Thesis proposal: Speedy charmonia

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The starting of LHC in 2008 has been a key moment for high energy physics. Even if the Standard Model of particle physics (SM) revealed very robust against numerous experimental tests performed since 40 years, some questions are still open and the SM has to be seen as an effective theory of low energy, in particular in flavor physics: origin of the strong hierarchy observed among quark masses, dynamics at work in the mixing pattern among quark flavors, excess of baryon-antibaryon asymmetry observed in Universe with respect to sources of CP violation contained in SM. Direct searches of New Physics (NP) scan the energy range from 100 GeV up to the TeV scale while increasing the luminosity allows to study lower energy processes that are highly suppressed in the SM and, hence, are sensitive to quantum fluctuations with exchanges of NP massive virtual particles. To fully exploit experimental data in flavor physics, detect deviations from the SM and then constrain efficiently NP scenarios, theorists have to reduce as much as possible uncertainties coming from the confinement of quarks in hadrons, in particular by means of lattice QCD simulations.
The Higgs field interacts with charged leptons and quarks through Yukawa couplings. Interactions with the quark sector, in particular c and b quarks, receive more and more attention compared to the electroweak sector. The motivation of the thesis is to closely examine $c-\bar{c}$ bound states with a high energy in the center of mass: those systems are suitable to have a fresh look on old questions about the confinement mechanism in quarkonia, described so far in phenomenological studies by quark models or effective theories, to assess their reliability to analyse exclusive Higgs decays into $c-\bar{c}$ states. Those will be studied at LHC with a good precision because a large amount of data is assumed to come in next runs and upgrades. A peculiarity here is that the pair of quarks may have a large energy compared to their own mass. Light-cone formalism is appropriate in that case and computations of light-cone distribution amplitudes have been performed, based on non-relativistic QCD or solutions of Schwinger-Dyson equations. Systematic limits are known for both of them: truncation error for Schwinger-Dyson and treating perturbatively some quantities possibly outside the reliability regime of perturbation theory. A check of those from ab-initio methods is welcome and has never been undertaken by lattice QCD. To achieve our proposal, several strategies are possible, either extracting the moments of light-cone distribution amplitude or computing quantities in the direct space with kinematical conditions getting closer and closer to the light-cone. Getting a good quality of the signal will be the first task. Renormalization pattern has to be fixed with great care and cut-off effects will need a dedicated study. Finally, a comparison with analytical methods prediction will be precious to know more about their validity and systematics.