Nuclear Force (ref. AKD, RPS)

Nuclear Force: Special types of force which are very strong and acting within the nuclear dimension (10^{-15} m) are known as nuclear forces which bind together the nucleons within the nucleus and make it stable.

For the purpose of details study of nuclear force we may divide it in two parts – (i) Nature of nuclear force and (ii) Origin and mechanism of nuclear force (Exchange forces).

(i) Nature of nuclear forces:

(a) Short range force: Nuclear force operates only within the nuclear dimension (10^{-15} m). It abruptly vanishes to zero on just crossing the nuclear border. Outside the nuclear border simple coulombic potential operates.

(b) Charge independence forces: It has been actually observed that the protons and neutrons are indistinguishable within the nucleus. The charge has no effect on nuclear forces. Actually all the nucleons participate equally in the nuclear force i.e. all possible interactions p-p, n-n or n-p are equally possible and contributory after allowing for the electrostatic repulsive force between the protons. So it may be concluded that the nuclear force is charge independence. It has been established in the mirror nuclei (e.g. ${}^{3}_{1}H$ & ${}^{3}_{2}He$) where replacement of a p-p force by a n-n force does not change the nuclear force except the p-p repulsive force.

(ii)Exchange forces *(meson exchange theory)* and mechanism of nuclear forces*:*

The model of exchange force among the nucleons can successfully explain all the characteristic features of nuclear forces. According to this theory, if an exchange interaction prevails through the sharing of some common property among the particles, then the overall energy of the system gets lowered down and more and more stable.

Meson exchange theory: According to Japanese physicist Hideki Yukawa (1935), like the two atoms held together by the mutual sharing of an electron – pair in a covalent molecule, a pair of nucleons may be held together by sharing a particle of appropriate mass and charge. Such a nuclear particle is known as л-mesons (or pions). Meson may have a positive charge (л$^{+}$), a negative charge (л$^{-}$) or no charge (л^{o}). They are having masses lying between those of electrons and protons. Each of the charge mesons ((л$^{+}$ and л$^{-}$) has the rest mass of 273 m_e and л^{o} meson is having rest mass of 264 m_e. They have no spin. According to Yukawa, the following inter-conversions are always going on very fast within the nucleus.

n ↔ p + л$^{-}$, p ↔ n + л$^{+}$ and p ↔ p + л^{o}, n↔ n + л^{o}

Actually, the exchange of charge mesons (л$^{+}$ and л$^{-}$) explains the binding energy between the neighbouring neutrons and protons. The transfer of a charge converts a neutron to a proton or vice versa. Similarly, the exchange of л^{o} meson can explain the binding energy between the nucleons of each kind. The resultant attractive bindings are indicated by doted lines as follows: