WIDTH DETERMINATIONS OF THE Υ STATES

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

$$\Gamma = \Gamma_{\ell\ell}/B_{\ell\ell} \ , \tag{1}$$

where $\Gamma_{\ell\ell}$ is one leptonic partial width and $B_{\ell\ell}$ is the corresponding branching fraction ($\ell = e$, μ, or τ). One then assumes e-μ-τ universality and uses

$$\begin{aligned} &\Gamma_{\ell\ell} = \Gamma_{ee} \\ &B_{\ell\ell} = \text{average of } B_{ee},\ B_{\mu\mu},\ \text{and } B_{\tau\tau} \ . \end{aligned} \tag{2}$$

The electronic partial width Γ_{ee} is also not directly measurable at e^+e^- storage rings, only the combination $\Gamma_{ee}\Gamma_{\rm had}/\Gamma$, where $\Gamma_{\rm had}$ is the hadronic partial width and

$$\Gamma_{\rm had} + 3\Gamma_{ee} = \Gamma \ . \tag{3}$$

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

$$\begin{aligned} \int_{\rm resonance} &\sigma(e^+e^- \to \Upsilon \to \text{hadrons})dE \\ &= \frac{6\pi}{M^2}\frac{\Gamma_{ee}\Gamma_{\rm had}}{\Gamma}C_r = \frac{6\pi}{M^2}\frac{\Gamma_{ee}^{(0)}\Gamma_{\rm had}}{\Gamma}C_r^{(0)} \ , \end{aligned} \tag{4}$$

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 $(b\overline{b}) \to e^+e^-$. The lowest order QED value $\Gamma_{ee}^{(0)}$, relevant for the comparison with potential-model calculations, is defined by the lowest order QED graph (Born term) alone and is about 7% lower than Γ_{ee}. In the past, this distinction had been overlooked by some authors as pointed out by ALEXANDER 89, BARU 86, COOPER 86, KOENIGSMANN 86, and others.

The Listings give experimental results on B_{ee}, $B_{\mu\mu}$, $B_{\tau\tau}$, and $\Gamma_{ee}\Gamma_{\rm had}/\Gamma$. The entries of the latter quantity have been re-evaluated using consistently the correction procedure of KURAEV 85. The partial width Γ_{ee} is obtained from the average values for $\Gamma_{ee}\Gamma_{\rm had}/\Gamma$ and $B_{\ell\ell}$ using

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

The total width Γ is then obtained from Eq. (1). We do not list Γ_{ee} and Γ values of individual experiments. The Γ_{ee} values in the Meson Summary Table are also those defined in Eq. (1) and no longer the lowest order quantities $\Gamma_{ee}^{(0)}$.