REPORT ON THE WORKSHOP: DETERMINATION OF THE FUNDAMENTAL PARAMETERS IN QCD: 7TH-12TH MARCH 2016

MAINZ INSTITUTE OF THEORETICAL PHYSICS

JOHANNES GUTENBERG UNIVERSITY OF MAINZ

The workshop was attended by some 30 participants, plus a few more from JGUM. This event was a follow-up to a previous workshop on the same topics that took place in Singapore in 2013, and had a similar attendance. The format was that of a true workshop, as opposed to a conference, in that afternoons were devoted entirely to discussions. The general atmosphere of the workshop was collegial, and the afternoon discussions proved to be extremely useful.

The topics covered at the workshop were: determinations of the QCD strong coupling, determinations of QCD quark masses and vacuum condensates, non-perturbative QCD, and the muon (g-2) anomaly. To describe it in more detail: (i) Determinations of the strong coupling covered the low energy region around the tau-lepton, where updated data from the ALEPH Collaboration sparked a fair number of reanalyses using QCD sum rules (QCDSR) and their moments. In this approach the issue of quark-hadron duality violations (DV) plays a role, and various attempts at quantifying their impact in the uncertainty on the coupling were discussed. More about DV will be dealt separately below. Above the tau-lepton region, there was a talk on the determination of the strong coupling using deep-inelastic electron-proton scattering. This approach is rather involved, and cannot be easily followed by non-experts. Finally, the strong coupling determinations in the heavy-quark region were reviewed, and all related issues covered, e.g. attempts at improving perturbative convergence by using mathematical methods, e.g. Pade approximants. The current status of the experimental data also received considerable attention. One could conclude that while there is still some room for improvement, nothing major should be expected before the next order in the perturbative QCD expansion is calculated. This will not take place before the next five-ten years. (ii) the next topic concerned the determination of the quark masses, with emphasis on the charm- and bottom-quarks. Lattice QCD (LQCD) results were presented, showing unprecedented accuracy, comparable to that now achieved analytically in the framework of QCD sum rules. (iii) The issue of potential renormalon ambiguities affecting the gluon condensate, the dimension d=4 term in the Operator Product Expansion (OPE), was dealt with in one talk. This is a contentious issue, as it is not possible to make quantitative estimates in a model independent way. The summation of very high order bubble-diagrams is model dependent. On the other hand, the gluon condensate entering the OPE, as used e.g. in QCDSR practical applications, should only be viewed as a parameter of the method, to be determined from the QCDSR themselves together with experimental data. Attempts at going beyond this approach fall outside this phenomenological approach. (iv) The current status of the muon magnetic moment anomaly was reviewed, with emphasis on a new method allowing for a determination of (g-2) without recourse to highly problematic electron-positron annihilation data. This method substitutes the contribution of these data by information on the first derivative of the electromagnetic correlator at the origin (q^2=0), in each of the three regions

(up-, down-, strange-quark), (charm-quark), and (bottom-quark). In the case of the charm- and bottom-quark regions these derivatives can be computed fully from QCD, using the heavy-quark expansion at q^2=0. The results obtained analytically in this method were recently fully confirmed by lattice QCD determinations. What remained was the derivative of the light-quark electromagnetic correlator. Triggered by a LQCD talk by Hartmut Wittig, showing results for this correlator as a function of q^2, the importance of this information was highlighted. Two months later, Wittig provided this valuable information, thus allowing for an entirely QCD determination of (g-2) of the muon, independent of the problematic electron-positron annihilation data. The result fully agrees with experiment, thus closing the window for "new physics" beyond the Standard Model, at least from this source. (v) The issue of potential quark-hadron duality violations lead to heated discussions between the proponents of such a scenario, and the sceptics. As pointed out long ago by Pich *et al.*, ***Violations of quark-hadron duality are difficult to estimate because those effects are unknown by definition.*** The Barcelona-York-San Francisco group made their case showing strong DV in the region of the tau-lepton, while the Mainz-Cape Town group presented categorical evidence for these DV to be either absent, or blurred by experimental errors. In addition the Valencia group showed rather clearly that the DV models of the Barcelona-York-San Francisco group were mere fits to the tau-data, thus not valid beyond the kinematical end point of tau-decay (as maintained by that group) The jury is out on this issue.

The written versions of the talks (up to 15 pages) will be published in the journal Modern Physics Letters A.

The infrastructure and manpower provided by MITP was truly exceptional and a special vote of thanks is due to the MITP staff involved.

Cesareo A. Dominguez

For the Organizing Committe