Exercises Physics VI (Nuclei and Particles)

Summer Semester 2009

Exercise sheet Nr. 4

Work out until 28.05.2008

Exercise 1: De-Broglie-wavelength (Points: 1)

What is the kinetic energy at which neutrinos ($m_\nu = 0$), electrons, muons or protons have a De-Broglie-wavelength of $\lambda = 2\pi\lambda = 1$ fm? What is the energy of a photon with wavelength 1 fm?

Exercise 2: Form factor (Points: 5)

a) Show that the form factor of a spherically symmetric ($\rho(\vec{r}) = \rho(r = |\vec{r}|)$) charge distribution is given by

$$F(\vec{q}) = F(q) = 4\pi \int_0^\infty \rho(r) \frac{\sin(qr/\hbar)}{qr/\hbar} r^2 dr$$

Here ρ is normalized to 1: $\int \rho(\vec{r}) d^3r = 1$.

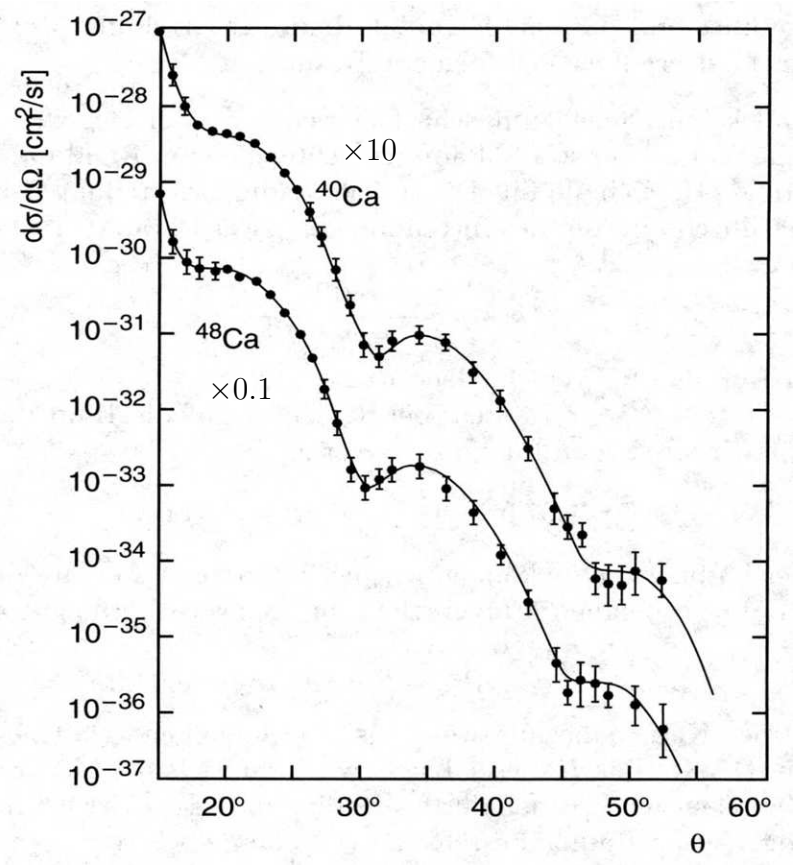
b) A nucleus can in first approximation be viewed as a homogeneously charged sphere with radius R. Demonstrate that under this assumption its form factor is

$$F(q) = \frac{3}{x^3} \cdot (\sin x - x \cos x) \quad \text{with} \quad x = \frac{qR}{\hbar}$$

c) Calculate $F(q = 0)$.

d) Identify (graphically or numerically) first three zero points of $F(x)$ ($F(x) = 0$).

e) The figure below shows the dependence of the measured cross section on the scattering angle for scattering of electrons with energy of $E = 750$ MeV on ^{40}Ca and ^{48}Ca. Which angles correspond to the zero points in the form factor from previous parts of this exercise? Using this information, calculate the radius R of both isotopes.



<u>Exercise 3</u>: Feynman diagrams (Points: 2)

a) Show all Feynman diagrams with single a photon exchange for $e^+e^- \to e^+e^-$ interactions. What is different if one considers $e^+e^- \to \mu^+\mu^-$ reactions instead of $e^+e^- \to e^+e^-$?

b) Show Feynman diagrams for β^--decay, β^+-decay and electron capture. Note that the exchanged W-boson couples to vertexes with nucleons or leptons. It does not couple to single vertex with both nucleon and lepton.