Modern Experimental Particle Physics (FYST17/EXTP35) - Problems 2014

Chapters 1-4; return by February 7

1. Elastic scattering of elementary particles preserves their identities, and proceeds via exchange of neutral gauge bosons. Estimate the maximal range over which such exchange can take place, if the exchanged boson is:

a) photon, $m_\gamma = 0\ GeV/c^2$

b) Z boson, $m_Z = 91.19\ GeV/c^2$

c) Higgs boson, estimated minimal mass $m_H = 125\ GeV/c^2$

2. Define which hadron quantum number combinations $(Q,B,S,C,\tilde{B})$ are allowed by the quark model, and suggest their quark constituents:

a) (0,0,1,0,0)
b) (2,1,0,1,0)
c) (0,0,0,0,1)
d) (-1,1,-2,0,-1)

3. A secondary particle beam can consist of several types of different particles. Separators are used to select the type of particle required. The separator consists of two parallel plates with a high potential between them. The beam passes between the plates and then through a deflecting magnet and slit system. Show that the difference in angular deflection, $\Delta\theta$, of two relativistic particles with momentum p and masses m_1 and m_2, after traversing an electric field of strength E and length L, is $\Delta\theta = eEL(m_1^2 - m_2^2)/2p^3$.

4. The critical energy of the electromagnetic shower development in iron is $E_C = 24\ MeV$, and one radiation length is $X_0 = 1.76\ cm$. Estimate the necessary thickness of a calorimeter that uses iron as an absorber, if initial electrons have energies not exceeding $E_0 = 100\ MeV$.

5. Electromagnetic decays of η meson to two pions have never been observed, which is explained by the parity conservation requirement. Use this knowledge to:

a) deduce the parity of η, knowing that it has spin 0;
b) deduce intrinsic parity of the pion, knowing that decays of η to three pions are readily observed.