Contribution ID: **142** Type: **Talk**

Bottom quark mass determination from bottomonium at N^{3}LO

Tuesday 26 September 2017 15:55 (20 minutes)

The precise determination of hadron spectroscopy from fundamental principles pursues to unveil QCD at its non-perturbative regime.
The non-perturbative nature of QCD at hadronic scales implied the development of phenomenological approaches such as quark models or, more recently, computer-based calculations using Lattice QCD.
However, the unique properties of heavy quarkonium systems allow an entire calculation in terms of non-relativistic perturbative QCD.
Within NRQCD
the predictions of heavy quarkonium energy levels rely on the accurate description of the static QCD potential $V_{\rm QCD}(r)$.
Most recent calculations computed the energy levels of the lower-lying bottomonium states up to $\mathcal{O}(\alpha_s^5 m)$ and $\mathcal{O}(\alpha_s^5 m \log \alpha_s)$ utilizing pNRQCD [1], which describes the interactions of a non-relativistic system with ultrasoft gluons organizing the perturbative expansions in α_s and the velocity of heavy quarks systematically. A closed expression for arbitrary quantum numbers can be found in Ref. [2].

The convergence of the perturbative expansion depends, though, on the short-distance mass scheme selected to ensure the $\mathcal{O}(\Lambda_{\rm QCD})$ renormalon cancellation. The authors of Ref. [3] employed the well-known $\overline{\rm MS}$ scheme, commonly used for physical situations in which the relevant scale is of the order or larger than the heavy quark mass. For quarkonium the typical scale is much smaller, therefore the results can be substantially improved by switching to a low scale short-distance scheme. Thus, in this work we study the predictions of the energy levels of heavy quarkonium at N^{3}LO using the MSR scheme [4], and determine the bottom quark mass including charm quark mass effects. Our results have smaller perturbative uncertainties than a similar recent analysis [5], which uses the Renormalon-Subtracted mass scheme.

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Authors: ORTEGA, Pablo G. (University of Salamanca); Dr MATEU BARREDA, Vicent (University of Salamanca)

Presenter: ORTEGA, Pablo G. (University of Salamanca)

Session Classification: Spectroscopy of mesons

Track Classification: Spectroscopy of mesons