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Research Statement

Starting with my master thesis and during my Ph.D. my studies focused on phenomenological aspects of high energy physics and in particular on the theory describing strong interactions, i.e. Quantum Chromodynamics (QCD). Computational tools??

Construction of an N^{3}LO DIS scheme

During my Master Thesis, under the supervision of Dr. Marco Bonvini and in collaboration with another Master student, I worked on the development of a so-called variable flavor number scheme (VFNS) for deep-inelasic-scattering (DIS) predictions at next-to-next-to-next-to-leading order (N^{3}LO) in perturbation theory. This is needed to correctly consider the heavy quarks mass effects when computing the electron-proton scattering, whose understanding is crucial in PDFs fit. Different proposal exist in the literature and they are all equivalent at all order in perturbation theory but differ at any given order in the way the different ingredients are combined. Moreover, in contrast with the available schemes, our construction takes into account the fact that the heavy quark PDFs are generated perturbatively (this is true in the case in which intrinsic components are neglected, while in the case in which they are not the scheme will have to be modified).
Currently, the ingredients needed for such a construction are completely known up to NNLO in perturbation theory, while at N^{3}LO there are still some missing informations. Even though a was also involved in the construction of the scheme, the bulk of the work I did during my Master thesis was to construct an approximation of the unknown terms of the N^{3}LO partonic cross section for DIS (the so-called coefficient functions) by combining some known limits. In this way it was possible to construct a VFNS at approximate N^{3}LO.
Ho approfondito bla bla bla
Perchè è importante?
As a result of this work two codes where written to produce the results. Both of them are now public and open source. The first one, `https://github.com/niclaurenti/adani`, is a `C++` code which computes the approximation of the heavy quark coefficient functions at N^{3}LO. The reason why the `C++` language was chosen is that in the N^{3}LO massive coefficient function there are some terms that are exactly known but only in numerical form since they are obtained through the integration of the lowest order coefficient functions and splitting functions. Therefore, a compiled code was more suitable to handle the heavy integrals that are required to be computed.
Then a `Python` code, `https://github.com/andreab1997/DIS_TP`, whose aim is to combine the different ingredients to actually compute the theory predictions with our scheme.
Regarding this work, a publication is in preparation.

PDFs fit

During my Ph.D. I continued with sudy of phenomenology in high energy phisics under the supervision of Prof. Stefano Forte. In particular I focused on the topic of PDFs fits: PDFs are objects that link the hadronic cross sections, that are what is actually observed experimentally, to partonic cross sections, that are what is computed theoretically. Being non-perturbative objects, the PDFs cannot be computed in perturbation theory but they must be fitted from data. I delved into this subject joining the NNPDF collaboration, where I had the opportunuty to study both the theoretical and the computational aspects.

My main project has been the inclusion of Quantum Electrodynamics (QED) effects in PDFs fit. The final aim was to provide the QED fit of the NNPDF4.0 series that replaced the old NNPDF3.1QED PDF set. In order to achieve it, different things had to be implemented in different codes. The first step is the implementation of QED corrections to the PDF evolution equations, i.e. the DGLAP equations. They are a system of integro-differential equations, whose solution is highly non-trivial. expand a bit The solution of DGLAP equations, in presence of QED effects, has been implemented in the public code `EKO` (`https://github.com/NNPDF/eko`): it is a `Python` code that solves DGLAP equation with the tecnique of Mellin transform, that before I joined the NNPDF collaboration was desined to handle only the pure QCD case. I extended it also to the QED case. Discuss the steps? i.e. find the evolution basis, find the form of DGLAP in this basis, mellin transform the splittings, implement them in EKO, find an appropriate solution

The second step has been the extension of the NNPDF fitting code to consider the presence of a photon PDF. Indeed, once we consider QED effects, that means that we allow photons emissions from the quarks inside the proton, we have to consider also a photon PDF. This is obtained through the LuxQED method [1, 2], that links it to the quarks and gluon's PDFs through a perturbative calculation. I interfaced the `FiatLux` code, that implements the LuxQED formula, with the NNPDF code (`https://github.com/NNPDF/nnpdf`)

Parlare di N^{3}LO

Side projects

References

[1] Aneesh Manohar, Paolo Nason, Gavin P. Salam, and Giulia Zanderighi. How bright is the proton? A precise determination of the photon parton distribution function. *Phys. Rev. Lett.*, 117(24):242002, 2016.

[2] Aneesh V. Manohar, Paolo Nason, Gavin P. Salam, and Giulia Zanderighi. The Photon Content of the Proton. *JHEP*, 12:046, 2017.