

## Exercises on Quantum Chromodynamics problem sheet 10

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*Worksheet : Callan-Gross relation and gauge symmetry.*

### Problem 1

In the lectures we have derived the Callan-Gross Relation for spin-1/2 partons

$$F_2(x) = 2xF_1(x). \quad (1)$$

Derive a similar relation for scalar partons.

### Problem 2

In the lectures we have formulated a general scheme how to calculate the quark-gluon running coupling constant  $g$  evaluating one-loop corrections to the quark and gluon propagators and quark-gluon vertex. We then eventually did most of the calculation explicitly in the exercises. The  $SU(3)$  gauge symmetry requires that the constant appearing in the QCD Lagrangian at the ghost-gluon vertex is EXACTLY the same as in the quark-gluon one. Therefore one can, alternatively, calculate the QCD beta-function by studying the renormalization of the coupling constant  $g$  that enters the "ghost" part of the QCD Lagrangian.

Explain how this calculation has to be done and write down the necessary diagrams.

[ We will not calculate these diagrams at the exercises, but you are of course welcome to do this calculation to test yourselves!]