

The Adler function: Theory vs. Experiment

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www-com.physik.hu-berlin.de/~fjeger/pQCDAdler.tar.gz

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Abstract

Description of FORTRAN package pQCDAdler

Not supported by any institution

Download and Installation

Download link: *>>> [pQCDA Adler.tar.gz]

The package for calculating the Adler function is available in two versions:

⇒ pQCDA Adler calculating the Adler function $D(Q^2)$

⇒ pQCDA Adler1 as above with in addition a preliminary attempt to use analytic perturbation theory (APT) as advocated by the DUBNA group

Adler Function Package

pQCDAdler

pQCDAdler is fairly compact and simple to install:

- ❖ `untar file pQCDAdler.tar.gz`
- ❖ `edit Makefile`; adjust directories, load path [compiler?] etc.
- ❖ `make`
- ❖ `run ./pQCDAdler.sh` → writes results to files `pQCDAdler.dat"xy"`
 - ❖ x number of flavors $n_f = 3, 4, 5, 6$
 - ❖ y order of full massive QCD perturbation theory `ior = 0, 1, 2`

corresponds to 1-, 2- and 3-loop massive QCD results; massless 4- and 5- loop can be included, they only improve effectively massless high energy tail

Warnings: the required running couplings $\alpha_s(s)$ in MSbar and BF-MOM schemes have been saved in data files for a given energy range (see below). If $D(Q^2)$ is called outside the given ranges warnings like **warning: alpha-s: e < e_min** are produced. If needed appropriate data files have to be generated by the programs the user can find in the sub-directory **qcd**. Of course this only works in limited ranges where pQCD is supposed to be applicable.

Output data files are for plotting with your favorite plot program. Headers written are for my GRAPHX plot program. The user should change these to their needs. Figures are plotted with **adlertest.par** (is a parameter file only but includes information about data files and formats utilized)

Taking into account full mass dependence is crucial. Therefore Background Field MOM (BF-MOM) scheme is used. Gauge dependence is removed upon normalization to the high energy MSbar scheme, which requires rescaling of

energy and masses (option parameter `isc`).

The BF-MOM 2-loop β function is mass dependent with physical decoupling thresholds and can be integrated numerically only (using Runge-Kutta routines from NAG library). Resulting effective couplings are generated in sub-directory `qcd` with the help of programs `qcdpar2`, `qcdpar2_test`, `make_qcdpar2test` and `qcdpar4`, `qcdpar4_test`, `make_qcdpar4test`

Running couplings are stored in data files `qcdpar2_alsi.ou1,2,3,4` and `qcdpar4_alsi.ou1,2,3,4` for MSbar and `qcdpar4_alsi.mo1,2,3,4` for BF-MOM effective couplings.

These may be generated by running the shell-script `qcdparx.sh`

QCD input parameters are set in `constants_qcd.f` and (historical reasons) processed via `rqcd-param.f`

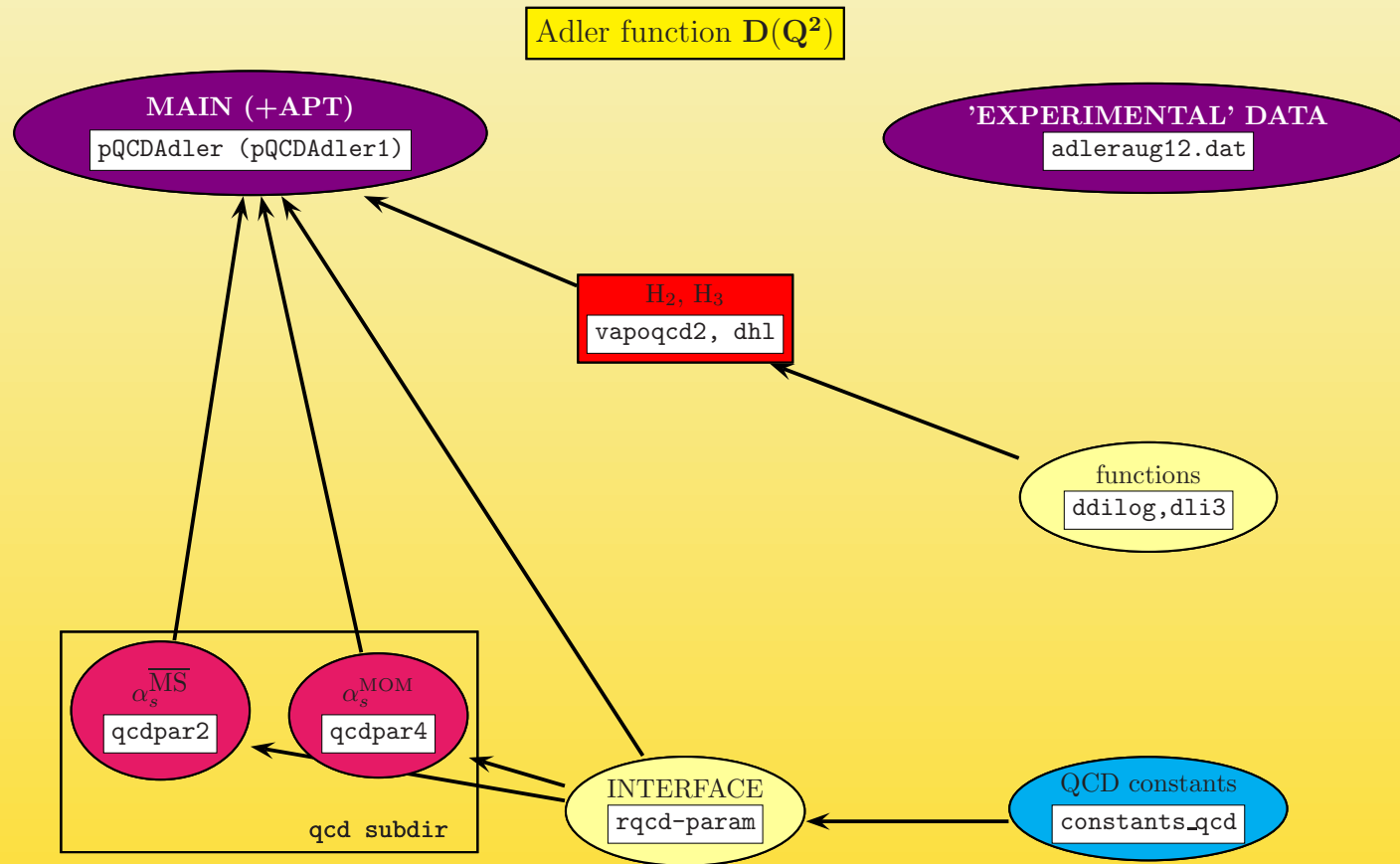
The routine `vapoqcd2.f` provides the 2-loop massive coefficient function, while `dh1.f` the 3-loop heavy-light insertions. Other 3-loop massive coefficient

contributions are in subroutines of the main program `pQCDAdler.f`

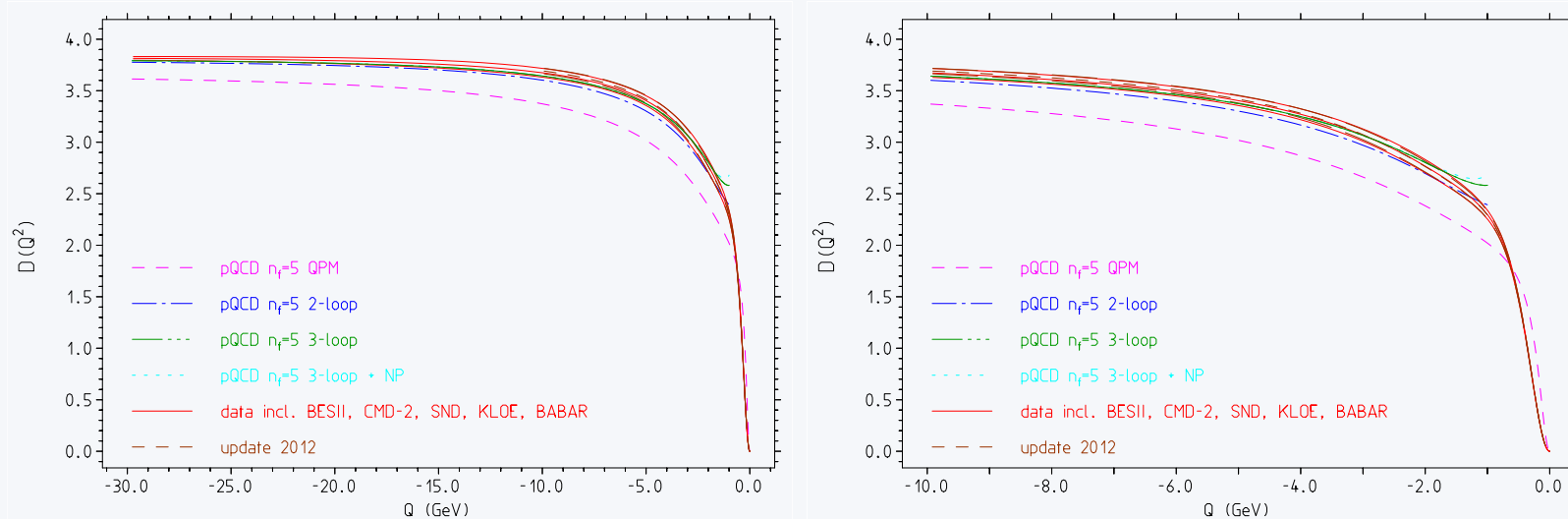
Programs may be executed via a shell script `pQCDAdler.sh` with option files `pQCDAdler.inp0,1,2`

pQCDAdler1

Is essentially the same as pQCDAdler but includes preliminary implementation of analytic perturbation theory (APT) The program structure is displayed in the following diagram:

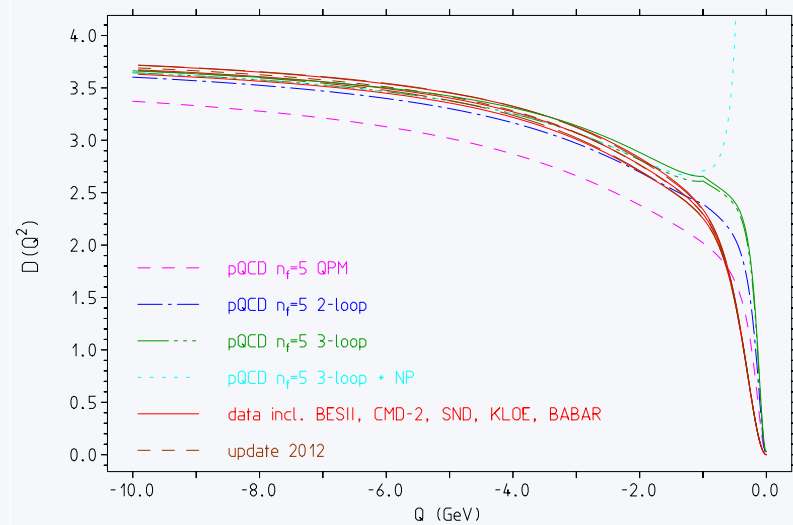
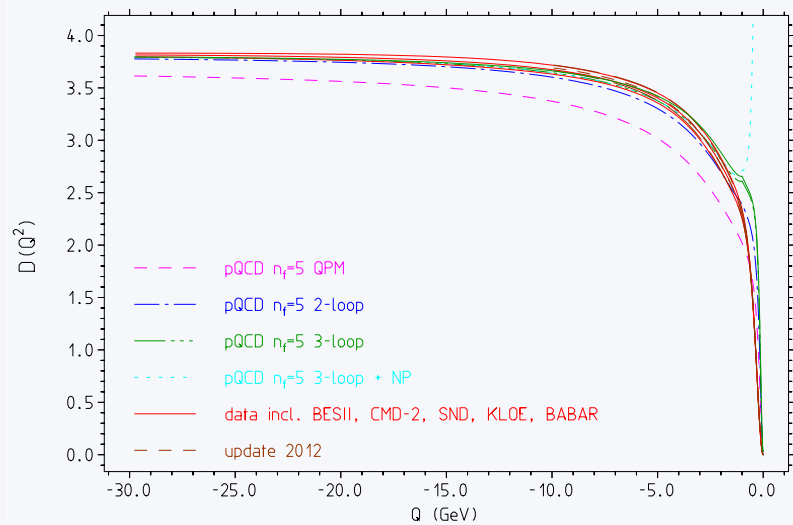


Sample Plots based on pQCD in BF-MOM scheme cut at 1 GeV:



Experimental data obtained by integrating $R^{\text{had}}(s)$ are listed in [adleraug12.dat5](#) in the range $E = -100 - 0$ GeV the sign indicating space-like region (older versions are [adleraug03.dat5](#) from 2003 and [adleraug06.dat5](#) from 2006).

Sample Plots as above with BF-MOM couplings replaced by APT couplings.



References

- S. Eidelman, F. Jegerlehner, A. L. Kataev and O. Veretin,
"Testing non-perturbative strong interaction effects via the Adler function",
Phys. Lett. B 454 (1999) 369 [hep-ph/9812521] and references therein

pQCDAdler makes use of BG-MOM RG; gauge parameter fixed by merging with MSbar in high energy limit

- F. Jegerlehner and O. V. Tarasov,
"Exact mass dependent two loop $\alpha_s(Q^2)$ in the background MOM
renormalization scheme",
abst Nucl. Phys. B 549 (1999) 481 [hep-ph/9809485] and references therein

For applications see also:

- F. Jegerlehner,
"Hadronic effects in $(g - 2)_\mu$ and $\alpha_{\text{QED}}(M_Z)$: Status and perspectives,"
In *Barcelona 1998, Radiative corrections: Application of quantum field theory

to phenomenology* 75-89, [hep-ph/9901386].

□ F. Jegerlehner,

“Hadronic contributions to the photon vacuum polarization and their role in precision physics,”

J. Phys. G **29** (2003) 101 [hep-ph/0104304].

□ F. Jegerlehner,

“The Running fine structure constant $\alpha(E)$ via the Adler function,”

Nucl. Phys. Proc. Suppl. **181-182** (2008) 135 [arXiv:0807.4206 [hep-ph]].