Measurement of sigma(e(+)e(-)->psi(3770)-> hadrons) at E-c.m.=3773 MeV

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Measurement of $\sigma(e^+e^- \to \psi(3770) \to \text{hadrons})$ at $E_{\text{c.m.}} = 3773$ MeV

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We measure the cross section for $e^+e^- \to \psi(3770) \to$ hadrons at $E_{\text{c.m.}} = 3773$ MeV to be $(6.38 \pm 0.08^{+0.41}_{-0.30})$ nb using the CLEO detector at the CESR e^+e^- collider. The difference between this and the $e^+e^- \to \psi(3770) \to D\bar{D}$ cross section at the same energy is found to be $(-0.01 \pm 0.08^{+0.41}_{-0.30})$ nb. With the observed total cross section, we extract $\Gamma_{ee}(\psi(3770)) = (0.204 \pm 0.003^{+0.041}_{-0.027})$ keV. Uncertainties shown are statistical and systematic, respectively.

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Two decades ago, the Mark III collaboration [1] measured the cross section for the reaction $e^+e^- \to \psi(3770) \to D\bar{D}$, using a double-tag technique. They found a cross section of about 5 nb. At roughly the same time, the Mark II [2] and Lead-Glass Wall [3] collaborations measured the cross section for $\sigma(e^+e^- \to \psi(3770) \to \text{hadrons})$ (including $D\bar{D}$), finding a cross section of about 10 nb. The indication that the decay of $\psi(3770)$ to non-$D\bar{D}$ final states was comparable to that to $D\bar{D}$ final states came as a surprise. The expectation was that the decay width of $\psi(3770)$ to non-$D\bar{D}$ final states would be comparable to that of $\psi(2S)$, which is below threshold for open charm decays. Thus $\mathcal{B}(\psi(3770) \to \text{non-}D\bar{D})/\mathcal{B}(\psi(3770) \to D\bar{D})$ should be small due to the large total width of $\psi(3770)$. The CLEO collaboration has recently measured the cross section for $e^+e^- \to \psi(3770) \to D\bar{D}$, finding $\sigma_{\psi(3770)\to D\bar{D}} = (6.39 \pm 0.10^{+0.17}_{-0.08})$ nb at $E_{\text{c.m.}} = 3773$ MeV [4]. In this Letter we present a measurement of the cross section for $\sigma(e^+e^- \to \psi(3770) \to \text{hadrons})$, $\sigma_{\psi(3770)}$, at $E_{\text{c.m.}} = 3773$ MeV, where $\psi(3770)$ refers to the yield at $E_{\text{c.m.}} = 3773$ MeV from $c\bar{c}$ annihilation into hadrons, not including continuum production of $q\bar{q}$ ($q = u, d, s$) and not including radiative returns to $\psi(2S)$ and to J/ψ.

We define $\psi(3770)$ as

$$\sigma_{\psi(3770)} = \frac{N_{\psi(3770)}}{\epsilon_{\psi(3770)} \mathcal{L}_{\psi(3770)}}, \quad (1)$$

where $\mathcal{L}_{\psi(3770)}$ is the integrated luminosity for the data taken at $E_{\text{c.m.}} = 3773$ MeV, $N_{\psi(3770)}$ is the number of hadronic events inferred to be directly from $\psi(3770)$ decays, and $\epsilon_{\psi(3770)}$ is the hadronic event selection efficiency of $\psi(3770)$ decays.

Our main observable is the background-subtracted number of hadrons produced in $\psi(3770)$ decays, $N_{\psi(3770)}$. At $E_{\text{c.m.}} \sim 3773$ MeV, the main backgrounds come from continuum production $e^+e^- \to q\bar{q}$ and radiative returns to $\psi(2S)$ and J/ψ. Thus $N_{\psi(3770)}$ is given by

$$N_{\psi(3770)} = N_{\text{on-}\psi(3770)} - N_{q\bar{q}} - N_{\psi(2S)} - N_{J/\psi} - \Sigma_{l=\tau,\mu,e} N_{l^+l^-}, \quad (2)$$

where $N_{\text{on-}\psi(3770)}$ is the observed number of hadronic events in the $\psi(3770)$ data taken at $E_{\text{c.m.}} = 3773$ MeV, $N_{q\bar{q}}$ is the number of observed hadronic events from $e^+e^- \to \gamma^* \to q\bar{q}$, $N_{\psi(2S)}$ and $N_{J/\psi}$ are the number of hadronic events from $\psi(2S)$ and J/ψ decays, respectively, and $N_{l^+l^-}$ is the number of events from $e^+e^- \to l^+l^-$ that pass our hadronic event selection criteria. We subtract these backgrounds by employing scaled numbers of hadrons observed in two other data samples, taken at the $\psi(2S)$ peak ($E_{\text{c.m.}} = 3686$ MeV) and at the continuum below this resonance ($E_{\text{c.m.}} = 3671$ MeV).

The three e^+e^- collision data samples taken at $E_{\text{c.m.}} = 3671$, 3686, and 3773 MeV were acquired with the CLEO-c detector [5] operating at the Cornell Electron Storage Ring [6], corresponding to integrated luminosities of $\mathcal{L} = (20.7 \pm 0.2)\ \text{pb}^{-1}$, $(2.9 \pm 0.1)\ \text{pb}^{-1}$, and $(281.3 \pm 2.8)\ \text{pb}^{-1}$, respectively. Components of the CLEO-c detector used for this analysis are the charged particle tracking system (the drift chamber) operating in a 1.0 T magnetic field along the beam axis and achieving a momentum resolution of $\sim 0.6\%$ at momenta of 1 GeV/c, and the CsI crystal calorimeter attaining photon energy resolution of 2.2% for $E_\gamma = 1$ GeV and 5% at 100 MeV. Together, they cover 93% of the solid angle for charged and neutral particles. The RICH detector and muon system are not used for this analysis.

To select hadronic events, we require that the observed number of charged tracks (N_{ch}) be at least three. The tracks are required to have well-measured momenta and to satisfy criteria based on track fit quality. They must also be consistent with originating from the interaction point in three dimensions (we vary these track quality requirements for study of systematic errors). The visible energy of charged and neutral showers (E_{vis}) must be at least 30% of the center-of-mass energy ($E_{\text{c.m.}}$). For $3 \leq N_{\text{ch}} \leq 4$, the total energy visible in the calorimeter alone (E_{cal}) must be at least 15% of $E_{\text{c.m.}}$ and, to suppress $e^+e^- \to e^+e^-$, the most energetic shower in the calorimeter must be less than 75% of the beam energy or $E_{\text{cal}} < 0.85\ E_{\text{c.m.}}$.

Some remaining backgrounds can be virtually eliminated with further restrictions. Two-photon fusion events ($e^+e^- \to e^+e^-\gamma^*\gamma^* \to e^+e^- + \text{hadrons}$) can be reduced to a negligible background by requiring there to be no large momentum imbalance along the beam direction (z axis). To accomplish this, we require that the ratio of the z component of the vector sum of all charged particles and photon candidates to the visible energy, $|\vec{P}_z^{\text{net}}|/E_{\text{vis}}$, be less than 0.3. Monte Carlo (MC) studies show that this selection causes a loss of only $\sim 4\%$ of signal events. Backgrounds from cosmic rays and collisions of beam particles with gas molecules or the walls of the vacuum pipe are suppressed by restrictions on the event vertex, defined as the average of the intersection points of all charged track pairs in an event. True e^+e^- collision events will peak sharply near the collision point, with rms widths of ~ 1 mm in the xy plane and ~ 1 cm along the z axis. We require the vertex be closer than 5 mm in the xy plane and 5 cm along the z axis, which leaves just a few tenths percent backgrounds from these sources.

Our event selection is designed to have a good efficiency for $\psi(3770) \to D\bar{D}$ events, but also for $\psi(3770) \to \text{non-}D\bar{D}$ events, assuming they are similar to $\psi(2S)$ decays. In particular, $\epsilon_{D\bar{D}} = 79.5\%$, $\epsilon_{\psi(2S)} = 68.1\%$, and $\epsilon_{q\bar{q}} = 60.5\%$. Since we use the data samples acquired with the same detector at lower energies for the subtractions for continuum $q\bar{q} \to \text{hadrons}$ and for radiative returns to $\psi(2S)$, the analysis has little sensitivity to uncertainties in modeling these processes. A large source of potential systematic uncertainty is avoided with this strategy.

$N_{J/\psi}$ and $N_{l^+l^-}$ in Eq. (2) are obtained by $N_{J/\psi} = \sigma_{e^+e^-\to\gamma J/\psi}\mathcal{L}_{\psi(3770)}\epsilon_{e^+e^-\to\gamma J/\psi}$ and $N_{l^+l^-} = \sigma_{e^+e^-\to l^+l^-} \times \mathcal{L}_{\psi(3770)}\epsilon_{e^+e^-\to l^+l^-}$ respectively, where the production cross sections, $\sigma_{e^+e^-\to\gamma J/\psi}$ and $\sigma_{e^+e^-\to l^+l^-}$, are theoretically estimated. In particular, $\sigma_{e^+e^-\to\gamma J/\psi}$ is calculated based on the radiative tail kernel [7] convoluted with the resonance Breit-Wigner shape with continuum interference (will be discussed later in this Letter). $\epsilon_{e^+e^-\to\gamma J/\psi}$ and $\epsilon_{e^+e^-\to l^+l^-}$ are the hadronic event selection efficiencies of events from radiative return to J/ψ and from $e^+e^- \to l^+l^-$, respectively, determined by the EvtGen event generator [8] and a GEANT-based detector simulation [9].

$N_{\psi(2S)}$ in Eq. (2) is given by $N_{\psi(2S)} = R_{\pi\pi ll}N_{\psi(2S)}(3686)$, where $R_{\pi\pi ll} = 0.59 \pm 0.01$ (stat.) is the ratio of observed numbers of $\pi^+\pi^-l^+l^-$ events at $E_{\mathrm{c.m.}} = 3773$ MeV [10] to that at 3686 MeV [11], $l^\pm \equiv e^\pm$ or $\mu^\pm$ and $N_{\psi(2S)}(3686)$ is the observed number of hadronic events $[(1019 \pm 1) \times 10^3]$ in data taken at $E_{\mathrm{c.m.}} = 3686$ MeV after subtracting continuum backgrounds $[(34.0 \pm 0.2) \times 10^3]$. To estimate the continuum contribution we scale the $E_{\mathrm{c.m.}} = 3671$ MeV hadronic yield by the ratio of integrated luminosities corrected for $1/s$ dependence of the continuum processes. Since this subtraction is small, $\psi(2S)$ contribution to the $E_{\mathrm{c.m.}} = 3671$ MeV data and different s dependence of the backgrounds from $e^+e^- \to \tau^+\tau^-$ and $e^+e^- \to \gamma J/\psi$ events can be safely neglected.

To obtain the largest background at $E_{\mathrm{c.m.}} = 3773$ MeV, $N_{q\bar{q}}$ in Eq. (2), we employ the data taken at $E_{\mathrm{c.m.}} = 3671$ MeV, which has small contaminations of $\psi(2S)$ decays as well as of J/ψ decays. Hence we obtain $N_{q\bar{q}}$ by

$$\begin{aligned} N_{q\bar{q}} &= SN_{q\bar{q}}(3671) \\ &= S\{N_{\mathrm{had}}(3671) - N_{\psi(2S)}(3671) - N_{J/\psi}(3671) \\ &\quad - \Sigma_{l=\tau,\mu,e}N_{l^+l^-}(3671)\}, \end{aligned} \tag{3}$$

where all $N(3671)$'s are the number of hadronic events at $E_{\mathrm{c.m.}} = 3671$ MeV. $N_{\psi(2S)}(3671)$, $N_{J/\psi}(3671)$, and $N_{l^+l^-}(3671)$ are all obtained in the same way as described previously but at $E_{\mathrm{c.m.}} = 3671$ MeV. The scaling factor, $S = 12.88 \pm 0.01$ (stat.), accounts for the luminosity difference between the two data sets and for the $1/s$ dependence of the cross section.

In addition to the above corrections, we must take into account the effect of interference between the final states of resonance decays (i.e., resonance $\to \gamma^* \to q\bar{q} \to$ hadrons) and nonresonant annihilation of e^+e^- (i.e., $e^+e^- \to q\bar{q} \to$ hadrons) as it distorts the shape and area of the intrinsic Breit-Wigner line shape. To estimate the size of this effect, we assume the following: (i) The amplitude for $\gamma^* \to q\bar{q}$ interferes in the same way as the one for $\gamma^* \to \mu^+\mu^-$. (ii) We can treat $ggg \to$ hadrons and $q\bar{q} \to$ hadrons as distinct final states. Thus they are incoherent and do not interfere with each other. The interference effects due to decay products of J/ψ should be negligible compared to that of $\psi(2S)$. They are taken into account by the subtraction of the scaled continuum data. With the first assumption, the change in cross section of $e^+e^- \to \gamma^* \to q\bar{q}$ due to the interference, $\sigma_{q\bar{q}}^{\mathrm{inter}}$, is given by

$$\sigma_{q\bar{q}}^{\mathrm{inter}} = \frac{R}{1 - 2\mathcal{B}_{\psi(2S)\to\mu^+\mu^-}}\sigma_{\mu\mu}^{\mathrm{inter}}, \tag{4}$$

where $\sigma_{\mu\mu}^{\mathrm{inter}}$ is the change in cross section due to the interference between $\psi(2S) \to \gamma^* \to \mu^+\mu^-$ and $e^+e^- \to \gamma^* \to \mu^+\mu^-$ [12,13]. We take a $\pm 25\%$ uncertainty in $\sigma_{q\bar{q}}^{\mathrm{inter}}$ as an estimate of the systematic error from this term. R is $\sigma_{q\bar{q}\to\mathrm{hadrons}}/\sigma_{\mu\mu}^0$, which can be also written as $N_{q\bar{q}}^{\mathrm{corr}}/(\mathcal{L}\epsilon_{q\bar{q}}\sigma_{\mu\mu}^0)$, where $\sigma_{\mu\mu}^0$ is the lowest-order $\mu^+\mu^-$ cross section, $N_{q\bar{q}}^{\mathrm{corr}}$ is the number of hadronic events from $e^+e^- \to \gamma^* \to q\bar{q}$, corrected for this interference effect, $\mathcal{L}$ is the integrated luminosity, and $\epsilon_{q\bar{q}}$ is the event selection efficiency of $e^+e^- \to \gamma^* \to q\bar{q} \to$ hadrons.

We obtain the final $N_{q\bar{q}}$ by correcting for the *destructive* and *constructive* interference effects at $E_{\mathrm{c.m.}} = 3671$ and 3773 MeV, respectively. We also account for the interference effects between $e^+e^- \to \gamma^* \to l^+l^-$ in continuum and $\psi(2S) \to \gamma^* \to l^+l^-$, but these effects are negligible compared to the one described above. The corrections for resonance-continuum $q\bar{q}$ interference in our data samples amount to an 11% downward shift in the cross section at $E_{\mathrm{c.m.}} = 3773$ MeV.

Tables I and II present the observed numbers of hadronic events (only statistical errors are shown) from various specific sources in the two data samples taken at $E_{\mathrm{c.m.}} = 3671$ and 3773 MeV, respectively.

In Eq. (1), the hadronic event selection efficiency, $\epsilon_{\psi(3770)}$, is expected to be close to $\epsilon_{D\bar{D}}$. To account for the uncertainty of $\epsilon_{\mathrm{non}\text{-}D\bar{D}}$, the hadronic event selection efficiency of non-$D\bar{D}$ decays of $\psi(3770)$, we include the non-$D\bar{D}$ component in the calculation of $\sigma_{\psi(3770)}$, using the formula

TABLE I. Numbers of events at $E_{\mathrm{c.m.}} = 3671$ MeV for various event types. The interference term represents the interference of $\psi(2S) \to \gamma^* \to q\bar{q} \to$ hadrons with the continuum annihilation, $\gamma^* \to q\bar{q} \to$ hadrons.

$N_{\mathrm{had}}(3671)$	$244\,400 \pm 500$
$N_{\psi(2S)}(3671)$	7200 ± 500
$N_{J/\psi}(3671)$	$13\,000 \pm 100$
$N_{\tau^+\tau^-}(3671)$	9300 ± 100
$N_{e^+e^-}(3671)$	2700 ± 500
$N_{\mu^+\mu^-}(3671)$	130 ± 20
Interference (*destructive*)	8900 ± 0
$N_{q\bar{q}}^{\mathrm{corr}}$	$221\,000 \pm 1000$

TABLE II. Numbers of events at $E_{\rm c.m.} = 3773$ MeV for various event types. The interference term represents the interference of $\psi(2S) \to \gamma^* \to q\bar{q} \to$ hadrons with the continuum annihilation, $\gamma^* \to q\bar{q} \to$ hadrons. The scaled $N_{q\bar{q}}$ is raised by ~2% to correct for the difference in efficiencies ($\epsilon_{q\bar{q}}$) at the two energy points, 3671 and 3773 MeV.

$N_{\text{on-}\psi(3770)}$	$5\,319\,000 \pm 2000$
$N_{q\bar{q}}$	$2\,915\,000 \pm 12\,000$
Interference (*constructive*)	$26\,800 \pm 100$
$N_{\psi(2S)}$	$583\,000 \pm 6000$
$N_{J/\psi}$	$140\,000 \pm 1000$
$N_{\tau^+\tau^-}$	$170\,900 \pm 300$
$N_{e^+e^-}$	$54\,000 \pm 8000$
$N_{\mu^+\mu^-}$	$2\,000 \pm 200$
$N_{\psi(3770)}$	$1\,427\,000 \pm 16\,000$

$$\sigma_{\psi(3770)} = \left(\frac{N_{\psi(3770)}}{\epsilon_{D\bar{D}}\mathcal{L}_{\psi(3770)}} - \sigma_{\psi(3770)\to D\bar{D}}\right)\frac{\epsilon_{D\bar{D}}}{\epsilon_{\text{non-}D\bar{D}}} + \sigma_{\psi(3770)\to D\bar{D}}. \quad (5)$$

We use CLEO's measurement [4] for $\sigma_{\psi(3770)\to D\bar{D}}$ and assume $\epsilon_{\text{non-}D\bar{D}}$ is the average of $\epsilon_{D\bar{D}}$ and $\epsilon_{\psi(2S)}$. We vary the efficiency between these two extremes to account for the uncertainty of $\epsilon_{\text{non-}D\bar{D}}$. However, as the difference between $\sigma_{\psi(3770)\to D\bar{D}}$ and $\sigma_{\psi(3770)}$ turns out to be small as we will show shortly, the final $\sigma_{\psi(3770)}$ becomes rather insensitive to $\epsilon_{\text{non-}D\bar{D}}$ and is more sensitive to the input value of $\sigma_{\psi(3770)\to D\bar{D}}$.

Figure 1 shows the distributions of track multiplicity (top) and visible energy normalized to $E_{\rm c.m.}$ (bottom) of events in our $\psi(3770)$ data sample that pass our hadronic event selection criteria (black-solid histograms). Also overlaid are various estimated and observed backgrounds.

The total fractional systematic uncertainty in $\sigma_{\psi(3770)}$ is $^{+6.5}_{-4.7}$%, which is the quadrature sum of the fractional uncertainties due to various sources shown in Table III. One of the major sources of systematic error is the accuracy of Monte Carlo modeling of those event characteristics that are used in event selection. We vary some of our event selection criteria, particularly the charged track multiplicity, $N_{\rm ch}$, and see the effect on our final $\sigma_{\psi(3770)}$. The uncertainty in the estimation of number of $\psi(2S)$ in on-resonance data comes mainly from a small difference in signal efficiency of selecting $\pi^+\pi^-l^+l^-$ events between the two data sets ($E_{\rm c.m.} = 3686$ and 3773 MeV). To estimate possible systematic variation in hadronic event selection efficiency of generic decay of $D\bar{D}$ due to incorrect D decay branching fractions used in the $D\bar{D}$ Monte Carlo simulation, we varied the D decay branching fractions so as to cause changes in charged particle multiplicity distributions and other inclusive distributions at the extreme allowed by data—Monte Carlo comparisons, and noted the changed in $\epsilon_{D\bar{D}}$. Based on this study, we conservatively assign 1.7% as an uncertainty in $\sigma_{\psi(3770)}$.

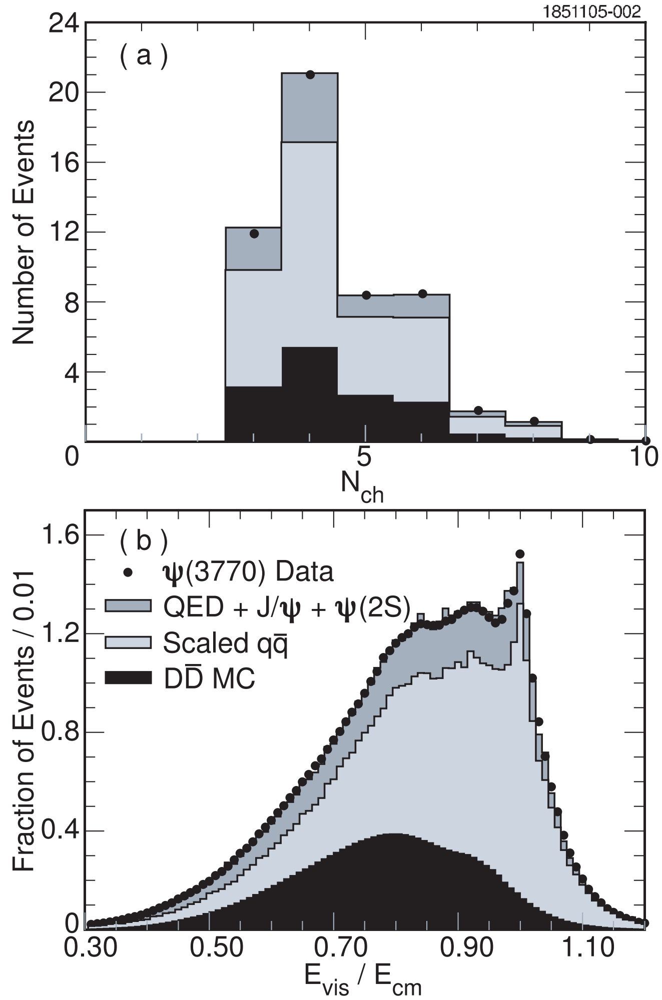

FIG. 1 (color online). $N_{\rm ch}$ (a) and $E_{\rm vis}/E_{\rm c.m.}$ (b) of our $\psi(3770)$ sample that pass our hadronic event selection criteria (black, solid histograms). Backgrounds are also overlaid [generic $D\bar{D}$ Monte Carlo sample [8,9], scaled continuum ($q\bar{q}$) data, summed QED events ($\Sigma_{l=e,\mu,\tau}(e^+e^- \to l^+l^-)$), plus radiative returns to $\psi(2S)$ and J/ψ]. The yield of $D\bar{D}$ Monte Carlo data is scaled to the size of the data assuming $\sigma(e^+e^- \to D\bar{D} \to \text{hadrons}) = 6.4$ nb.

The final cross section, including systematic uncertainty, is $\sigma_{\psi(3770)} = (6.38 \pm 0.08^{+0.41}_{-0.30})$ nb, where the first error is statistical and the second error is systematic. The difference between $\sigma_{\psi(3770)\to D\bar{D}}$ [4] and $\sigma_{\psi(3770)}$ is $(-0.01 \pm 0.08^{+0.41}_{-0.30})$ nb, which is consistent with recently observed non-$D\bar{D}$ decays of $\psi(3770)$ [10,14].

In addition to the measurement of $\sigma_{\psi(3770)}$, we also extract $\Gamma_{ee}(\psi(3770))$. The experimentally observed cross section at $E_{\rm c.m.} = 3773$ MeV is related to the Born-level cross section by radiative corrections [7,15], which, by convention, do not include vacuum polarization effects, allowing them to be absorbed into the definition of Γ_{ee}. These radiative effects account for virtual photon effects as well as real radiation down to lower energies on the $\psi(3770)$ line shape, effectively reducing the observed cross

TABLE III. Summary of various relative systematic uncertainties for hadronic cross section of $\psi(3770)$.

Source of error	(%)	(nb)
Two-Photon suppression	0.1	0.01
BeamGas/Wall/Cosmic subtraction	0.6	0.04
$N_{\psi(2S)}$	0.9	0.06
$N_{J/\psi}$	0.8	0.05
Track quality cuts	0.6	0.04
Luminosity	1.1	0.07
Continuum scaling	2.2	0.14
Hadronic event selection criteria	$^{+4.7}_{-1.4}$	$^{+0.30}_{-0.09}$
$\sigma_{\psi(3770)\to D\bar{D}}$	$^{+0.1}_{-0.2}$	0.01
$\epsilon_{D\bar{D}}$	1.7	0.11
Ratio of $q\bar{q}$ efficiencies	0.9	0.06
Interference ($q\bar{q} \to$ hadrons)	2.8	0.18
Total	$^{+6.5}_{-4.7}$	$^{+0.41}_{-0.30}$

section and amount to a reduction factor of $f = 0.77 \pm 0.03$ based on the known mass M and width Γ of $\psi(3770)$ [16]. The quoted uncertainty is dominated by the uncertainty in M but also includes contributions from the uncertainties in $E_{\rm c.m.}$ (1.0 MeV) and in the phase space suppression of $D\bar{D}$ final states.

The Born-level cross section at the $\psi(3770)$ mass M is related to that at $E_{\rm c.m.} = 3773$ MeV via the relativistic Breit-Wigner formula,

$$\sigma_{\rm Born}(E_{\rm c.m.}) = \frac{12\pi\Gamma_{ee}\Gamma_{\rm total}}{(E^2_{\rm c.m.} - M^2)^2 + M^2\Gamma^2_{\rm total}}, \quad (6)$$

which can be reduced to $\sigma_{\rm Born}(M)/\sigma_{\rm Born}(E_{\rm c.m.}) = 1.078^{+0.152+0.055}_{-0.006-0.038}$ for $E_{\rm c.m.} = 3773$ MeV, in which the first error accounts mostly for the uncertainty in the PDG (Particle Data Group) values for M and Γ and the second for the 1.0 MeV uncertainty in $E_{\rm c.m.}$.

The Breit-Wigner formula can then be used to extract $\Gamma_{ee}(\psi(3770))$ as

$$\Gamma_{ee} = \frac{\sigma^{\rm obs}(E_{\rm c.m.})}{f} \times 1.078 \times M^2 \times \Gamma_{\rm total}/(12\pi). \quad (7)$$

We obtain with PDG resonance parameters $\Gamma_{ee}(\psi(3770)) = (0.204 \pm 0.003^{+0.041}_{-0.027})$ keV, where the first error is statistical and the second error is systematic including uncertainties of the input PDG values. The result is lower than, but consistent with and comparable in precision to, the PDG value of 0.26 ± 0.04 [16] [the systematic errors there are mostly dominated by the uncertainties in Γ and M of $\psi(3770)$].

In summary, we have measured the hadronic cross section of $\psi(3770)$ at $E_{\rm c.m.} = 3773$ MeV, taking into account the effects of interference between the final states of resonance decays and nonresonant annihilation of e^+e^- with an improved relative uncertainty. The observed cross section is significantly smaller than some of the previous measurements [2,3]. By combining the reported cross section with that for $\psi(3770) \to D\bar{D}$ [4], we obtain $\sigma_{\psi(3770)} - \sigma_{\psi(3770)\to D\bar{D}}$. Based on the observed cross section of $\psi(3770)$, we also extract $\Gamma_{ee}(\psi(3770))$.

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