Cluster of Excellence Precision Physics, Fundamental Interactions and Structure of Matter
PRISMA

Mainz Institute for Theoretical Physics

The Evaluation of the Leading Hadronic Contribution to the Muon Anomalous Magnetic Moment

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19 – 23 February 2018

The topical workshop focused on the hadronic contribution to the anomalous magnetic moment of the muon, both analyzing the most recent experimental results for its determination in time-like processes and taking into consideration the most recent dedicated lattice calculations.

In this context, a series of seminars and discussions were devoted to consider a recently proposed possibility of extracting the muon anomalous magnetic moment by using an alternative method which exploits experiments where space-like processes are involved such as the μ-e scattering or Bhabha processes. The aim was to discuss and to explore in detail the state of the art of precision radiative corrections to μ-e scattering and Bhabha processes in order to master the theoretical tools necessary to develop dedicated Monte Carlo simulation codes. Finally, part of the discussion was devoted to survey the experimental challenges for the extraction of the hadronic contribution to the running of the electromagnetic coupling constant in space-like processes. The foreseeable impact is represented by the possibility of testing the consistency of the standard model at the level of quantum corrections with an unprecedented precision and the possibility of ascertaining the presence of new physics virtual effects in a robust (and unambiguous) way.

The state of the art of the determination of the muon anomalous magnetic moment has been the main physics issue beyond the topical workshop. The latter was meant to directly focus on an alternative and independent determination of the hadronic contribution to the anomalous magnetic moment, i.e. the recently proposed possibility of extracting the muon anomalous magnetic moment by exploiting experiments that consist in space-like processes as the Bhabha scattering or t-channel in muon-electron scattering. The long standing discrepancy between the experimental value and the standard model prediction of the muon anomalous magnetic moment is dominated, on the theoretical side, by the leading order hadronic contribution. Traditionally, this is computed via a dispersion integral by using the hadronic production cross section in electron-positron annihilation at low energies. In the near future, the theoretical determination of the hadronic contribution will be further improved by the continuous efforts in the measurement of the low energy hadronic cross section.

The topical workshop explored the theoretical and experimental feasibility of an independent and competitive determination of the hadronic contribution w.r.t. the dispersive approach to g-2 by means of a high precision determination of the electromagnetic running coupling constant in the space-like region. The experimental challenges posed by the measurement of the effective electromagnetic coupling in the space-like region at low-momentum transfer with high precision was addressed. Together with the possibility of performing the measurement by means of the elastic scattering of 150 GeV muons (currently available at CERN North area) on atomic electrons of a low-Z target as well as by the Bhabha process at flavor factories.

As an introduction, the most recent experimental results for its determination in time-like processes as well as the most recent dedicated lattice calculations were reviewed. In the following discussions were devoted to exploit both the theoretical and the experimental issues involved in the new approach proposed.

In the first part of the topical workshop, the implications for a calculation of the electron muon impact section with NNLO accuracy were discussed. The calculation with these accuracy represents the necessary preliminary theoretical basis. The multi-loop calculation techniques by means of this evaluation will be possible were explored. A further important point was the development of a Monte Carlo code for the simulation of the events with comparable NNLO accuracy. The possibility of implementing NNLO precision calculations into a simulation code was analyzed. A preliminary version of a code accurate at the NLO was presented. World experts described the state of the art of Monte Carlo simulation codes for the processes under consideration. Contributions from the teams that developed codes such as BABAYAGA, PHOKHARA were presented.

In the subsequent sessions a series of important experimental aspects was discussed such as particle identification and hypotheses of possible detector structure especially in view of a test beam program scheduled for the year 2018. The detector is going to be optimized in order to be able to keep the systematic effects at the required level of 10 ppm.

The tracking system and the set up of the silicon detectors were discussed. The state of the art as well as the possible options for MUonE were considered. An extensive discussion was devoted to the issue of multiple scattering effects within the detector and to modelling the multiple scattering of the targets and simulations of the same effects. A several results in reproducing multiple scattering were obtained. Further work on this is underway.

The discussions during the sessions were alive. During all the presentations the discussions and comments were extremely useful. Some hypotheses of future collaborations concerning the theoretical accounts at NNLO were discussed, also the development of alternative MonteCarlo codes for the simulation of particle identification and robust particle identification. The latter issue was part of an open and thorough discussion.

To sum up, the topical workshop made it possible to come up with the bases of the most relevant theoretical and experimental questions. The competences of the participants helped to define and consolidate many of the working hypotheses. With regard for all aspects discussed, further investigations will be necessary and work is in progress. Progress on the physics issues discussed was possible thanks to the active and continuous participation of our colleagues.