v2 [hep-ex]; contributed to the ICHEP 2008 Conference.
16. A. Abulencia *et al.* (CDF), *Phys. Rev. Lett.* **98**, 132002 (2007).
17. B. Aubert *et al.* (*BABAR* Collaboration), *Phys. Rev.* D **77**, 011102 (2008).
18. B. Aubert *et al.* (*BABAR* Collaboration), *Phys. Rev. Lett.* **102**, 132001 (2009).
19. K. Nakamura *et al.* (Particle Data Group), *J. Phys.* G **37**, 075021 (2010).
20. Preliminary results of this analysis were presented at the *Quarkonium Working Group Workshop 2010*, 18th-21st May, 2010, Fermilab, Batavia, Illinois, USA.
21. E. S. Swanson, *Phys. Rep.* **429**, 243 (2006).
22. S.-K. Choi *et al.* (Belle Collaboration), *Phys. Rev. Lett.* **100**, 142001 (2008).
23. B. Aubert *et al.* (*BABAR* Collaboration), *Phys. Rev.* D **79**, 112001 (2009).
24. R. Mizuk *et al.* (Belle Collaboration), *Phys. Rev.* D **80**, 031104 (2009).
25. R. Mizuk *et al.* (Belle Collaboration), *Phys. Rev.* D **78**, 072004 (2008).
26. B. Aubert *et al.* (*BABAR* Collaboration], *Phys. Rev.* D **74**, 091103 (2006).
27. M. Ablikim *et al.* (BES Collaboration), *Phys. Rev. Lett.* **100**, 102003 (2008).
28. C. P. Shen *et al.* [Belle Collaboration], *Phys. Rev.* D **80**, 031101 (2009).
29. K.-F. Chen *et al.* (The Belle collaboration), arXiv:0808.2445 [hep-ex]; to appear in the Phys. Rev. D(RC).