

Subatomic Physics II

Problem Set 4

Due on October 28, 2021, 23:59

Problem 4.1: Deep inelastic lepton-nucleon scattering

The HERA particle collider at DESY in Hamburg provided collisions between electrons ($E_e = 30$ GeV) and protons ($E_p = 900$ GeV). Consider neutral-current scattering reactions: $ep \rightarrow eX$, where X denotes any hadronic system. Among other things, the energy E_0 and polar scattering angle θ_e of the scattered electron were measured by the detectors H1 and ZEUS surrounding the two HERA interaction regions.

- Express the variables Q^2, x and y in terms of E_e, E_p, E_0, θ_e using relativistic kinematics. (3pt)
- Express the variables Q^2, x, y and W^2 in terms of the Mandelstam variables s, t and u . (1pt)
- What should be the energy reached by an electron beam hitting a solid proton target to have the same centre-of-mass energy as HERA? (1pt)

Problem 4.2: Structure functions

- The integral of combinations of DIS structure functions over the entire range $[0, 1]$ allowed gives rise to several interesting so-called “sum rules”. Find an expression in terms of the PDF for the following sum rules, based on the quark-parton model: (2pt)
 - Adler $S_A = \int_0^1 \frac{dx}{x} (F_2^{\nu n} - F_2^{\nu p})$
 - Gottfried $S_G = \int_0^1 \frac{dx}{x} (F_2^{ep} - F_2^{en})$

What do you expect as outcome? (1pt)

- The Adler sum rule is experimentally better satisfied than the Gottfried sum rule. Can you think of a reason why? (2pt)