Contribution ID: **176** Type: **Poster**

Spectroscopy of the heavy quarkonia: energy levels splitting and relativistic corrections

Thursday, 3 September 2015 16:30 (1h 30m)

Experimental data on spectra of heavy quarks prove an existence of the quark spin dependent relativistic interactions, which are absent in the nonrelativistic potential models. There are experimentally observed (in the radiative E1-transitions N3S1-N-13PJ-N-l3 S1) triplets 3Pj of states with the splitting of dozens MeV (in charmonium and bottonium). The radiative M1 transitions between orto- (3S1) and para- (1S0) states are also observed in the charmonium family. An adequate account of relativistic effects is absolutely needed. We present a generalized relativistic model of quarkonium spectra, which is based on the numerical solving the relativistic Dirac equation with the corresponding QCD potentials. The total Dirac Hamiltonian contains a bare Dirac Hamiltonian with adding the quark spin dependent Breit-Fermi operator and spin independent one. Naturally, the Hamiltonian is broken on Lorentz-scalar and Lorentz-vector parts. The problem of Lorentz structure of the inter-quark potential provides a necessity of introducing a dynamical quark mass. The results of estimating spectra for families of charmonium and bottonium, radiative E1 transitions and lepton decay widths in charmonium are presented and compared with the results of other available potential model calculations and experimental data. Besides, the results of calculation of energy levels splitting in quarkonium in dependence upon the different form of the potential with teta-functional feature are presented.

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Session Classification: Poster