Thesis proposal: Higgs coupling to heavy quarks as a probe of New Physics scenarios

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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 $c-\bar{c}$, $b-\bar{b}$ and $b-\bar{c}$ bound states as they shed light on scenarios of NP with various extensions of the Higgs sector. Testing the existence of a light CP-odd Higgs boson, tracked by its mixing with quarkonia states, made of a $c-\bar{c}$ or a $b-\bar{b}$ pair, brings useful information if one knows the hadronic parameters associated to the leptonic width of pseudoscalar quarkonia: the SM contribution to those decays is highly suppressed because it is mediated by quantum loops. Scenarios beyond the SM allowing weak decays mediated by a charged Higgs boson through a right-handed current are attractive as well: very recent analyses of semileptonic decays of B_c meson into vector charmonium, performed at LHCb, give a further anomaly about flavor lepton universality, after those observed in $B \to K^{(*)} l^+ l^-$ and $B \to D^{(*)} l \nu_l$; however an issue is the relatively large uncertainty on form factors encoding the long-distance effects of QCD.

After dedicated studies to make systematically clean the extraction of physical information from correlation functions of quarkonia and *Bc* meson, obtained after lattice QCD simulations, and to cure large cut-off effects induced by simulating heavy quarks on the lattice and the extraction of form factors in a wide range of q^2 , this thesis will study the impact that the results will have for bounds on couplings of the extended Higgs sector to the heavy quark sector.

The thesis will benefit of a partial support by Agence Nationale de la Recherche, who has granted the project “LatHiggs”.