Two photon width of $\eta_c$

N. Fabiano 1, G. Pancheri 2

1 Perugia University and INFN, via Pascoli 06100, Perugia, Italy
2 INFN National Laboratories, P.O. Box 13, 00044, Frascati, Italy

Received: 25 October 2001 / Revised version: 7 March 2002
Published online: 30 August 2002 – © Springer-Verlag / Società Italiana di Fisica 2002

Abstract. We discuss the measured partial width of the pseudoscalar charmonium state $\eta_c$ into two photons. Predictions from potential models are examined and compared with experimental values. On including radiative corrections, it is found that present measurements are compatible both with a QCD type potential and with a static Coulomb potential. The latter is then used to give an estimate on the $\eta_b$ decay into two photons. Results for $\eta_c$ are also compared with those from $J/\psi$ data through the NRQCD model.

1 Introduction

In this paper we revisit the calculation of the two photon width of $\eta_c$, highlighting the latest experimental results and updating the potential model calculation. This allows for a reliable estimate of the two photon width of $\eta_b$, which has been searched in $\gamma\gamma$ collisions [1]. We shall see that the expected two photon width of $\eta_b$ is within reach of the precision in the LEP data being analyzed.

The charmonium spectrum has been the basic testing ground for a variety of models for the interquark potential, ever since the discovery of the $J/\psi$ in 1974 [2]. The experimental scenario describing the $c\bar{c}$ bound states is close to completion, with the observed higher excitation states $3P_0$, $3P_1$ and spin $2$ $3P_2$ states [3]: decay widths into various leptonic and hadronic states have been measured and compared with potential models [4,5]. Most of this note is dedicated to an examination of the theoretical predictions for the electromagnetic decay of the simplest and lowest lying of all the charmonium states, i.e. the pseudoscalar $\eta_c$.

2 Experimental values and relation to $J/\psi$ electromagnetic width

The first evidence of the $\eta_c$ state has been found in the inclusive photon spectra of the $\psi'$ and $J/\psi$ decays [11,12]. Subsequently, through $\gamma\gamma$ collisions, the decay width of $\eta_c$ into two photons has been measured in different experiments. The most recently reported values for the radiative decay width are shown in Fig. 1 [13–22], together with the Particle Data Group average [23], which reads

$$\Gamma_{\text{exp}}(\eta_c \to \gamma\gamma) = 7.4 \pm 1.4 \text{ keV}.$$  

In order to compare the experimental determinations with theoretical predictions, we start with the two photon decay width of a pseudoscalar quark–antiquark bound state [24] with first order QCD corrections [25], which can be written as

$$\Gamma(\eta_c \to \gamma\gamma) = \Gamma_{\text{PB}} \left[1 + \alpha_s \pi \left(\frac{\pi^2}{2} - \frac{20}{3}\right)\right].$$  

3 Introduction

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be obtained by comparing (2) with the expressions for the bound state which can be calculated from potential models. For the calculation of the wavefunction at the origin, we have used four different models, namely the scalar and the vector state. This is true up to errors of 1/3.

The correction can be computed from the two loop estimate agrees within 1% from the RHWilson equation to evaluate the photonic width, evaluated from (5), for the wavefunction at the origin (see for instance [27,28]).

As one can see from Fig. 2 the experimental width within 0.52, the Richardson factor is

\[ \Gamma \approx 3 \pm 0.57 \]

and

\[ \Gamma \approx 5.5 \pm 1.0 \text{ keV} \]

with potential models predictions for \( \eta \rightarrow J/\psi \) and \( J/\psi \rightarrow \gamma \gamma \).

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