The Evaluation of the Leading Hadronic Contribution to the Muon $g-2$: Towards the MUonE Experiment

November 14th - 18th, 2022

EXECUTIVE SUMMARY

The topical workshop was devoted to the theoretical evaluation of the Leading Hadronic contribution to the muon $g-2$ ($a_\mu^{\rm HLO}$), with a strong emphasis on an alternative and independent determination of it, *i.e.* the possibility of extracting $a_\mu^{\rm HLO}$ from space-like scattering data such as the muon-electron scattering process (MUonE experiment).

The long standing discrepancy between the experimental value and the Standard Model (SM) prediction of a_μ is dominated, on the theoretical side, by the uncertainty on the leading order hadronic contribution. Traditionally, this is computed via a dispersion integral by using the hadronic production cross section in e^+e^- annihilation at low energies.

The discrepancy has become even larger after the latest measurement at Fermilab, reaching the 4.2σ. In the near future, new results from Fermilab and from J-PARC will further reduce the experimental error, possibly enlarging the difference with respect to the SM predictions.

In this framework, in recent years, theoretical calculations of $a_\mu^{\rm HLO}$ using Lattice QCD (LQCD) greatly improved, yielding results that tend to bring a_μ closer to the experimental value, and thus showing a tension with the standard data-driven $a_\mu^{\rm HLO}$ evaluations.

In this context, MUonE can shed light over this cumbersome situation. The main goal of MUonE is measuring the running of the QED coupling constant in the space-like region at low-momentum transfer with high precision, which in turn can be used to provide a space-like evaluation of $a_\mu^{\rm HLO}$. The main challenge at MUonE is measuring the differential cross sections with an accuracy at the 10^{-5} level, which demands a dedicated effort both on the experimental and theoretical side. The latter occupied a large part of the program and discussions at the workshop.

The first day was devoted to overview the state of the art of the muon $g-2$ experimental measurements and theoretical evaluations, and to discuss the status of MUonE. Some interesting results from the on-going MUonE *Test Run* were presented for the fist time at the workshop.

During the second day, the theoretical status of calculations for MUonE, up to NNLO accuracy in QED, and their Monte Carlo implementation was discussed in detail. The discussion continued on the third day, where also

the possibility to include, in the future, part of N3LO QED corrections was discussed.

During the fourth day, general parameterizations of the hadronic vacuum polarization function in the space-like region were discussed, giving crucial input for MUonE data analysis. There were then contributions on NLO and NNLO kernels in the space-like region and finally, in the afternoon, LQCD calculations and results were summarized and possible interplay with MUonE data scrutinized.

The last day was finally devoted to an open discussion among all the participants, where open questions were analyzed and a strategy to attack open issues was devised.

In summary, the workshop was extremely successful and we received positive feedback from all the participants. The community which in the years gathered around the MUonE project had the opportunity to overview the results reached so far, to set the bases for future work and to consolidate the collaboration.

Progress on the physics issues discussed was possible thanks to the active and continuous participation of colleagues and to the excellent organization offered by the MITP staff. We are extremely grateful to both.