WIDTH DETERMINATIONS OF THE Υ STATES

As is the case for the \( J/ψ(1S) \) and \( ψ(2S) \), the full widths of the \( b\bar{b} \) states \( Υ(1S), Υ(2S), \) and \( Υ(3S) \) are not directly measurable, since they are much narrower than the energy resolution of the \( e^+e^- \) storage rings where these states are produced. The common indirect method to determine \( Γ \) starts from

\[
Γ = Γ_{ℓℓ}/B_{ℓℓ} , \tag{1}
\]

where \( Γ_{ℓℓ} \) is one leptonic partial width and \( B_{ℓℓ} \) is the corresponding branching fraction (\( ℓ = e, μ, \) or \( χ \)). One then assumes \( e-\mu-\tau \) universality and uses

\[
Γ_{ℓℓ} = Γ_{ee} \]

\[
B_{ℓℓ} = \text{average of } B_{ee}, B_{μμ}, \text{ and } B_{ττ} . \tag{2}
\]

The electronic partial width \( Γ_{ee} \) is also not directly measurable at \( e^+e^- \) storage rings, only in the combination \( Γ_{ee}Γ_{\text{had}}/Γ \), where \( Γ_{\text{had}} \) is the hadronic partial width and

\[
Γ_{\text{had}} + 3Γ_{ee} = Γ . \tag{3}
\]

This combination is obtained experimentally from the energy-integrated hadronic cross section

\[
\int \sigma(e^+e^- → Υ → \text{hadrons})dE\]

\[
= \frac{6π^2}{M^2} \frac{Γ_{ee}Γ_{\text{had}}}{Γ} C_r = \frac{6π^2}{M^2} \frac{Γ_{ee}^{(0)}Γ_{\text{had}}^{(0)}}{Γ} C_r^{(0)} , \tag{4}
\]

where \( M \) is the \( Υ \) mass, and \( C_r \) and \( C_r^{(0)} \) are radiative correction factors. \( C_r \) is used for obtaining \( Γ_{ee} \) as defined in Eq. (1), and contains corrections from all orders of QED for describing \( (b\bar{b}) → e^+e^- \). The lowest order QED value \( Γ_{ee}^{(0)} \), relevant for comparison with potential-model calculations, is defined by the lowest order QED graph (Born term) alone, and is about 7% lower than \( Γ_{ee} \).
The Listings give experimental results on $B_{ee}$, $B_{\mu\mu}$, $B_{\tau\tau}$, and $\Gamma_{ee}\Gamma_{\text{had}}/\Gamma$. The entries of the last quantity have been re-evaluated consistently using the correction procedure of KURAEV 85. The partial width $\Gamma_{ee}$ is obtained from the average values for $\Gamma_{ee}\Gamma_{\text{had}}/\Gamma$ and $B_{\ell\ell}$ using

$$\Gamma_{ee} = \frac{\Gamma_{ee}\Gamma_{\text{had}}}{\Gamma(1 - 3B_{\ell\ell})}. \quad (5)$$

The total width $\Gamma$ is then obtained from Eq. (1). We do not list $\Gamma_{ee}$ and $\Gamma$ values of individual experiments. The $\Gamma_{ee}$ values in the Meson Summary Table are also those defined in Eq. (1).