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Notes for:
B. Sc. Part-III
Paper - VIIIB

"Nuclear models"

It was assumed that the apart from the A Protons, the nucleus contained (A - Z) electrons, each carrying the charge negative -e. This would make the total charge of the nucleus + Ze. Since the mass of the electron is much smaller than that of the proton, the total mass of the nucleus would still be close to the total mass of the A Protons in it.

This Proton - electron hypothesis of the nuclear constitution has however many flaws. There are reasons to believe that electrons can not remain with nuclei which have radii of the order of 10^{-14} m or less. According to Heisenberg's uncertainty principle, the uncertainty in the momentum p of the electron in the nucleus would then be -

$$\Delta p = \frac{\hbar}{\Delta x} = \frac{\hbar}{R} \sim \frac{10^{-34}}{10^{-14}} = 10^{-20} \text{ kg.m/s}$$

An electron with momentum of this order of magnitude would have the energy

$$E - c\Delta p = \frac{3\times10^{8}\times10^{-20}}{1.6\times10^{-13}} = 20 \text{ MeV}$$

There is no experimental evidence of the existence of such high energy electrons within the nuclei of atoms. Such a high energy electron would have remain in a very deep potential well within the nucleus. According to Dirac electron theory, some of the electrons from the negative energy states could then make transitions to the positive energy states ~~could then make transitions~~ within this well, as a result of which electron - positron pairs would be created.

The chemical nature of an element is determined by the number of Protons within its nucleus. →

(P.T.O)

(from pg-1)

In order to understand the observed properties of the nucleus of an atom it is necessary to have an adequate knowledge about the nature of the internucleon interaction. A very strong short range force acts between the nucleons. The exact mathematical form this interaction is still not known. However, there are alternative approaches in which more than one pion exchange is also taken in to account. None of the proposed theory gives us a full understanding of the nature of the internucleon interaction.

It may be noted that even if the exact nature of the internucleon interaction were known, it would have been extremely difficult to develop a satisfactory theory of the structure of the nucleus made up a large number of neutrons and protons, since it is impossible to solve the Schrodinger equation exactly for such a many body system.

The situation is quite different if we consider the theory of atomic structure. The nature of the forces acting on the electrons in the atom is electromagnetic which is well understood. The quantum mechanical theory of the atomic structure is extensively developed and agrees well.

In developing a satisfactory theory of nuclear structure, different models have been proposed for the nucleus, each of which can explain some of the different characteristics of the nucleus.

Various models which have been proposed for the nucleus are the different collective models, Fermi gas model and the shell models with different types of coupling.

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