Contribution ID: **9**

Type: **Oral**

Up- and Down- Quark Masses from QCD Finite Energy Sum Rules

Tuesday, 4 December 2018 17:20 (20 minutes)

Due to quark-gluon confinement in QCD, the quark masses entering the QCD Lagrangian cannot be measured directly like, for example, the electron or the proton mass. They must be determined either numerically from Lattice QCD, or analytically using QCD sum rules. The latter makes use of the complex squared energy plane, and Cauchy's theorem for the current-current correlator of the axial-vector divergences. This procedure relates a QCD expression containing the quark masses, with a hadronic expression in terms of known hadron masses, couplings, and lifetimes/widths. Thus, the quark masses become a function of known hadronic information.

We determine the up- and down- quark masses from a QCD Finite Energy Sum Rule, using the pseudoscalar correlator to six-loop order in perturbative QCD, with the leading vacuum condensates and higher order quark mass corrections included. We reduce the systematic uncertainties stemming from the hadronic resonance sector by introducing an integration kernel in the Cauchy integral in the complex squared energy plane. Further, we examine the issue of convergence of the perturbative QCD expression of the pseudoscalar-current correlator. Both the Fixed Order Perturbation Theory (FOPT) method and Contour Improved Perturbation Theory (CIPT) method are explored. Our results from the latter exhibit very good convergence and stability in the wide window $s_0 = 1.5 - 4.0$ GeV^2, where s_0 is the radius of the integration contour in the complex squared energy s-plane. The results are: $(m_u + m_d)/2 = 4.36 \pm 0.36$ MeV (at a scale Q = 2 GeV), m_u(Q = 2 GeV) = 2.83 ± 0.23 MeV, and m_d(Q = 2 GeV) = 5.90 ± 0.48 MeV.

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Session Classification: Parallel 06