Mass Spectrum of Quarkonia: Role of Closed Mesonic Channels

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We address the long standing problem of the mass spectrum of quarkonia states. Various potential models describing successfully gross features of the mass spectra of quarkonia fail to reproduce their fine details, particularly those related to spin degrees of freedom. The combined action of forces involving spins of the quarks (spin-orbit and tensor forces) results in the mass splitting of the ^3P_J quarkonia states. The latter translates in the non-zero value of the ratio R defined as follows:

$$R(\chi) = \frac{m(^3P_2) - m(^3P_1)}{m(^3P_1) - m(^3P_0)} \tag{1}$$

All the approaches to the problem based on a potential description of the heavy quark interaction resulted in the following relations between values of R for various types of quarkonuim:

$$R(\chi_b') \gtrsim R(\chi_b) > R(\chi_c) \tag{2}$$

Predictions of potential models are in qualitative disagreement with the experimental results reading

$$R(\chi_b) > R(\chi_b') > R(\chi_c) \tag{3}$$

This long-standing problem casts doubts on the validity of a potential-based description of the interaction between heave quark and antiquark, or, at least, on the generally accepted Lorentz structure of the $\tilde{Q}Q$ potential.

We consider a mechanism which allows explaining experimentally observed regularities (3) in the framework of the conventional picture of the $\tilde{Q}Q$ interaction. Due to the quantum-mechanical production of light-quark pairs the quarkonia states dissociate into a pair of heavy mesons

$$(\tilde{Q}Q) \leftrightarrow (\tilde{Q}q) + (Q\tilde{q})$$

A coupling between the states of quarkonia and the heavy-meson states affects the mass spectrum of the former. *Qualitative* analysis shows that such a coupling alters the R values (1) bringing them in correspondence with the experimentally observed hierarchy (3). These findings are supported by numerical calculations of the effect in a simple model of the quarkonium dissociation. Thus the considered mechanism provides a clue to the solution of a long-standing problem of the quarkonia physics.