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From quarkonium wave functions to $\gamma^*\gamma^* \to \eta_c(1S, 2S)$ transition form factors

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We discuss $\gamma^*\gamma^* \to \eta_c(1S)$, $\eta_c(2S)$ transition form factor
for both virtual photons. The general formula is given.
We use different models for the $c\bar{c}$ wave function
obtained from the solution of the Schr\"odinger equation for
different $c\bar{c}$ potentials: harmonic oscillator, Cornell,
logarithmic, power-law, Coulomb and Buchm\"uller-Tye.
We compare our results to the BaBar experimental data for $\eta_c(1S)$, for one real
and one virtual photon. We discuss approaching of
$Q_1^2 F(Q_1^2, 0)$ or $Q_2^2 F(0, Q_2^2)$ to their asymptotic value
$\frac{8}{3} f_{\eta_c}$ predicted by Brodsky and Lepage formalism.
We discuss applicability of the collinear and/or massless limit and delayed onset of
asymptotic behaviour.
We present some examples of two-dimensional
distributions for $F_{\gamma^*\gamma^* \to \eta_c}(Q_1^2, Q_2^2)$.
A scaling in $\omega = (Q_1^2 = Q_2^2)/(Q_1^2 + Q_2^2)$ was obtained.
A factorization breaking measure is proposed and factorization breaking effects are quantified and shown
to be weakly model dependent.
The cross section for the $e^+e^- \to e^+e^-\eta_c$ reaction are given for double
tagging (e^+ and e^-) case and the effect of (Q_1^2, Q_2^2) dependence of the
transition form factor is quantified.

I. Babiarz, V. Goncalves, R. Pasechnik, W. Schafer and A. Szczurek,
a paper in print i Phys. Rev. D (see also arXiv)

Additional comments

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