Problem Set 5

Standard model of particle physics
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Data used in this exercise was retrieved from `http://hepdata.cedar.ac.uk/pdf/pdf3.html`. Firstly, we wanted to see if we would get the proton charge to one from the parton distributions. using notation $f_p = f_p(x, Q)$ to denote the parton distribution for fermion f, the integral I calculated was

$$q(p) = \int_0^1 \mathrm{d}x \frac{2}{3}u_p - \frac{1}{3}d_p - \frac{2}{3}\bar{u}_p + \frac{1}{3}\bar{d}_p.$$

The reason why I didn't include the strange, charm, bottom etc. is because their antiparticle parton distributions are so similar that they give virtually no contribution to the result. I extracted data from the website with logarithmically scaling values of x between 0.0001 and 1, with stepsize 0.0001. Q was chosen to be 100 GeV^2. The integral was performed using the trapz function in numpy (Python). The numerical result in units of e was

$$q(p) \approx 0.982.$$

I also checked the dependence of the proton charge on Q, Table 1 shows the numerically calculated value of $q(p)$, for different values of Q.

Tabell 1: $q(p)$ dependence on Q.

Q [GeV^2]	50	100	200	1000
$q(p)$ [e]	0.9821	0.9812	0.9802	0.9782

From the table we observe a slight but not very significant dependence on Q.

If we wanted to study the parton distributions for the antiproton or neutron, we can use isospin invariance. For the antiproton we could just let $u \to \bar{u}$, $d \to \bar{d}$. Similarly, a neutron is basically a proton where one lets $u \to d$, $d \to u$. To check if this reasoning is sound, I tried calculating the antiproton and neutron charges using this logic. My result indicates that it works, since I got $q(\bar{p}) = -0.9812$ and $q(n) = -0.0022$ in units of e. Which are both very close to the true values.