The atomic nucleus first discovered by Ruthenford in 1911 by α- particle scattering experiment.

The atom consist of very small nucleus of the size 10^{-14}
surrounded by electrons.

Nuclei consist of protons and nutrons, protons are +ve charged and nutrons are electrically nutral. Protons and nutrons are two different charge state of the same particle called the nucleons.

A ~~ttt~~ nucleus is represented by $_{Z}X^{A}$

$_{11}Na^{22}$ $\quad$ $Z \longrightarrow$ atomic no

$A \longrightarrow$ mass

* classification of nucleus

(1) Isotops: Nuclei having same atomic no (Z) but different ~~ttt~~ mass no. are called isotops.

Ex — $_{14}Si^{28}$, $_{14}Si^{29}$

(2) Isobar: Nuclei having same mass no (A) but different atomic no. are called Isobars.

Ex — $_{8}O^{16}$, $_{7}N^{16}$

Isotons: Nuclei with equal no. of nutrons are called Isotons. Ex - ${}_{6}C^{14}$, ${}_{7}N^{15}$

Isomer: There are atoms which have same Z and A but differ from one another in their nuclear energy state, and exhibit differences in their internal structure.

Such nuclei are called isomeric nuclei / isomer

Mirror nuclei: Nuclei which have same A but the no of protons in ① is equal to the no. of ~~protons~~ nutron in ② are called mirror nuclei. Ex - ${}_{4}Be^{7}$, ${}_{3}Li^{7}$

* Properties of Nucleus

1) Charge: If Z is the ~~charge~~ atomic no. of nucleus i.e no. of protons in it then charge of the nucleus = +Ze

where e is the +ve charge equal to the charge of the electron = 1.6×10^{-19} C

(2) <u>Mass</u>: If A is the mass no. i.e the total no. of nucleons in the nucleus i.e Z protons and (A − Z) ~~nt~~ neutron, then the mass of the nucleus is very nearly equal to A amu.

If terms of amu the mass of carbon atom C^{12} is taken (12 amu) ~~and 1 amu (1u)~~

$$1 \text{ amu} = 1.6604 \times 10^{-27} \text{ kg}$$ ~~1.6×10^{-19}~~ eV. $\times 10^{6}$

$$= 931.48 \text{ MeV}$$

(3) <u>~~Nucleus~~ Radius</u>: As the ~~radius~~ nucleus is approximately spherical it volm is proportional to total no. of nucleons in it

$$\therefore \tfrac{4}{3}\pi r^3 \propto A$$

$$\Rightarrow r \propto A^{1/3}$$

$$\Rightarrow r = r_0 A^{1/3}$$

$$r_0 = 1.3 \times 10^{-15} \text{ m} = 1.3 \text{ Fermi } (F)$$

(4) <u>Density</u>: Nuclear density $\rho_N = \dfrac{\text{Nuclear Mass}}{\text{Nuclear Vol}^m}$

$$\text{Nuclear mass} = A m_N$$

A = mass no

m_N = mass of nucleon (P+N)

$= 1.67 \times 10^{-27}$ kg

Nuclear $Vol^m = \frac{4}{3}\pi r^3$

$$= \frac{4}{3}\pi \left(r_o A^{1/3}\right)^3$$

$$\rho_N = \frac{A m_N}{\frac{4}{3}\pi (r_o^3 A)}$$

$$= \frac{1.67 \times 10^{-27}}{\frac{4}{3}(3.14)(1.3 \times 10^{-15})^3}$$

$$= 1.816 \times 10^{17} \text{ Kg m}^{-3}$$

This shows that the nuclear matter is in a highly compressed state.

Q) What are nuclear forces explain the properties of nuclear forces:

Ans → A nucleus consist of protons and nutrons. Since the protons are +ve ly charged the electrostatic force of repulsion betn them ~~lost~~ should cost a distribution of the nucleas. The gravitational force of attraction betn the neutrons is too weak to account for the observed binding energy of the nucleus.

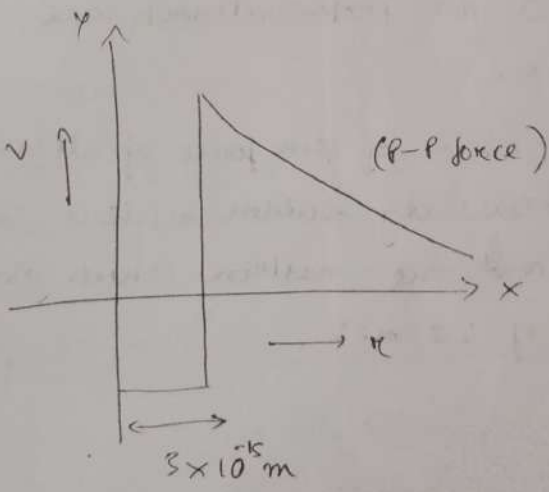
So, there must be some other forces which binds the nucleons. There are ~~tt~~ Three types of attraction forces -

(1) Force betn two proton (P-P)

(2) Force betn proton and nutron (P-n)

(3) Force betn two nutrons (n-n)

(1) P-P force: The force betn two protons has been examine by P-P scattering experiment. This experiment shows that the force can be represented by the potential curves shown in fig.

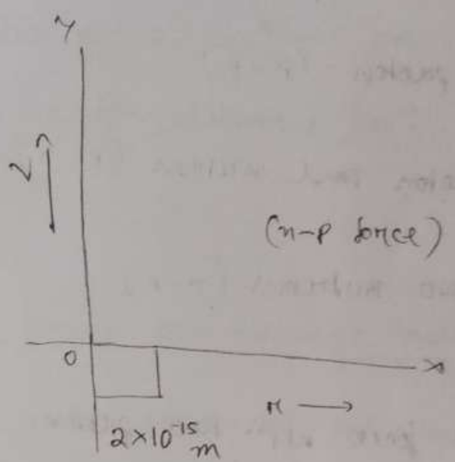


At large distance of separation the protons repale each other by coulmb electrostatic force. At a distance of approximately 3×10^{-15} m, the protons strongly ~~attra~~ attract each other. And this strong attractive force is the ~~nuclear~~ nucleon force betn the pair of forces.

2) P-n force: The force betn a proton and nutron Pr

has been examine by n-p scattering experiment.

This experiment shows that the nutron-proton force can be represented by potential curve (1)



(2)

At large distance of seperation betn a nutron and a proton, their is no force betn the two particles. But at a distance about 2×10^{-15} m the nutron and the proton attract one another by a nuclear force.

The existance of p-n force of attraction is prooved by the stability deutron nucleas consisting of one proton and one nutron which has a (3) binding energy of 2.2 meV.

(3) n-n force:

The nutron excess in heavily nuclei conform that n-n forces are attractive but not sufficiently large to let to a stable di-nutron just at a di-proton doesn't exist. The scattering length of n-n interaction approach to have the same chains as the p-p interaction.

Properties of nuclear forces:

(1) Nuclear forces are short ranged: Nuclear forces exist only when the distance betn the nucleon the order of 2.2×10^{-15} m or 2.2 fm. The force vanishes if the distance betn is greater than 4.2×10^{-15} m.

(2) Nuclear forces are charge independent:-
From the study of the mirror nuclei we have found that there are three types of forces (p-p, p-n, n-n) are almost equal magnitude. It is found that the total binding energy depends only on the total number of nucleons and not on their nature. In other words the nuclear forces are charge independent.

(3) Nuclear forces are the strongest known forces in nature: The magnitude of nuclear forces is many times the electrostatic repulsive force betn the protons and about 10^{38} times the gravitational force betn the nutrons

4) Nuclear forces are spin dependent

It has been observed that the force of betn two nucleons having parallel spin (↑↑) is stronger ~~that~~ than the force betn two nucleons having antiparall spin (↑↓)

5) Nuclear forces have property of saturation

Nuclear forces are limitted in range
Each nucleon interect ~~tot~~ only with a limited number of nucleon nearest to it.
This effect is known as saturation of nucleon.

6) Nuclear forces are non-central

The force existing betn two nucleons has a non-central component that ~~it~~ doesn't point along the line joining the two nucleons.
This non-central component depends upon how the nucleus spin are oriented relative to the line joining the nucleus.

7) Nuclear forces exchange forces
Nuclear forces come into existance due to the exchange of π^+, π^-, π^0 meson (pions) betn the nucleas

(8) At too close distance of approach betn the nucleons nuclear forces become force of repulsion.