INTERACTION OF NEUTRON AS HADRON IN NUCLEUS

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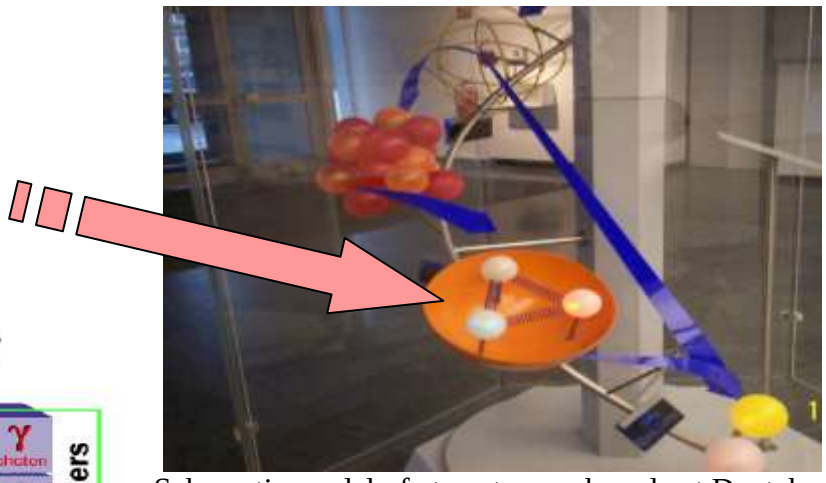
Abstract. Neutron comprises of three quarks i.e. one up (u) quarks and two down (d) quarks. As the most abundant particle and bounded together with protons in a nucleus, neutrons neutralise the repulsive charge of protons within the nucleus to stabilise the nucleus.. This paper discusses the interaction of baryon neutron bounded as hadron in the nucleus.

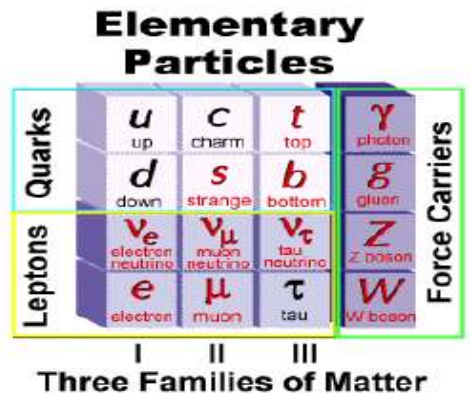
Introduction. **Hadrons are particles bounded together a in nucleus** by strong forces via **composite quarks**. Hadrons are classified into two families i.e. baryons which has three quarks and mesons with has two quarks. As a hadron in a family of baryon, neutron has of three quarks i.e**. one up (u) quarks and two down (d)** quarks. In Quantum Chromodynamics, changes of one quark flavors into another involve the radiation of gluons mediating strong interactions.



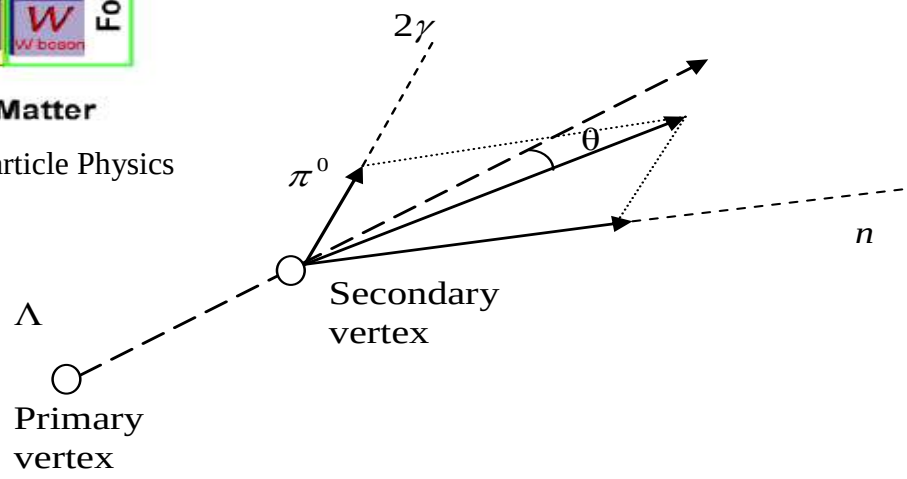
Schematic model of atom-to-quark scale at Deutches Elektronen Sychrotron (DESY), Hamburg

NEUTRON

- **Neutral particle ^{0}n – charge zero**
- **Magnetic moment** $\mu = -1.913\mu_N$
- **Family of Baryons**
  - **Has 3 quarks: u d d**
  - **Bound by strong force**
- **Rest mass: 939.6 MeV**
- **Mean life** $\tau = 885.7s$
- **Decay length** $c\tau = 2.655\times10^8 km$
- **Decay mode** $n \to p + e^- + \bar{\nu}_e$
- **Electric dipole moment (EDM)** ~10^{-28}ecm



Standard Model of Particle Physics



Neutron moves in a straight path, in decay channel $\Lambda \to n\pi^0$ channel (35.8% yield) where the two decay products moved along its original trajectories in two undetectable tracks, with $\pi^0 \to 2\gamma$ (98.8%).

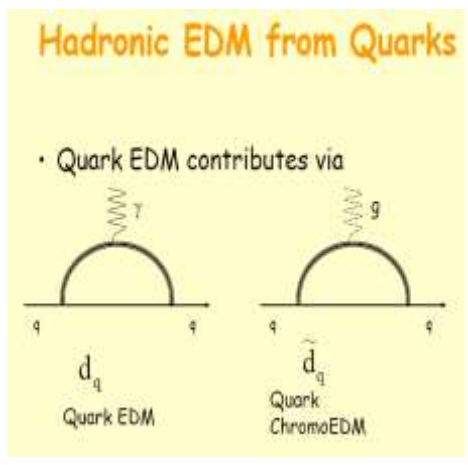
Although electrically neutral overall, the neutron is made up of charged quarks. An imbalance of charge on one side would cause a non-zero **Electric Dipole Moment (EDM)**. A **neutron EDM** is believed to exist at some level to explain the matter-antimatter asymmetry of the Universe.

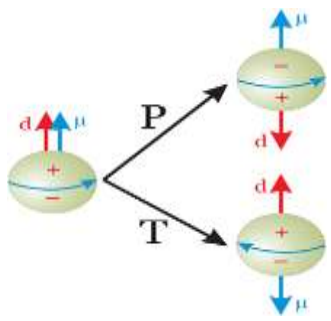
- Standard Model $10^{-31} – 10^{-32}$ ecm,
- supersymmetric: $10^{-25} – 10^{-28}$ecm.

A shift in the neutron Larmor spin precession frequency ν, when the applied electric field E is reversed, is given by:

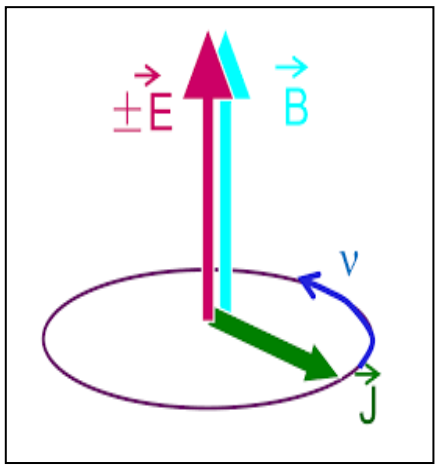
$$h\nu = 2dE \pm 2\mu B$$

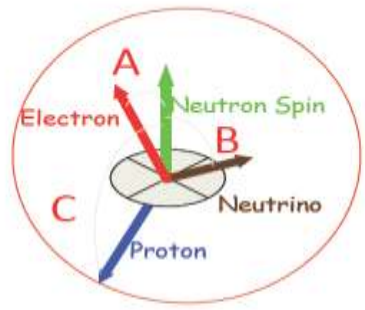
where d is the EDM, μ is the magnetic dipole moment, B is the magnetic field, and h is the Planck constant.



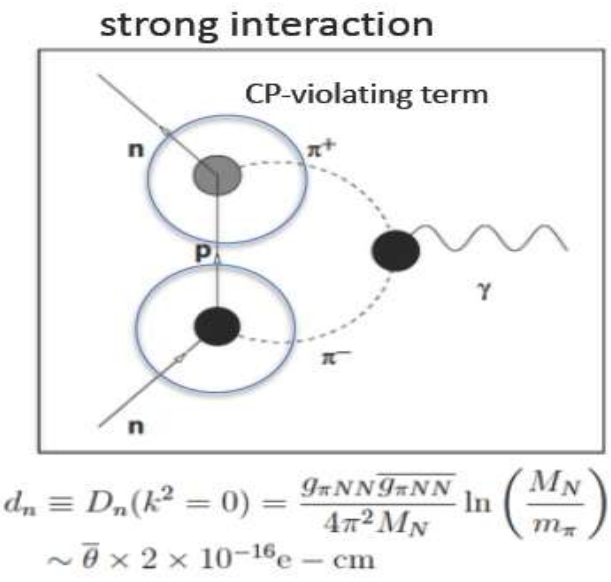


Parity (P) and time reversal (T) violation due to an electric dipole moment



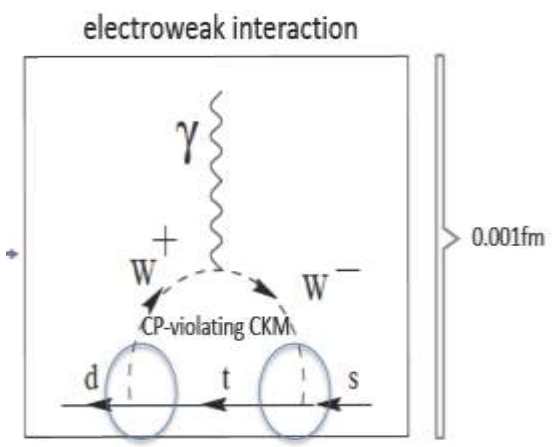


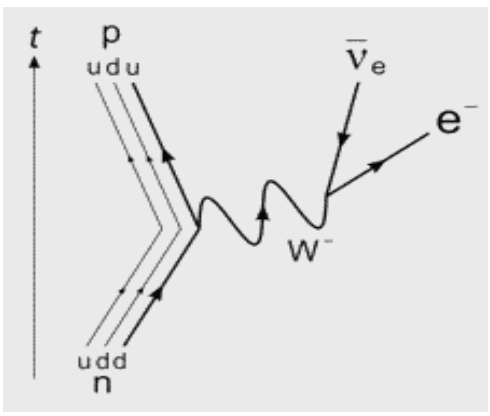
A: electron asymmetry
C: proton asymmetry
B: electron spectrum
a: proton spectrum
D: triple product



$$d_n \equiv D_n(k^2=0) = \frac{g_{\pi NN}\overline{g_{\pi NN}}}{4\pi^2 M_N}\ln\left(\frac{M_N}{m_\pi}\right) \sim \bar{\theta}\times 2\times 10^{-16}\mathrm{e-cm}$$

Strong interaction between neutron and proton in bounded state as hadron via an exchange of meson $\pi^{\pm}$ with the emission of γ
(source: Stephan Paul et.al, The neutron and the Universe History of a Relationship TU-München 2016)





Decay mode $n \to p + e^- + \bar{\nu}_e$
via a boson W$^-$ interaction

Conclusion. Neutrons are bounded with protons in nucleus by strong forces via the exchange of meson $\pi^{\pm}$. These hadrons may change undergo electric dipole moments when subjected to external field at femto scale and may cause the emission photons in the process.