

95. Width Determinations of the Υ States

As is the case for the $J/\psi(1S)$ and $\psi(2S)$, the full widths of the $b\bar{b}$ states $\Upsilon(1S)$, $\Upsilon(2S)$, and $\Upsilon(3S)$ 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

$$\Gamma = \Gamma_{\ell\ell}/B_{\ell\ell} , \quad (95.1)$$

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

$$\begin{aligned} \Gamma_{\ell\ell} &= \Gamma_{ee} \\ B_{\ell\ell} &= \text{average of } B_{ee}, B_{\mu\mu}, \text{ and } B_{\tau\tau} . \end{aligned} \quad (95.2)$$

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

$$\Gamma_{\text{had}} + 3\Gamma_{ee} = \Gamma . \quad (95.3)$$

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

$$\begin{aligned} &\int_{\text{resonance}} \sigma(e^+e^- \rightarrow \Upsilon \rightarrow \text{hadrons})dE \\ &= \frac{6\pi^2}{M^2} \frac{\Gamma_{ee}\Gamma_{\text{had}}}{\Gamma} C_r = \frac{6\pi^2}{M^2} \frac{\Gamma_{ee}^{(0)}\Gamma_{\text{had}}}{\Gamma} C_r^{(0)} , \end{aligned} \quad (95.4)$$

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. (95.1), and contains corrections from all orders of QED for describing $(b\bar{b}) \rightarrow e^+e^-$. The lowest order QED value $\Gamma_{ee}^{(0)}$, 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 [1]. The partial width Γ_{ee} is obtained from the average values for $\Gamma_{ee}\Gamma_{\text{had}}/\Gamma$ and $B_{\ell\ell}$ using

$$\Gamma_{ee} = \frac{\Gamma_{ee}\Gamma_{\text{had}}}{\Gamma(1 - 3B_{\ell\ell})} . \quad (95.5)$$

The total width Γ is then obtained from Eq. (95.1). 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. (95.1).

References:

1. E.A. Kuraev, V.S. Fadin, Sov. J. Nucl. Phys. **41**, 466 (1985).